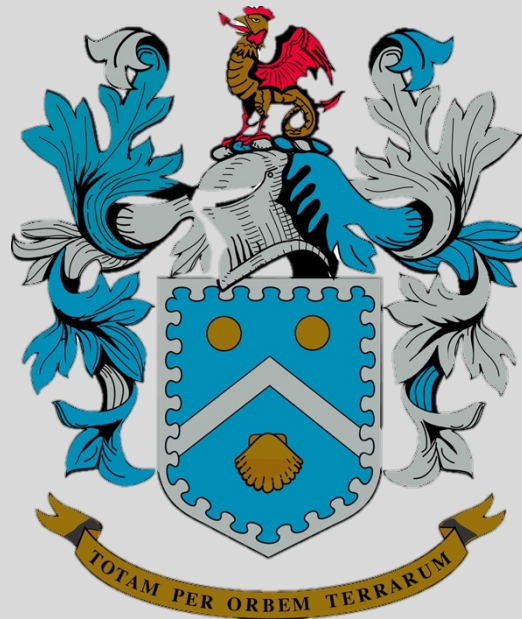


Society of South African Geographers



Proceedings of the 2024 Biennial Conference of
the Society of South African Geographers,
16 – 18 September, Potchefstroom, South Africa

*30 Years of Change and Beyond: Geography,
Democracy, Development, and Future Pathways*

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Free State)

Proceedings of the 2024 Biennial Conference of the Society of South African Geographers - *30 Years of Change and Beyond: Geography, Democracy, Development, and Future Pathways*

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FOREWORD

The 2024 Biennial Conference of the Society of South African Geographers (SSAG) commemorated three decades of development and change since South Africa's transition to democracy in 1994, as well as 30 years since the merger of two societies to form the SSAG. Hosted by North-West University from the 16th to the 18th of September for the academic portion, followed by the Student Conference on the 19th and 20th of September, the conference centered around the theme, "*30 Years of Change and Beyond: Geography, Democracy, Development, and Future Pathways.*"

The last time North-West University (NWU) hosted this conference was in 1991, when it was still known as the Potchefstroom University for Christian Higher Education. Since then, the university has undergone a significant transformation, merging with two other institutions to form NWU, symbolising a broader era of change. This transformation aligns well with the conference theme, which made the NWU a fitting host for the 2024 event.

The 2024 conference brought together a diverse range of participants—academics, students, and industry professionals—providing a dynamic platform to reflect on geography's role in addressing pressing issues such as inequality, urbanisation, climate change, and political instability, both in South Africa and globally. The event highlighted the interdisciplinary nature of modern geography, showcasing research that intersects with fields such as environmental science, political economy, and geographic information systems (GIS).

In line with SSAG's goals of promoting inclusivity, the 2024 conference attracted participants from a wide range of institutions. Delegates came from universities such as University of Cape Town, University of Mpumalanga, University of Zululand, and Stellenbosch University, as well as international institutions like the University of Sheffield (UK) and West Point (USA). The conference also addressed issues pertinent to southern Africa, focusing on geography's role in development initiatives, environmental sustainability, and policies enhancing resilience to socio-political and environmental shocks.

As a flagship event, the SSAG Biennial Conference provided a vital platform for sharing research and engaging in discussions on critical issues. Key topics included:

- Democratic Governance and Social Justice: Examining geography's role in analysing spatial inequalities and the socio-economic legacies of apartheid.
- Developmental Geography: Exploring how geographic research contributes to sustainable development in both urban and rural contexts.

Environmental Change and Climate Adaptation: Presenting research on climate change impacts and ecosystem resilience, with sessions on climate adaptation strategies and resource management.

REVIEW PROCESS FOR FULL PAPERS

A total of 70 abstracts were submitted for consideration, with five authors opting to submit full papers for potential inclusion in the conference proceedings. Following a rigorous double-blind peer review process, where each paper was evaluated by at least two expert reviewers (involving ten reviewers overall), three papers were ultimately selected for publication. The selection criteria focused on academic merit and alignment with the conference themes. Authors incorporated reviewer recommendations, which were then verified by the editors to ensure high standards prior to final publication in the Proceedings.

REFEREES

The editors wish to thank the referees for their valuable input and assessment of papers: Theuns de Klerk, Sam Adelabu, Innocent Sinthumle, Lobina Palamuleni, Leizel Williams-Bruinders, Christo Coetzee, Roelof Burger, Adriaan van der Walt

CONFERENCE PROCEEDINGS PEER REVIEW EVALUATION CRITERIA

The review criteria were as detailed below.

CONFERENCE PROCEEDINGS PEER REVIEW EVALUATION FORM

Title of manuscript:

Authors:

The Editors rely on the Reviewers' judgment in deciding whether to accept or reject a paper for the SSAG peer reviewed conference proceedings. Please indicate your evaluation and overall general comment of this paper for each of the following statements. All comments will be kept confidential.

1 The title of the paper is adequately phrased:

| Strongly agree (5) | Agree (4) | Neutral (3) | Disagree (2) | Strongly disagree (1) | N/A |
|-----------------------|--------------|----------------|-----------------|--------------------------|-----|
| | | | | | |

Comments (if applicable):

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2 The language and writing style are of an acceptable standard:

| Strongly agree (5) | Agree (4) | Neutral (3) | Disagree (2) | Strongly disagree (1) | N/A |
|-----------------------|--------------|----------------|-----------------|--------------------------|-----|
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Comments (if applicable):

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3 If any, the tables and figures are correct and of an acceptable standard, and are meaningfully titled:

| Strongly agree (5) | Agree (4) | Neutral (3) | Disagree (2) | Strongly disagree (1) | N/A |
|-----------------------|--------------|----------------|-----------------|--------------------------|-----|
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Comments (if applicable):

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4 The paper and reference list are correct:

| Strongly agree (5) | Agree (4) | Neutral (3) | Disagree (2) | Strongly disagree (1) | N/A |
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Comments (if applicable):

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5 The paper has cited relevant literature/published work:

| Strongly agree (5) | Agree (4) | Neutral (3) | Disagree (2) | Strongly disagree (1) | N/A |
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Comments (if applicable):

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6 The paper includes unethical, discriminatory and potentially harmful information/statements:

| Strongly agree (5) | Agree (4) | Neutral (3) | Disagree (2) | Strongly disagree (1) | N/A |
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Comments (strongly agree or agree please elaborate why you say so):

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Overall assessment:

| | |
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| Manuscript can be accepted as is | 5 |
| Manuscript can be accepted with minor technical, editorial corrections | 4 |

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| Manuscript has to be resubmitted to editors only | 3 |
| Manuscript has to be resubmitted to reviewer | 2 |
| Manuscript cannot be published at all | 1 |
| | Overall assessment: |

General comments:

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AUTHORS

Altogether 5 full paper authorships represent 4 separate institutions, comprising three universities and one research council. No institution exceeded the 40% limit as prescribed by the DHET:

- | | |
|-------------------------------------|-----------|
| 1. University of the Free State: | 1 (16.6%) |
| 2. Walter Sisulu University: | 1 (16.6%) |
| 3. University of the Witwatersrand: | 2 (33.3%) |
| 4. Agricultural Research Council: | 2 (33.3%) |

PAPERS

The Role of Institutional Actors in the Water Supply Systems of Lesotho: Problems and Opportunities

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Water availability in water-scarce regions such as sub-Saharan Africa requires careful management through institutional and societal governance structures and frameworks. However, water governance frameworks in sub-Saharan countries do not always perform well or do not include all relevant actors and stakeholders. For example, Lesotho is often portrayed as a country rich in water resources, but ineffective water governance results in lack of water access, poor water service delivery and polluted water sources. This study explores the role of key institutional actors and other stakeholders in water access issues, in the area of Maputsoe in urban northern Lesotho. This is achieved by document analysis of institutional water management and regulatory strategies in order to identify the ecosystem of collaboration and information sharing between different bodies, and the extent to which community stakeholders are included in this process. This analysis is supported by stakeholder interviews amongst key institutional actors in water management. This analysis shows that different governance levels and government departments are involved in water management issues, but that local-scale stakeholders are commonly not considered in narratives of water management. This lack of integrated management limits the effectiveness of the management process to address water supply issues in these developing world communities.

Keywords: *Climate change adaptation, Sustainability, Urban communities, Water access*

Introduction

Water is a primary natural resource that aids the development and maintenance of ecosystems and human activities (Mishra, 2023). Globally, water challenges related to resource availability, water quality and equity are expected to increase in the future as a result of climate change and increased resource demand, in combination (Akhtar *et al.*, 2021). This is particularly the case in sub-Saharan Africa where water availability and quality play a significant role in determining ecological and environment conditions, public health, and socioeconomic development (Arden and Jawitz, 2019). Studies suggest that conventional water resource management systems may not be able to address the forecasted challenges affecting water supply and use (Jain & Singh, 2023). Therefore, more effective and integrated water resource management is needed especially when it includes participatory, technical and scientific considerations (Basco-Carrera *et al.*, 2017; Katusiime & Schütt, 2020). The UN 2030 Agenda explicitly encourages multiple sectors and actors to collaborate in carrying out their unique duties towards achieving the Sustainable Development Goals (SDGs). SDG17 points out that stakeholder involvement and partnerships are significant in the sharing of knowledge, expertise and resources. This can include public participation in environmental and resource management. SDG6 describes the need for the sustainable management of water and sanitation systems, which requires such an integrated management approach and involving different sectors and actors. The application of integrated management and governance systems to address the SDGs is an established approach for environmental resource management in Africa (Sivapalan *et al.*, 2014; Falayi *et al.*, 2021), and local-scale water management should be seen in this context. Nonetheless, there are issues in developing

such a management framework and for the effective implementation of decision-making to achieve positive outcomes. The study describes the institutional frameworks that currently exist in managing water resources in Lesotho, focusing in particular on the Maputsoe area in northern Lesotho as an example. The purpose behind this study is to explore how different institutions and stakeholders interact with each other through formal or informal governance, regulatory or management frameworks; the effectiveness of these interactions in producing positive outcomes for local communities and the environment; and any limitations of such interactions. This analysis is needed because it can highlight where these governance frameworks can be strengthened and how local communities can become more empowered in decision-making and in enacting resource management strategies. Through exploring these issues using the case study of Maputsoe, a more nuanced understanding of water management and decision-making frameworks can be developed.

Conceptual Framework

Various conceptual frameworks exist that can help describe the interactions between different actors and stakeholders (in various sectors of society, industry and government) in addressing environmental issues and in managing environmental resources. The first is by considering water resources as an example of natural capital. This concept refers to the stock of renewable and non-renewable natural resources that combine to yield a flow of benefits to people and society (Meraj *et al.*, 2021). Water in the environment also contributes to the provision of other environmental resources (soil, plants, animals) and the services that are derived from them (Chenoweth *et al.*, 2018; Pettinotti *et al.*, 2018). Capital therefore arises from assigning values to resources and how they are

commodified by institutions and societies. This value may depend on how a resource is perceived and managed, thus the perceived value can vary over time and space even without a change in resource type or availability. The properties of water as a resource are closely linked to weather and climate conditions, and environmental changes caused by human activity. These in turn can influence the provision of environmental services provided by water and therefore its natural capital (Pettinotti *et al.*, 2018). Furthermore, the restoration or sustainability of natural capital can help address the relevant SDGs (Costanza and Daly, 1992; Blignaut and van der Elst, 2014). This can be done by (1) increasing the availability of environmental and ecosystem resources, (2) increasing the quality of the resource, (3) making the resource cheaper, and/or by (4) making the resource more sustainable or resilient to use or change.

The second conceptual approach to stakeholder interactions is through adopting a 'top-down' governance framework that focuses on the application of national- to regional-scale policy to address local-scale environmental issues (Dessai and Hulme, 2004). This has been most commonly developed in the field of climate change adaptation, of which variations in water availability and access is part. Here, the main driver is the development of national-scale policies and legislation to address environmental and resource issues, pollution, management and conservation. The advantage of this approach is that it provides a consistent and equitable framework for water management that is underpinned by institutional financial, administrative and technical expertise, support and delivery (Huntjens *et al.*, 2012; Arden and Jawitz, 2019). This includes defining the roles and responsibilities of different stakeholders involved in water resource management

(Jiménez *et al.*, 2020). Apart from government departments and agencies, this may include the roles of local stakeholders such as community-based organizations, traditional cultural leaders within communities, and any other non-governmental stakeholders such as charities, industry or philanthropic organizations. Several studies have examined how top-down national-scale policies for water management have been developed in sub-Saharan Africa, in particular focusing on the roles of national governmental institutions (Huntjens *et al.*, 2012; Makaya *et al.*, 2020). An effective institutional framework can enable the provision of water for people and communities whilst also enabling conservation and protection practices (Ako *et al.*, 2010). However, limitations of this approach include how national legislation can be applied to different climatic, social and infrastructure conditions that may vary according to the communities under examination (Mirumachi and van Wyk, 2010; Förster *et al.*, 2017). This is because different communities may have different needs, especially between rural and urban areas of Africa with varying water infrastructure and economic systems (e.g., agriculture).

The third conceptual approach focuses on the role of community-based adaptation strategies that deal with issues such as water conservation, rainwater harvesting and grey water use (Mwenge Kahinda *et al.*, 2010; Kirkby *et al.*, 2018). This can be considered as a 'bottom-up' approach (Dessai and Hulme, 2004) where the emphasis is on local communities identifying their own needs and developing their own strategies to address them. An advantage of this approach is that it empowers local communities to become resourceful and independent (Godden and Ison, 2019; Miller *et al.*, 2020). However, this may be limited by lack of access to technical expertise, lack of funding and lack of

coordination, or disagreements amongst different stakeholders (Workman, 2019). This approach may also lead to inequalities of water provision if some communities are more vocal, active or more highly resourced than others (Mbana and Sinthumule, 2024). An additional limitation is that local strategies may be different to or in conflict with national strategies, and this may get worse over time.

All of these conceptual approaches focus on developing institutional and community resilience to risks associated with water insecurity, such as those amplified by climate change (Huntjens *et al.*, 2012; Ensor *et al.*, 2018). It also highlights the importance of cooperation, collaboration and communication between different actors and stakeholders in water governance (Colvin *et al.*, 2008; Workman, 2019). This can be undertaken through public participation approaches where the local population is offered an opportunity to participate in the public decision-making process, in this case, relating to issues in water resource management (Hügel and Davies, 2020).

Thus, public participation can play a vital role in water resource management as it is the local community that can provide the necessary experience and ideas that could resolve water-related problems. This follows the four principles of the Dublin Statement on Water and Sustainable Development (1992), which are that (1) Water is a finite and vulnerable resource essential to sustain life, development, and the environment; (2) Water development and management should be based on a participatory approach, involving users, planners, and policymakers at all levels; (3) Women play a central part in the provision, management and safeguarding of water, in particular in the developing world; and (4) Water is a public good, based on its natural capital, and has a social and economic value in all its competing uses.

Lack of public participation and public trust may result in unnecessary antagonism between water resource users and other stakeholders because of misunderstood water situations or conflicting priorities (Tseng, 2018; Biancardi Aleu *et al.*, 2022). However, the level of public participation is still low in most countries and may also be hampered by inadequate or uncoordinated governance systems (Makaya *et al.*, 2020).

Methods

The main purpose of this study was to evaluate the role of key institutional actors and other stakeholders who are involved in water management in Lesotho, with particular reference to Maputsoe.

This area is one of the two major urban centres of Leribe and is the second-most populous urban centre in Lesotho after the capital city. It is a commercial and industrial centre and constitutes several small factories and a small industrial estate. It lies close to Ficksburg in the Free State, which can be accessed via the principal crossing point between Lesotho and South Africa across the Caledon River. Water in Maputsoe comes from three major sources which are the Mohokare River, well-points and a borehole.

However, despite this there is poor water availability in the area and many communities experience intermittent water supply, poor water quality, and inadequate infrastructure (for piped water, waste-water removal, and sanitation).

This study examined publicly-available strategy and policy documents from relevant government departments, agencies and other institutions involved in water supply and management, to identify how these institutions collaborate and share information, and the

extent to which they consider the concerns of community stakeholders. This analysis was supplemented by individual semi-structured interviews with government and non-governmental officials from these institutions, and with village heads. This was done to explore issues of water governance and management in more detail, to clarify points of concern and to identify any governance gaps, in particular related to community water provision. This element of the study gained research ethics clearance (H22/11/30). The data were analysed using thematic analysis.

Results

In Lesotho the main institutional stakeholders involved in water management are national government departments and agencies followed by non-governmental organisations (NGOs), and community stakeholders and organisations. The connections that exist between these major actors in water delivery and management in Lesotho, with particular relevance to the study area, are illustrated in Figure 1. These different actors are now described.

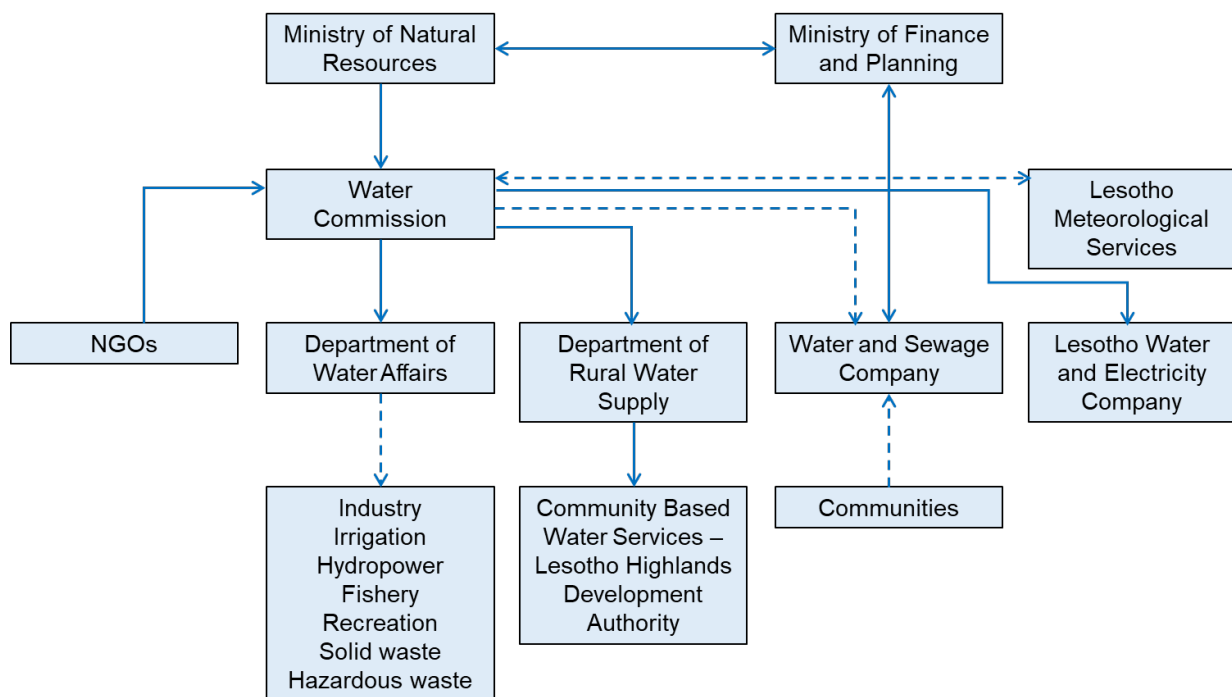


Figure 1. Relative Water management ecosystem in Lesotho with the major actors given in the boxes. Arrows indicate dialogue pathways that exist between these actors, as described in the policy documents and as identified in semi-structured interviews. Solid lines indicate strong dialogue pathways, dashed lines indicate weak dialogue pathways.

The Government of Lesotho

Water Commission

The Water Commission coordinates all water-related activities in the country. It does this by synchronising the duties and functions

of the Department of Water Affairs, Department of Rural Water Supply, and water parastatals such as the Water and Sewage Company (WASCO). One of the Water Commission's main objectives is to draw up a long-term water and sanitation strategy. This

includes key focus areas such as the establishment of Integrated Catchment Management plans, water resources, climate and environmental issues, and the Water Commission works with all sectors and departments responsible for these areas. Concerning climate change, there is a team from the Lesotho Meteorological Services delegated to work with the Water Commission, the Department of Water Affairs, the Department of Environment, and WASCO. The interview with a Water Commission official highlighted that monitoring of these resources has to be quarterly but due to financial constraints this is not happening. The main challenge is the shortage of financial, human and equipment resources. The Water Commission official stated that vandalism of infrastructure is the main challenge at the community level, and where people abstract water without a water use permit. The Department of Water Affairs allows people to pay to make use of certain water resources but some community members just assume that a river is free for anyone to use. River water in particular is over-exploited and polluted by intensive activities such as construction.

Department of Water Affairs

The main aim of this government department is to manage water resources in the country. It executes this aim by monitoring the quality and quantity of different water sources. The department is made up of different divisions and one division is particularly responsible for water resources management and water rights. The Lesotho long-term water and sanitation strategy of 2014 and the Water Act no 15 of 2008 are the main tools used as a guideline for the implementation of the department's objectives.

The Water Commission manages water resources through the Department of Water

Affairs with duties in the department shared among its different divisions such as the groundwater division and the surface water division, which are responsible for monitoring of groundwater and boreholes, as well as rivers and springs, respectively. Thus, these are the sections that execute water monitoring. Monitoring and evaluation are particularly important if data are needed for specific projects such as dam construction where long-term monitoring is required. The Department of Water Affairs interviewee noted that other stakeholders also have to be engaged in water resources protection in order to promote its quantity and quality but that this is often not done at the community level.

Water and Sewage Company (WASCO)

WASCO is a parastatal company in which the government is a major shareholder through the Department of Water Affairs, Ministry of Natural Resources. Thus, the company does not belong to any government department or ministry but rather it reports to the Water Commission. The mandate of the company is to abstract, treat and distribute potable water. It also collects wastewater and disposes of it back into the environment safely. There are guidelines for abstracting water, treating water, monitoring water quality through sampling and analysis, as well as for distribution of water, however, these guidelines are confidential. WASCO was given the responsibility to distribute water to Maseru and then to other urban centres in the country. This was done by utilising two rivers, Maqalika and Mohokare. However, this was not sufficient as the river flows decrease during the dry season with the result that WASCO consulted and advised the Water Commission that from 2015 the water demand will exceed supply. This was addressed by WASCO by construction of Metolong Dam along the Phuthiatsana (Little Caledon) River in 2016 to supply water to Maseru and other urban

centres. This is the only dam that has been constructed for this purpose so far. Water in the dam is monitored by WASCO to check its quality so that necessary actions are done according to the acquired results. When it comes to dam safety, the dam wall is monitored, not the water inside. The health of the river and the catchment coming into the dam is also monitored.

Although WASCO primarily operates in urban centers, this is changing as large water treatment plants are now located in rural areas. These plants have the potential to supply water to rural communities through existing pipelines, but this has not yet been implemented. While this shift has not been formally incorporated into the company's mandate, it reflects the current trend in operations. Initially, in these rural areas WASCO used to install community standpipes, however communities now prefer reticulation of water/taps to their households. There are clear guidelines on how water must be connected in households. There is a main pipe water supply but connection fees depend on the distance of the household from the pipeline which is referred to as bands 1, 2, 3 and 4 according to distance. Households that are too far away, or beyond a certain point, do not get the connection right away. For the connection, there are also specific guidelines on distance and connectivity to households. This means that water supply to scattered or remote households especially in rural areas is not provided. Interviews conducted with two WASCO officials highlighted that the main challenge is that some water pipelines are very old so there are frequent bursts and leakages.

Lesotho Meteorological Services

Lesotho Meteorological Services has played a role by forming the national climate change committee which is made up of government

officials, the private sector, development partners, NGOs, civil society groups and faith-based organizations. It is further separated into three subcommittees, climate finance, monitoring and evaluation, and public outreach. The public outreach subcommittee is the one that is led by mostly NGOs because they are the ones that go to the villages to talk to the community. That is how information is relayed to the grassroots level to encourage sustainable management of water resources as a way to adapt to climate change. Annually, Lesotho Meteorological Services releases seasonal forecasts. If there are extreme weather events expected such as above-normal rainfalls, different stakeholders will then be informed, so this allows the officials in the water sector to be proactive and to start developing measures to adapt.

Village heads and communities

Village heads/Chiefs request meetings with government officials such as WASCO regarding water affairs, as communities across the country and in Maputsoe struggle with water access. For example, if water pipes are broken, the village heads inform WASCO so that they come to fix them. This means they act as the mediator between the government and the community. The outcomes from such meetings are normally positive in the sense that they bring forth changes that are better for the community. However, implementation of policy is the biggest challenge and it is normally because of the negligence of a certain office, not the community. Interviews with village heads highlighted their pessimism when working with government officials, where promises were often made but never kept and implemented. In addition, even when improvements or actions are taken, this does not result in long-term benefits because their solutions are normally only short-lived and infrastructure is often destroyed, vandalised or becomes broken.

Discussion

As in many other areas of sub-Saharan Africa, one of the primary developmental problems in Maputsoe and other parts of Lesotho is the provision of safe drinking water and adequate water supply services to all (Bishoge, 2021). Community-based issues with water provision and management in Lesotho have been previously highlighted (e.g., Workman and Ureksoy, 2017; Workman, 2019; Sekamane *et al.*, 2023). These indicate the societal impacts of inadequate water supply and water quality and the precarity of household socioeconomic activities as a result. Many previous studies have shown that, for water resource management to be successful, there has to be an effective institutional framework (Förster *et al.*, 2017; Jiménez *et al.*, 2020; Mayaka *et al.*, 2020). Although there is an institutional framework in place (Figure 1), it is neither efficient nor effective. The main reason for this is the lack of coordination among different stakeholders and relevant parties, as each does not take into account the duties and actions of the other (Jager *et al.*, 2016). Previous studies have suggested this is due to the hierarchical nature of governance, such as the top-down policy framework approach, where there is a power vacuum or gap between levels, or where institutions overreach their roles (Biancardi Aleu *et al.*, 2021; Lukat *et al.*, 2023). Cooperation between different levels and building trust and accountability are key (Colvin *et al.*, 2008; Mirumachi and van Wyk, 2010; Neto and Camkin, 2022). The different institutions responsible for water resources management also appear to operate in silos, with limited or sporadic cooperation.

Results show that the interaction between water resource managers and the community mainly takes place reactively when the community complains about poor water access. This contributes to a lack of public trust in institutions (Tseng, 2018). The lack of participatory governance approaches developed here means that the local community does not always have an opportunity to develop ideas and adaptations that could resolve water-related issues. Local community activities can build the capacity of stakeholders to participate in decision-making in water governance in a more inclusive and transparent way (Ako *et al.*, 2010; Neto and Camkin, 2022). One of the main reasons why water access appears to be a challenge in the Maputsoe area may be the absence of community engagement in decision-making (e.g., Hügel and Davies, 2020).

Cooperative and participatory governance is highlighted in many studies as advantageous in environmental resource management and sustainability (e.g., Colvin *et al.*, 2008; Brown, 2011; Huntjens *et al.*, 2012; Godden and Ison, 2019; Lukat *et al.*, 2023). However, this requires willingness and proactive engagement on the part of all actors and stakeholders, and this does not appear to be the case in Maputsoe. There is also a lack of communication and information sharing opportunities such as forums or meetings where all stakeholders can come together. Although the regulatory framework through the Water Commission exists, this does not feed through into action.

Conclusions

Water is a resource that has to be accessible to all communities worldwide as a basic human right as described in the SDGs. Therefore, it has to be managed as a commons resource. In Maputsoe, interactions in water management

are currently lacking between relevant actors and stakeholders, resulting in water and related environmental issues not being addressed and communities not receiving sufficient water supplies. There is a need for more effective stakeholder engagement at all levels, and for WASCO to deliver water infrastructure to all communities. There may also be a need for a single body that is responsible for facilitating such coordination and ensuring that plans are successfully implemented. Empowering community action through education, training and management may result in more sustainable water use and better environmental outcomes.

This research makes it evident that water resource management is an essential instrument in dealing with issues of water access. Looking at the significance of water resources management in development, and physical planning in the form of water management infrastructure, should be implemented in the country as a priority.

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Assessing the Impact of Land-Use Practices on the Water Quality of the Mthatha River

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Less than half of the rural population in South Africa has no access to a safe and reliable water source, and over 12 million people lack access to clean water. As a vital component of environmental health, water quality affects both the sustainability of ecosystems and human well-being. Regular surface water sampling in the Mthatha River is part of the monitoring programme, which assesses the river's chemical, biological, and physical properties. This study aims to assess the impact of land-use transition on the water quality of the Mthatha River. Water quality data comprising six water quality parameters (pH, ammonia, electrical conductivity, phosphates, faecal matter, and *Escherichia coli*) were analysed. Significant variations were observed in the concentration of all parameters examined across the sampling stations. However, when analysing seasonal effects, the concentration of *E. coli* remained stable, while the concentrations of pH, phosphates, ammonia, and faecal matter varied. Furthermore, the composition of water parameters varied significantly between seasons and across sampling sites. The results suggest that different sites have varied water quality levels, with certain areas showing indicators of pollution that can be linked to urban growth, industrial discharge, and agricultural runoff. Anthropogenic activities and seasonal variations dynamically alter water quality characteristics. The insights gained from this study are crucial in assisting stakeholders, water resource managers, and policymakers to develop plans that will manage and conserve the water quality of the Mthatha River effectively. By putting targeted measures into place and encouraging community involvement, it is possible to reduce pollution sources and protect water resources for current and future generations.

Keywords: *Water quality, pollution, development, activities, water parameters, physicochemical properties, seasonal variations.*

Introduction

South Africa is one of the top 30 driest countries in the world, with an average annual rainfall of almost 40% less than the global average (Nair *et al.*, 2022). Despite this scarcity, water is essential for all forms of life, comprising 50–97% of the weight of plants and animals, and 70% of human body weight (Nair *et al.*, 2022). Globally, about 97.2% of the

hydrosphere consists of sea water, while the remaining 2.8% is freshwater (Strahler & Strahler, 2005).

Water is poorly managed in many parts of the world; for example, Zhang *et al.* (2021) opine that the water crisis in Pakistan is attributable to poor water management. Poor management of water may be due to the discharge of industrial effluent into waterbodies, resulting

in pollution (Bholanth *et al.*, 2021; Chimwanza *et al.*, 2005). Furthermore, water pollution may be caused by untreated or inadequately treated wastewater, leachates from wastewater dumps, human settlements that lack proper sanitary infrastructure, and land-use activities, such as agriculture (Fatoki *et al.*, 2001; Zamxaka *et al.*, 2004). Brontowiyono *et al.* (2022) argue that green spaces globally have become industrial and habitational places. According to earlier studies, water quality and land-use types are significantly correlated (Brontowiyono *et al.*, 2022). Conversely, vegetated area improves water quality, whereas built-up and agricultural land use degrades it. River water quality is lowered during the rainy season when huge quantities of fertilizer are released into the stream due to soil erosion in agricultural land use. In addition, the amount of organic matter and nutrients in river water is influenced by built-up land use (Brontowiyono *et al.*, 2022; Minh *et al.*, 2020; Divya & Belagali, 2013). Butu *et al.* (2022) opines that increasing urbanisation and industrialisation contribute significantly to waste generation and its associated environmental impacts, including surface water pollution. Point and non-point sources of untreated effluent are the most frequent causes of surface pollution in urban areas worldwide (Camara *et al.*, 2019; Lemessa *et al.*, 2023). For instance, surface runoff collects and transports pollutants deposited in impermeable areas, along with eroded soil particles from porous areas. Furthermore, contaminants from landfills and septic tanks are transported by ground water, with suspended particles, metals, bacteria, aerobics, nutrients, and fats all present in urban runoff. The sources of these pollutants include road packing, construction activities, the use of

pesticides and fertilizers, cars, and animal dung (Camara *et al.*, 2019).

Water pollution not only alters the quality of water but may harm aquatic species, terrestrial animals and human beings relying on the polluted waterbodies (Fatoki *et al.*, 2001). The paucity of water in South Africa heightens the urgent need to safeguard water resources against pollution-induced deterioration that impedes its usage (Fatoki *et al.*, 2001). This study was conducted in the Mthatha River (referred to interchangeably as 'the Mthatha River' or 'the River'), a major source of water for the construction and agricultural industries, as well as for fishing, swimming, and domestic use (Fatoki *et al.*, 2002). Previous studies have shown that the River is contaminated by various pollution sources, such as sewage pipe leaks, direct and indirect solid waste dumping, and both point and non-point sources (Bangani *et al.*, 2023; Vika *et al.*, 2024; Fatoki *et al.*, 2001). For example, as informal settlements grow, increasing amounts of waste are disposed of on the banks of the River (Bangani *et al.* (2023). This alters the River's electrical conductivity, pH, dissolved oxygen, *E. coli*, and nitrite levels, impacting water quality (Vika *et al.*, 2024). Although previous studies have assessed the quality of water in the River, the focus of those studies has been on the spatiotemporal concentration of the water (Vika *et al.*, 2024; Fatoki *et al.*, 2001), as opposed to composition of water quality parameters of the River. Additionally, there is a lack of research on the transitional stages of land use and the long-term effects of these changes on water quality. Considering this knowledge gap, the purpose of this study is to analyse the water quality spatiotemporal composition of the Mthatha River in addition to concentrating on the concentration of water quality metrics, as has been the case with earlier studies. Researching the spatiotemporal composition of water is essential for resource management, human

health, ecological health, and environmental impact mitigation. It offers information that facilitates well-informed decision-making in a variety of industries.

Methods

Study Area

The study was carried out along the Mthatha River in the King Sabata Dalindyebo Local Municipality, Eastern Cape, South Africa (Figure 1). The Mthatha River catchment (T20), the Xhora River catchment (T80), and the Mngazi River catchment (T70) are the three secondary catchments that make up the Mthatha River (Amoo et al., 2024). The Mthatha River rises in the Eastern Cape

plateau, roughly halfway between the Indian Ocean and the Drakensberg Escarpment. The River's catchment (MRC) spans up to 50 km in width and roughly 100 km in length (Fatoki et al., 2001). The catchment has a steep escarpment in the headwaters and is typically hilly, undulating, and fractured towards the shore. The geology of MRC is made up of Beaufort Group mudstones and sandstones up to 30 km from the coast, followed by Ecca Group shales, mudstones, and sandstones, with exposures of dolerite intrusions primarily in the higher elevations (Fatoki et al., 2001). The MRC is exposed to a variety of land-use activities, including mining, construction, agriculture, wastewater treatment plants (WWTP), forestry, built environment, and automotive mechanics.

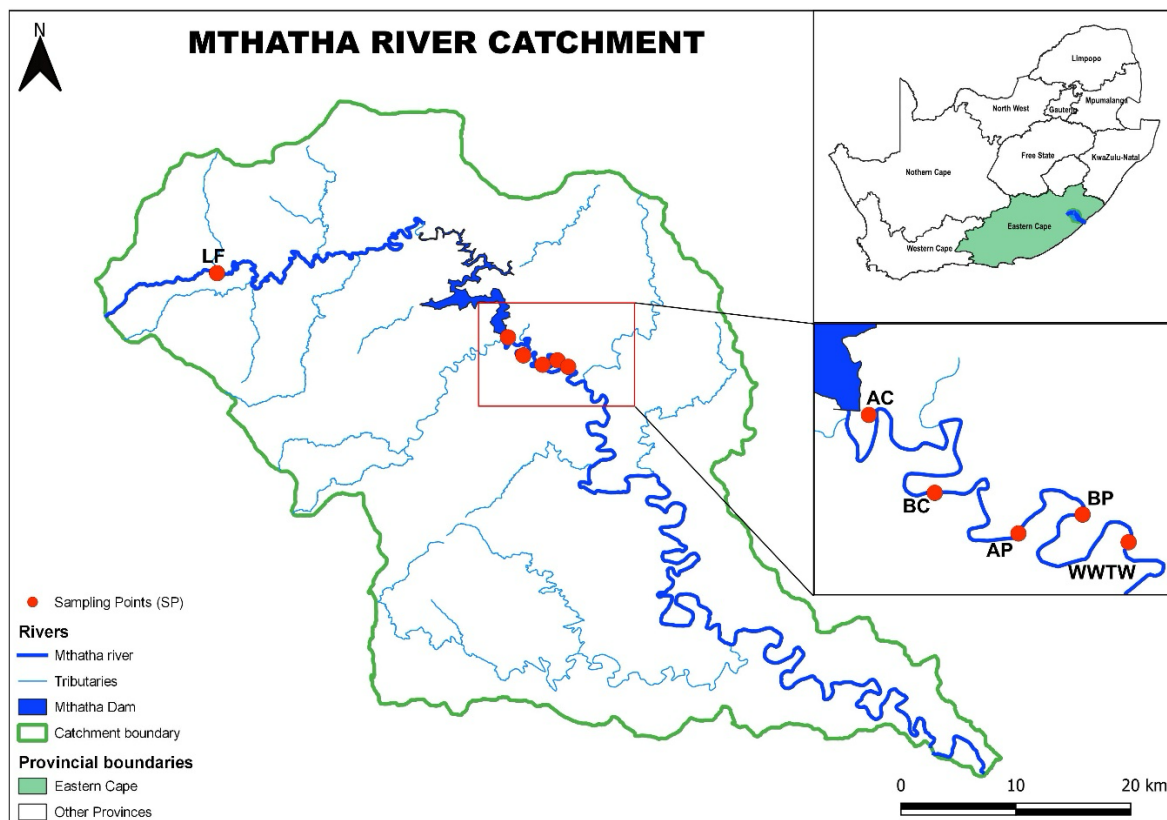


Figure 1. Map of Mthatha River and its tributaries showing the sampling points.

Sampling Design

Six sampling sites were established along the Mthatha River, near different land uses (Figure 1), including brick manufacturing industry, agriculture, wastewater treatment works, motor mechanic, and illegal waste disposal. Certain sampling points were exposed to a single type of land use, while others were exposed to a combination.

The first sampling point, referred to as Langeni Forest (LF), is situated at the headwaters, where there is less activity in terms of land use. Following LF, below the Mthatha Dam, is Above Cikirha (AC), which is encircled by agricultural activities. The third site, Below Cikirha (BC), is situated in an informal settlement with poor municipal waste collection services (making it a prominent location for unlawful waste disposal). Additionally, livestock are prevalent at BC site. The fourth site, Above Prison (AP), is located two meters from a tarred road, and is distinguishable by the dominance of alien and native vegetation. Illegal waste disposal is also evident at AP site. The fifth site, Below Prison (BP), is located near heaps of improperly disposed waste (including untreated sewage), waste stabilization ponds and agricultural land. Lastly, the Wastewater Treatment Works (WWTW) site is adjacent to a wastewater treatment plant directly below Mthatha town.

From 2012 to 2022, water samples were collected once monthly from each of the six sampling sites. A total of 2 116 water samples were collected and analysed, either *in situ* or transported to the laboratory. The water parameters measured were pH, electrical conductivity, phosphate, ammonia and faecal matter and *E. coli*.

Data Analyses

Data analyses were conducted in Statistical Package for Social Scientists (SPSS) Version 29, which offers a range of statistical procedures, including inferential statistics techniques like ANOVA and Chi-square. In addition, R version 4.1.2 (R Core Team) and PRIMER 7 were also used to analyse data. Analyses were performed to assess variations in the concentration and composition of water quality parameters across locations and seasons. To evaluate water quality status for domestic purposes, drinking water quality index (WQI) was computed utilizing electrical conductivity, pH, and ammonia, these three parameters being selected as they satisfy the BI standard's WQI requirements. The Shapiro-Wilk test was used to test the concentration data for normality (Rochon *et al.*, 2012). The dataset for each water parameter was tested for normality separately. The Shapiro-Wilk test showed that the water parameters were not normally distributed ($p < 0.05$), necessitating the use of the Kruskal-Wallis test to determine differences in median water parameters across the sampling sites. The Kruskal-Wallis test is appropriate for comparing the means of three or more independent groups when data defy normality assumptions (Lee, 2022; Sam-Uroupa & Ogbeibu, 2020). To test the impact of effluent discharge on the composition of water quality parameters, which was based on the combination of all measured water parameters, the permutational multivariate analysis of variance (PERMANOVA) in PRIMER 7 was used. Prior to the use of PERMANOVA, data were log-transformed and normalised, and the Euclidean distance was used for analyses (Anderson *et al.*, 2008).

Results

The drinking water quality index (WQI) results showed an increasing trend from the headwaters (least disturbed, LF) downstream (most disturbed, WWTW). The following WQI scores were recorded, LF = 4.5, AC = 10.7, BC = 15.8, AP = 47.5, BP = 62.9 and WWTW = 47.6.

Spatial Concentration and Composition of Water Quality Parameters

There were statistically significant variations ($p < 0.001$) in the concentrations of all the water quality measures (pH, electrical conductivity, phosphate, ammonia, faecal, and *E. coli*) at the different sampling sites. Phosphate, faecal, and *E. coli* concentrations showed a similar pattern, with WWTW having the highest concentration, followed by BP, AP, BC, AC, and then LF, which had the lowest concentration (Table 1, Figures 2a, b, c). Ammonia and electrical conductivity concentrations also differed, with LF registering the lowest concentration. The concentration at AC was less than the

concentrations that were found at BC, AP, WWTW and BP (Table 1, Figures 2d and e). On the other hand, LF, AC, and BC recorded similar pH concentrations, which subsequently decreased at AP < BP < WWTW following an decreasing order (Table 1, Figure 2f).

The sampling sites significantly impacted (Pseudo-F = 9.58, $p = 0.0001$) the composition of water quality parameters. The composition of water quality parameters at LF differed from that at AC ($t = 2.58$, $p = 0.0001$), BC ($t = 3.41$, $p = 0.0001$), AP ($t = 3.85$, $p = 0.0001$), BP ($t = 4.80$, $p = 0.0001$), and WWTW ($t = 4.98$, $p = 0.0001$). The composition of water quality parameters at AC also differed significantly from that at BC ($t = 1.76$, $p = 0.031$), AP ($t = 2.43$, $p = 0.0003$), BP ($t = 3.84$, $p = 0.0001$), and WWTW ($t = 3.88$, $p = 0.0001$). Before Cicerha sampling site differed from the BP site ($t = 2.51$, $p = 0.001$) and WWTW ($t = 2.85$, $p = 0.0012$). However, BC did not differ from AP ($t = 1.17$, $p = 0.20$) in terms of composition. Moreover, AP differed from BP ($t = 1.53$, $p = 0.0338$). Finally, WWTW did not differ from AP ($t = 0.95$, $p = 0.45$) and BP ($t = 0.90$, $p = 0.53$).

Table 1. shows spatiotemporal Concentration of Mthatha River Water Quality based on Pairwise Comparisons. Significant differences are flagged in bold across the sampling sites which are LF - Langeni Forest, AC - Above Cicerha, BC - Below Cicerha, AP - Above Prison, BP - Below Prison, WWTW - Wastewater Treatment Works

| pH Concentration across Locations | | | Concentration of Ammonia | | | Phosphate Concentration across Seasons | | |
|-----------------------------------|------|-------------|--------------------------|------|--------------|--|--------|--------------|
| Location | | Sig | Locations | | Sig. | Seasons | | Sig. |
| LF | AC | 0.27 | LF | AC | 0.39 | Autumn | Summer | 0.123 |
| LF | BC | 0.41 | LF | BC | 0.047 | Autumn | Winter | 0.001 |
| LF | AP | 0.00 | LF | AP | 0.001 | Autumn | Spring | 0.001 |
| | | 3 | | | | | | |
| LF | BP | 0.00 | LF | BP | 0.001 | Summer | Winter | 0.030 |
| | | 1 | | | | | | |
| LF | WWTW | 0.00 | LF | WWTW | 0.001 | Summer | Spring | 0.003 |
| | W | 1 | | W | | | | |
| AC | BC | 0.78 | AC | BC | 0.263 | Winter | Spring | 0.30 |

| AC | AP | 0.07 | AC | AP | 0.003 | Electrical conductivity concentration across seasons | | |
|-----------------------------------|----------|--------------|--------------------------------|----------|--------------|---|--------|--------------|
| AC | BP | 0.004 | AC | BP | 0.001 | Seasons | | Sig. |
| AC | WWT W | 0.006 | AC | WWT W | 0.001 | Autumn | Summer | 0.55 |
| BC | AP | 0.036 | BC | AP | 0.072 | Autumn | Winter | 0.002 |
| BC | BP | 0.002 | BC | BP | 0.001 | Autumn | Spring | 0.001 |
| BC | WWT W | 0.002 | BC | WWT W | 0.001 | Summer | Winter | 0.013 |
| AP | BP | 0.29 | AP | BP | 0.104 | Summer | Spring | 0.001 |
| AP | WWT W | 0.34 | AP | WWT W | 0.158 | Winter | Spring | 0.18 |
| BP | WWT W | 0.92 | BP | WWT W | 0.835 | | | |
| Phosphate across locations | | | Faecal across locations | | | Ammonia concentration across seasons | | |
| Locations | | Sig. | Locations | | Sig. | Seasons | | Sig. |
| LF | AC | 0.81 | LF | AC | 0.010 | Autumn | Summer | 0.13 |
| LF | BC | 0.20 | LF | BC | 0.001 | Autumn | Winter | 0.001 |
| LF | AP | 0.016 | LF | AP | 0.001 | Autumn | Spring | 0.001 |
| LF | BP | 0.001 | LF | BP | 0.001 | Summer | Winter | 0.017 |
| LF | WWT W | 0.001 | LF | WWT W | 0.001 | Summer | Spring | 0.001 |
| AC | BC | 0.13 | AC | BC | 0.19 | Winter | Spring | 0.43 |
| AC | AP | 0.008 | AC | AP | 0.007 | Faecal concentration across seasons | | |
| AC | BP | 0.001 | AC | BP | 0.001 | Seasons | | Sig. |
| AC | WWT W | 0.001 | AC | WWT W | 0.001 | Autumn | Summer | 0.010 |
| BC | AP | 0.270 | BC | AP | 0.176 | Autumn | Winter | 0.005 |
| BC | BP | 0.001 | BC | BP | 0.041 | Autumn | Spring | 0.001 |
| BC | WWT W | 0.001 | BC | WWT W | 0.06 | Summer | Winter | 0.96 |
| AP | BP | 0.001 | AP | BP | 0.48 | Summer | Spring | 0.11 |

| Electrical conductivity across locations | | | <i>E. coli</i> across locations | | | Winter | Spring | 0.09 |
|---|----------|-------------------------|------------------------------------|----------|--------------|--------|--------|------|
| locations | | Sig. | Locations | | Sig. | | | |
| AP | WWT W | 0.01 6 | AP | WWT W | 0.57 | | | |
| BP | WWT W | 0.45 6 | BP | WWT W | 0.90 | | | |
| LF | AC | 0.00 1 | LF | AC | 0.007 | | | |
| LF | BC | 0.00 1 | LF | BC | 0.001 | | | |
| LF | AP | 0.00 1 | LF | AP | 0.001 | | | |
| LF | BP | 0.00 1 | LF | BP | 0.001 | | | |
| LF | WWT W | 0.00 1 | LF | WWT W | 0.001 | | | |
| AC | BC | 0.00 3 | AC | BC | 0.23 | | | |
| AC | AP | 0.00 1 | AC | AP | 0.029 | | | |
| AC | BP | 0.00 1 | AC | BP | 0.001 | | | |
| AC | WWT W | 0.00 1 | AC | WWT W | 0.001 | | | |
| BC | AP | 0.24 | BC | AP | 0.33 | | | |
| BC | BP | 0.00 3 | BC | BP | 0.005 | | | |
| BC | WWT W | 0.01 6 | BC | WWT W | 0.013 | | | |
| AP | BP | 0.07 | AP | BP | 0.07 | | | |
| AP | WWT W | 0.21 | AP | WWT W | .013 | | | |
| BP | WWT W | 0.56 | BP | WWT W | 0.77 | | | |

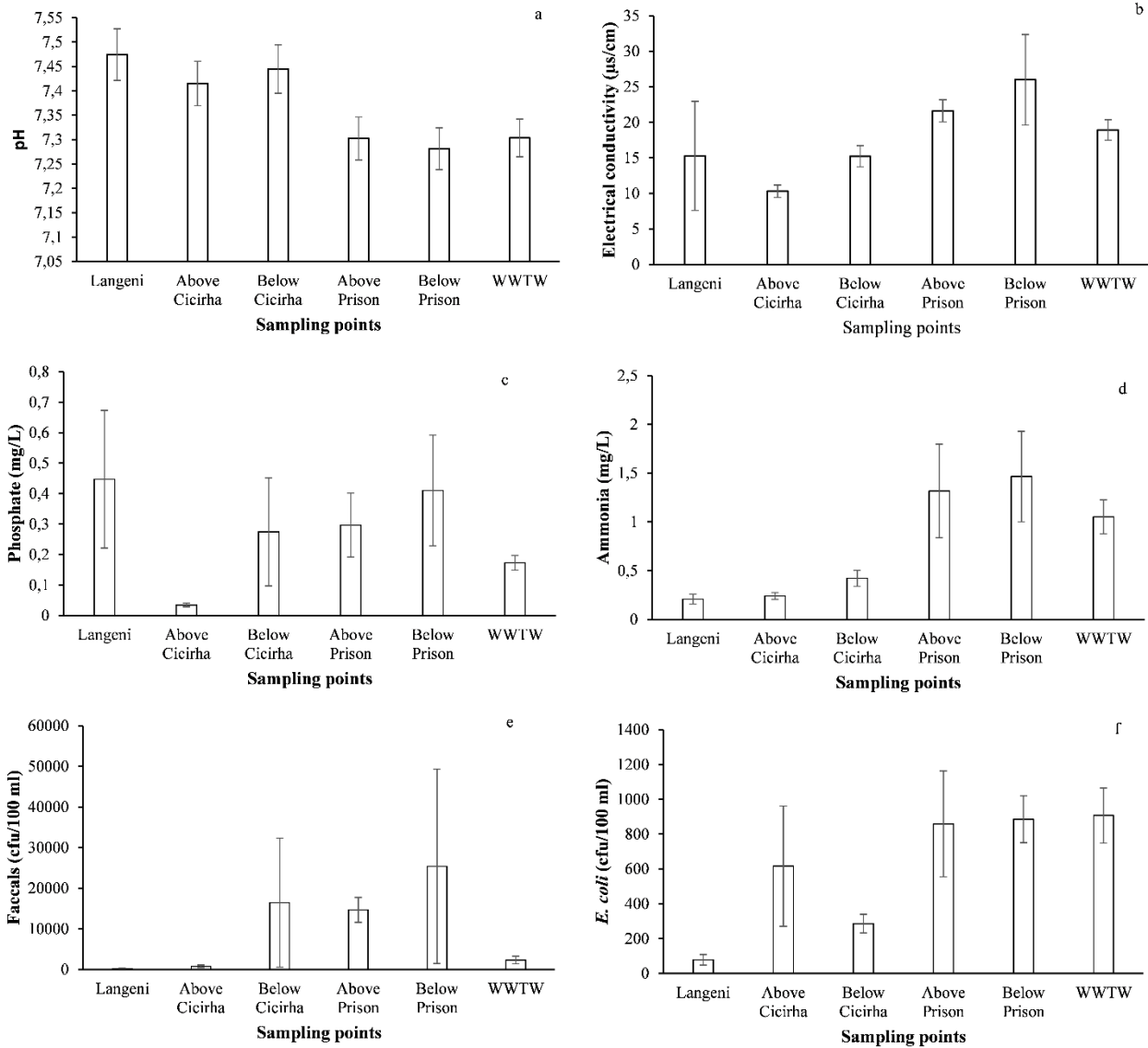


Figure 2. Bar graphs showing varying water quality parameters across sampling points.

Temporal Concentration and Composition of Water Quality Parameters

The comparison between the different seasons revealed statistically significant variations ($p < 0.001$) in electrical conductivity, phosphate, ammonia, and faecal matter concentrations. Autumn and summer had similar concentrations of electrical conductivity, phosphate and ammonia, and these (electrical conductivity, phosphate and ammonia) were lower in autumn and summer compared to the spring and winter seasons; however, these did not differ statistically (Table 1, Figures 3a, b, c).

Additionally, significantly higher concentrations of faecal matter were recorded in the spring, winter and summer seasons compared to autumn (Table 1, Figure 3d). Water pH ($p = 0.2$) and concentration of *E. coli* ($p = 0.12$) were not influenced by seasonal change.

The composition of water quality parameters was significantly impacted by changes in season (Pseudo-F = 6.9991, $p = 0.0001$), with spring composition measurements differing from those taken in summer and autumn (see Table 2). However, there were similarities in

composition between spring and winter seasons. Moreover, Summer differed in composition from both the autumn and winter seasons. Lastly, there were significant

differences in the composition of water parameters between autumn and winter seasons (see Table 2).

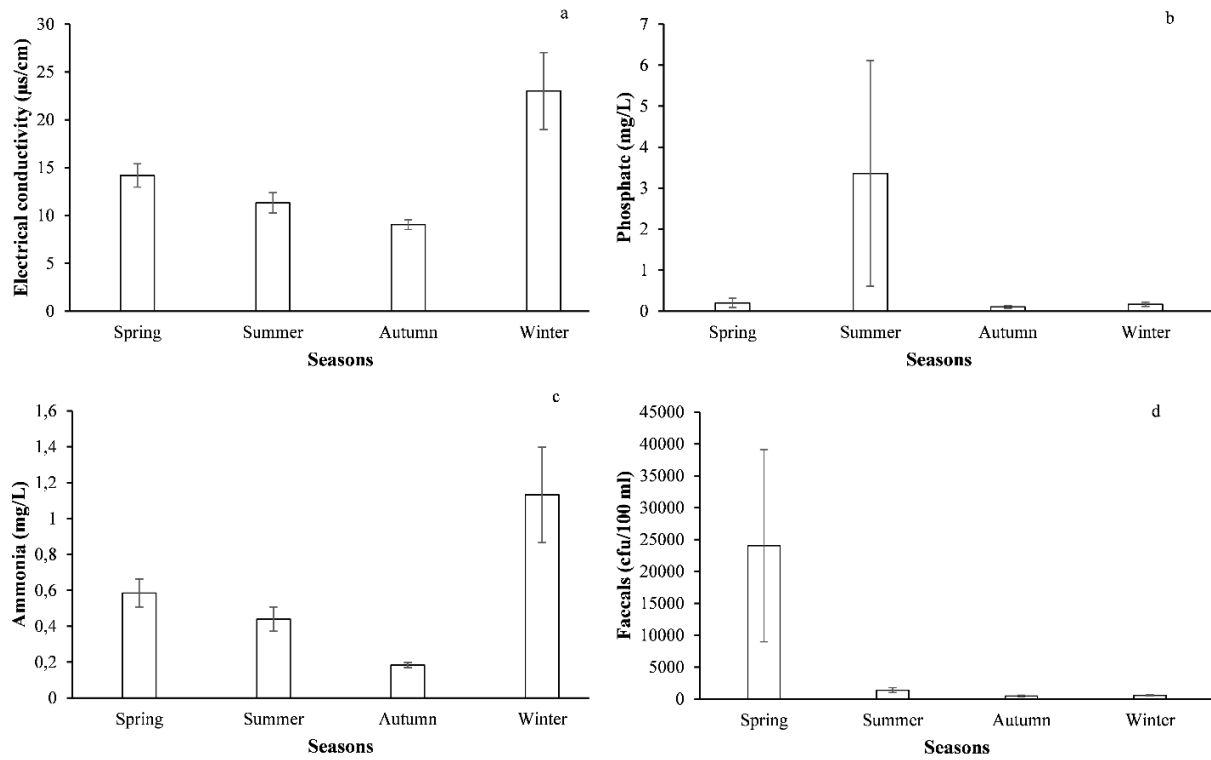


Figure 3 Bar graph showing varying water quality parameters across seasons.

Table 2. The Composition of Mthatha River Water Quality. Significant differences are flagged in bold across the sampling sites which are LF - Langeni Forest, AC - Above Cicerha, BC - Below Cicerha, AP - Above Prison, BP - Below Prison, WWTW - Wastewater Treatment Works

| Composition of water parameters across locations | | | | Composition of water parameters across locations | | | |
|--|------|------|---------------|--|--------|------|---------------|
| Locations | | t | Sig. | Locations | | T | Sig. |
| LF | AB | 2.58 | 0.0001 | Spring | Summer | 2.25 | 0.001 |
| LF | BC | 3.41 | 0.0001 | Spring | Autumn | 3.82 | 0.0001 |
| LF | AP | 3.85 | 0.0001 | Spring | Winter | 1.4 | 0.06 |
| LF | BP | 4.80 | 0.0001 | Summer | Autumn | 1.6 | 0.03 |
| LF | WWTW | 4.98 | 0.0001 | Summer | Winter | 2.6 | 0.0001 |
| AC | BC | 1.76 | 0.0307 | Autumn | Winter | 3.75 | 0.0001 |
| AC | AP | 2.43 | 0.0003 | | | | |
| AC | BP | 3.84 | 0.0001 | | | | |

| | | | |
|----|------|------|---------------|
| AC | WWTW | 3.88 | 0.0001 |
| BC | AP | 1.17 | 0.20 |
| BC | BP | 2.51 | 0.0001 |
| BC | WWTW | 2.25 | 0.0012 |
| AP | BP | 1.52 | 0.0338 |
| AP | WWTW | 0.95 | 0.45 |
| BP | WWT | | 0.53 |

Discussion

Spatial Concentration and Composition of Water Quality Parameters

The study demonstrated that the concentration of Mthatha River water quality is affected by different land-use activities (Table 3) across the different sampling sites. The River's electrical conductivity, phosphate, ammonia, faecal count and *E. coli* show an increasing trend as one moves downstream. This pattern is supported by the WQI results. These findings align with those of previous studies, which found that the upper section of the River had a lower phosphate concentration than the lower section (García-Ávila *et al.*, 2022; Briciu *et al.*, 2020; Chimwanza *et al.*, 2005; Phiri *et al.*, 2005).

Waterbodies with high phosphate content encourage the growth of aquatic plants, which has a detrimental impact on water quality, depleting oxygen by speeding up the growth of algal clumps, which causes anoxic conditions, foul odours, and discolouration (Badamasi *et al.*, 2019). The Mthatha River's lower reaches have higher phosphate concentrations than the upper reaches, which indicates that land-use activities, such as farming and wastewater treatment plants, may contribute to the River's phosphate load. The study's findings corroborate earlier research explaining that phosphorus in surface water comes from a range of sources, such as sewers, fertilizer, and animal waste (Madilonga *et al.*, 2021; Maillard & Santos, 2008).

A similar trend was observed in the concentrations of *E. coli* and faecal matter of the River, with the upper reaches showing lesser concentration than the lower reaches. The illegal connection of private residents' sewer pipes into the river, the discharge of effluent containing raw sewage, and the disposal of solid waste, including diapers, all contribute to the rising concentrations of *E. coli* and faecal matter as one moves downstream. These findings are consistent with those of Alkali *et al.* (2022), who observed that *E. coli* was present in every water sampling site tested and that this was caused by human activities occurring in the river basin, such as the release of human waste and domestic and agricultural wastewater into the Gundutse River in Kano, Northern Nigeria. Furthermore, these findings support Makupula *et al.* (2023) in linking an increase in the concentration of faecal matter to both people and livestock. Similarly, Bangani *et al.* (2023) associated the presence of diapers in the water column to the River's high faecal count.

Additionally, the study showed a balanced pH level between the first three sampling sites, which began to decline as one moved away from the AP site. This demonstrates that land-use activities did not directly impact the River's pH content in the upper reaches. However, it was affected by the wastewater from both prison sites (AP and BP) and WWTW. These findings align with those of Phiri *et al.* (2005), who found lowered pH concentrations in the River's lower reaches in Malawi. Ammonia and electrical conductivity displayed a similar trend,

increasing from the upper reaches until BP, then declining as one moves towards WWTW. The gradual increase in ammonia concentration downstream is attributable to the pollution of the river. For example, the high levels of organic materials around the River, which can come from various sources, including homes, industrial activities, and agricultural waste, tend to be the primary source of the high

ammonia content in the water. Similarly, Wondim *et al.* (2016) found that waste from the upstream is the major contributor to increased ammonia concentration. In addition, the increased electrical conductivity measured can be associated with the presence of organic materials in the river. The decline in electrical conductivity after the BP site may indicate the River's ability to purify itself.

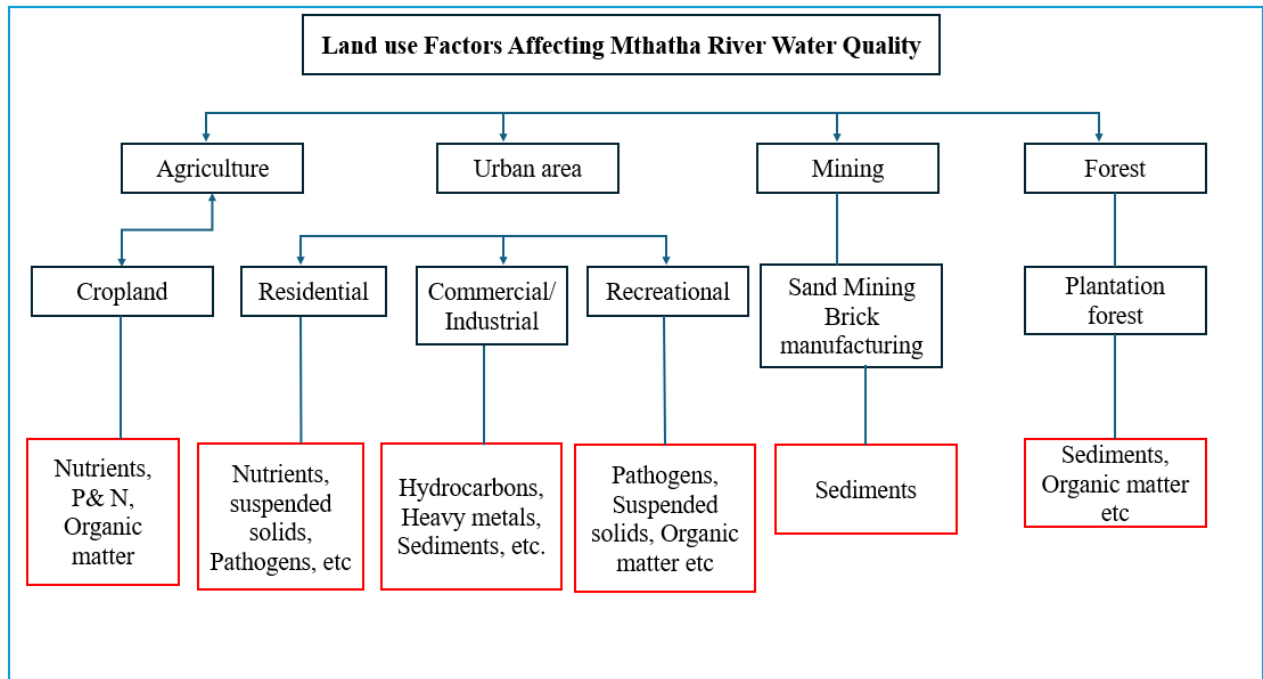


Figure 4: Land Use Factors Affecting Mthatha River Water Quality

Temporal Concentration and Composition of Water Quality Parameters

The low concentration of phosphate, electrical conductivity and ammonia during the wet seasons could be due to the addition of water from rainfall, diluting these parameters. For example, ammonia in elevated concentrations is known to be toxic to most organisms (Hossain *et al.*, 2007). Therefore, the lowered ammonia and phosphate concentration during the wet season could be beneficial for the River's ecosystem in that it contributes to better water quality and is less harmful to the

ecosystem. These findings support those of Hossain *et al.* (2007), who also recorded high ammonia levels during the dry season. Similarly, Phiri *et al.* (2005), in a study conducted in Malawi, found that high electrical conductivity values were recorded during the dry season. This demonstrates how the electrical conductivity is not diluted by freshwater from the rain. Therefore, the dilution of salts resulting from increased water volume in the river is the cause of the low electrical conductivity during the rainy season.

Higher concentrations of *E. coli* were anticipated during the dry season compared to the wet season because of the lack of rainfall to dilute the wastewater from the different sources of pollution in the Mthatha River basin. However, this study found no significant variations in the concentration of *E. coli* across the seasons. This contradicts the findings of a study conducted in Limpopo, which observed elevated *E. coli* during the dry season compared to the wet season (Edokpayi *et al.*, 2018). However, other studies found that the wet season had higher *E. coli* counts than the dry season (Vika *et al.*, 2024; Traore *et al.*, 2016).

The results of the study demonstrate how the various land-use activities occurring in the Mthatha River catchment change the composition of water quality measures. For instance, the discharge of raw sewage and the disposal of solid waste, including diapers, significantly increase the amount of *E. coli* and faecal matter in the River, and the concentration of ammonia and phosphate is raised due to agricultural operations. Water quality parameters showed considerable variances in this study because, for instance, agricultural activities and the discharge of raw sewage impacted on both AP and BP sites, as well as WWTW.

Conclusions

The spatiotemporal fluctuations of Mthatha River were examined from 2012 to 2022. Water quality was assessed using the WQI, and differences between seasons and sampling sites were determined using the Kruskal-Wallis test. The permutational multivariate analysis of variance (PERMANOVA) in PRIMER 7 was utilized to

examine the impact of effluent discharge on the composition of water quality measures. The research area is heavily inhabited and contributes significantly to the regional economy. The main cause of this is the presence of the Mthatha River, a body of water that supports farming, fishing, and serves as a supply of water for both residential and commercial use. Consequently, the water quality of the River is contaminated and unfit for human consumption. Many factors contribute to the pollution of the water, such as improperly treated sewage dumped into the river, unlawful disposal of waste into the river channel, surface runoff from the industrial area as well as agricultural practices that are occurring in the River basin.

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Evaluation of ERA5-based Reanalysis Products for the Representation of Cold Extreme Temperature Indices Over Southern Africa

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Over southern Africa, cold extreme temperature events (CETEs) continue to occur despite robust warming trends for surface air temperatures – such a CETE occurred as recently as 10 July 2023, when many high-lying interior regions experienced unusual snowfall. In a warming world, CETEs are expected to be less intense and occur less frequently, however, they are still expected to be negatively impactful for winter cropping activities, and livestock and human health, for instance. Therefore, continued research on CETEs is extremely important. For a data-sparse region such as southern Africa, one valuable research avenue is exploring the strengths and weaknesses of reanalysis datasets in representing CETE characteristics. Hence, for 1979-2021, this study explores the performance of three ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land) for the spatiotemporal representation of various CETE indices (e.g., number of frost days and magnitude of coldest day and night temperatures) for June-August winter months. Compared to the National Oceanic and Atmospheric Administration Climatology Prediction Centre gridded observation-based temperature reference dataset, results show that the ERA5-based datasets performed generally well in most instances, adequately representing the spatial climatologies of the CETE indices, while temporally, there were uncertainties evident, but overall, the interannual (and intra-annual) variation patterns and temporal trends were mostly well represented. There were also notable biases evident, however, they were relatively low in most instances. Overall, our results highlight that the ERA5-based reanalysis products are useful to apply for further research considering, for instance, agricultural and human health impacts associated with CETEs over southern Africa; importantly, however, uncertainties and limitations must be acknowledged.

Keywords: Cold extreme temperature indices; ERA5-based reanalysis datasets; Gridded observation-based dataset; Dataset reliability; Southern Africa

Introduction

A large body of evidence demonstrates that average surface air temperatures (SATs) have increased, by ~0.2 °C/decade since ~1950, over southern Africa, and in many instances, statistically significant (i.e., robust) trends have

been detected (Kruger and Nxumalo, 2017; Jury, 2018; Engdaw et al., 2022). Projections of average SAT are similarly robust and reflect an increase (relative to the 1850-1900 period) of up to 5 °C at a high 4 °C global warming level (Engelbrecht et al., 2024). Consequently, the

frequency, duration and magnitude of hot extreme temperature events (ETEs; e.g., heatwaves and hot days) has increased since ~1950, and again many regions have experienced robust trends (Kruger *et al.*, 2019; van der Walt and Fitchett, 2021), while projections reflect that these trends will persist into the future (Mbokodo *et al.*, 2020). The opposite (i.e., a decline) has been observed and projected for the characteristics (i.e., frequency, magnitude and duration) of cold ETEs (CETEs; e.g., coldwave and cold snap) over southern Africa (Kruger *et al.*, 2019; van der Walt and Fitchett, 2021); like hot ETEs, CETEs represent only a small proportion of SATs within the overall SAT distribution, and herein are defined as below-normal temperatures, within the lower tail-end of the temperature distribution, for at least one day (van der Walt and Fitchett, 2022).

Despite these observed and projected trends, research reflects that CETEs will still occur both globally and across southern Africa (Kodra *et al.*, 2011; van der Walt and Fitchett, 2021). In fact, while writing this manuscript in July 2024, several cold fronts reached southern Africa, causing a cold snap from roughly 7-11 July 2024 (SAWS, 2024). Similarly, notable CETEs have occurred in recent years, such as the cold snap of 22-24 July 2021 (Chikoore *et al.*, 2024) and a rare snowfall event that reached Gauteng on 10 July 2023 (SAWS, 2023). Typically, over southern Africa, CETEs occur more commonly during austral winter (i.e., June-August) and are associated with ridging South Atlantic Anticyclones (SAA) occurring together with a mid-tropospheric cut-off low or trough and sometimes with cold fronts, with ridging SAAs particularly contributing to advect cold air over southern Africa from cooler, higher latitudes (Ndarana *et al.*, 2021). Such a weather system configuration was evident for the 22-24 July 2021 event (Chikoore *et al.*, 2024). When

these CETEs occur, their impacts are vast, with examples including elevated energy demands for household consumption (Mudzingiri *et al.*, 2024), frost damage to crops (Moeletsi and Tongwane, 2017), loss of vulnerable livestock (Archer *et al.*, 2021), and cold stress to homeless populations (Roffe *et al.*, 2023). Their notable impacts and the fact that CETEs will still occur despite global warming trends justifies continued research towards improving our understanding and monitoring capabilities of CETEs.

Therefore, one key research focus is on the types of data that can be used to analyse and monitor CETEs. Over southern Africa, weather stations are more typically used, however, there are associated spatial limitations, representing one of the most pressing limitations associated with weather station data (van der Walt and Fitchett, 2022). Alternatively, many studies in southern Africa have relied on gridded data products, including reanalysis temperature datasets (e.g., Meque *et al.*, 2022) and satellite-derived temperature datasets (e.g., Moeletsi and Walker, 2012). However, the performance of these datasets varies both spatially and temporally (Moeletsi and Walker, 2012; Lawal *et al.*, 2021; Roffe and van der Walt, 2023). Thus, a thorough analysis of the performance of gridded datasets should be undertaken before their application in any region. In undertaking performance validations, a range of characteristics of the variable in question should be considered. In the context of SAT, this means assessing the dataset in terms of representing mean and extreme conditions, whereby the latter can be defined in many ways (Deng *et al.*, 2021). For example, according to the World Meteorological Organization's (WMO) Expert Team on Sector-specific Climate Indices (ET-SCI), roughly 30 different indices can be used to define various characteristics of ETEs depending on location

and sector of consideration (Herold and McComb, 2021). These indices can therefore be used to assess whether a gridded dataset reliably represents the range of SAT characteristics (Keller and Wahl, 2021). Over southern Africa, Roffe and van der Walt (2023) utilised six of these indices and demonstrated that three ERA5-based reanalysis temperature products (i.e., AgERA5, ERA5 and ERA5-Land) perform relatively well overall in representing various heatwave and coldwave characteristics. Following this study, there are still many indices to apply towards determining the reliability of the ERA5-based products for their representation of CETE characteristics over southern Africa. Therefore, our study is similar to Roffe and van der Walt (2023) in that we focus on the period 1979-2021 and utilise the same reference dataset, being the National Oceanic and Atmospheric Administration Climatology Prediction Centre (NOAA CPC) gridded observation-based SAT dataset. However, for the same ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land), we instead explore their performance for their spatiotemporal representation of winter period (i.e., June-August) CETE indices. Moreover, we focus on the same study region as in Roffe and van der Walt (2023; Figure 1a), however, we define new thermal regions based on the context of this study (see section 2.3; Figure 1b).

Materials and methods

Data

Following Roffe and van der Walt (2023), this study utilises the NOAA CPC station-based gridded dataset as a reference dataset to evaluate the reliability of ERA5-based datasets for their representation of CETE indices (Table 1). To justify our use of a gridded reference dataset as opposed to weather station records, we refer the reader to Roffe and van der Walt (2023) and highlight that our main reason is

that weather station data are spatially and temporally sparse across some southern African countries.

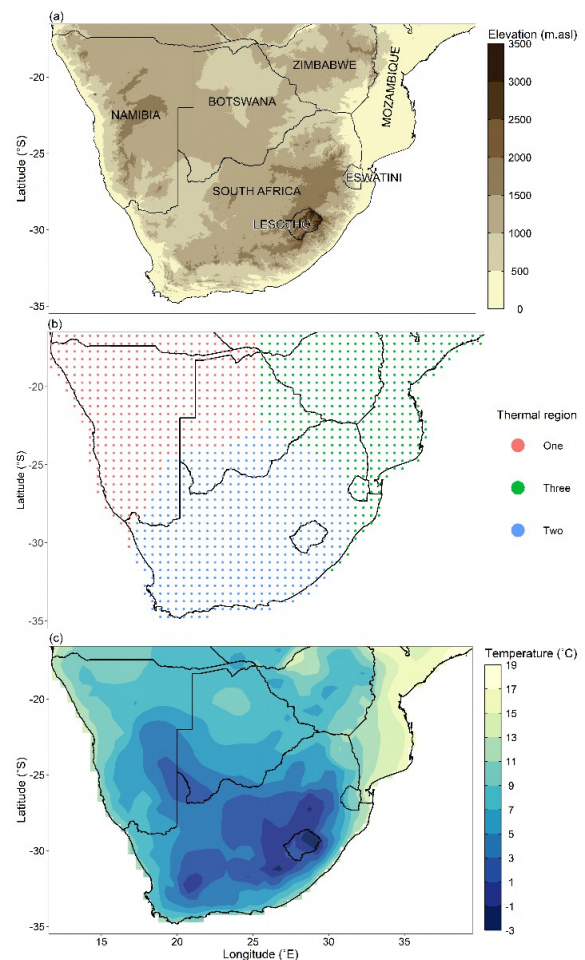


Figure 1. Maps displaying the study region's a) countries and elevation characteristics, b) thermal subregions defined as per section 2.3, and c) the 1979-2021 June-August TN climatology derived from the NOAA CPC reference dataset.

Therefore, despite limitations associated with an observation-based gridded dataset and the one we utilise herein, our study had to rely on such a dataset. To justify why we selected the NOAA CPC dataset, we again refer to Roffe and van der Walt (2023) and note this is because this dataset has a relatively fine spatial resolution, with the requisite variables of daily minimum, maximum and

average temperature (TN, TX and SAT, respectively) required to calculate the indices applied herein (Table 1-2). It also reliably characterises SATs across southern Africa (e.g., Iyakaremye *et al.*, 2021, 2022), which is also highlighted by good comparability with the CRU dataset (Roffe and van der Walt,

2023), which is known to be reliable over southern Africa and is also an observation-based gridded dataset (e.g., Gleixner *et al.*, 2020; Steinkopf and Engelbrecht, 2022).

Table 1. Description of the gridded datasets used within the context of this study. All datasets were used for June-August for 1979-2021.

| Dataset | Inputs | Variables and temporal resolution | Spatial resolution | Reference |
|--------------------------|--|-----------------------------------|--------------------|------------------------------------|
| AgERA5 | European Centre for Medium Range Weather Forecasts (ECMWF) forecast system | Daily TN and TX | 0.1 ° x 0.1 ° | Boogaard <i>et al.</i> (2020) |
| ERA5 | ECMWF forecast system | Hourly TN and TX | 0.25 ° x 0.25 ° | Hersbach <i>et al.</i> (2020) |
| ERA5-Land | ECMWF forecast system | Hourly SAT | 0.1 ° x 0.1 ° | Muñoz-Sabater <i>et al.</i> (2021) |
| NOAA (reference dataset) | CPC Weather station observations | Daily TN and TX | 0.5 ° x 0.5 ° | NOAA (2022) |

As in Roffe and van der Walt (2023), towards selecting gridded datasets to validate, we considered the ERA5-based reanalysis datasets listed in Table 1. This is because they contain the requisite variables for calculation of the CETE indices described in Table 2. Moreover, their spatial and temporal resolutions also make these datasets useful for climate monitoring applications. Elaborated on, the ERA5-based reanalysis products can therefore offer a fine spatial resolution understanding of CETEs. Furthermore, the fact that these datasets are updated regularly offers a user the ability to continuously monitor

changes and variations in the characteristics of CETEs, while our study provides an assessment of whether the ERA5-based datasets reliably represent CETEs over southern Africa. For further information on the ERA5-based datasets applied herein see Roffe and van der Walt (2023) and the references listed in Table 1. Finally, to prepare the datasets to calculate the CETE indices (Table 2), we applied several pre-processing steps, using the Climate Data Operators (CDO) command line (Schulzweida, 2023) and the R statistical software (R Core Team, 2022),

previously described in Roffe and van der Walt (2023).

Cold temperature indices

To determine the reliability of the ERA5-based reanalysis products for describing CETE characteristics over southern Africa, our study focused on the indices listed in Table 2 and considered these for the June-August months between 1979-2021. We focused on these months because they are statistically shown to represent southern Africa’s winter period (van der Walt and Fitchett 2020), being the months during which CETEs are more likely (Chikoore *et al.*, 2024). Above this, we selected the listed indices because they represent the WMO ET-SCI cold temperature indices which are more typically applied over southern Africa to characterise CETE climatologies and case studies (e.g., Chikoore *et al.*, 2024), trends and interannual variability patterns (e.g., Kruger and Sekele, 2013; du Toit and O’Connor, 2017;

van der Walt and Fitchett, 2021), and projections (e.g., Kruger *et al.*, 2019). Moreover, their resulting outputs represent cooler temperatures at the lower tail-end of the temperature distribution, which are CETEs (Zhang *et al.*, 2011). Collectively, towards understanding the impacts of CETEs, the selected indices also provide insight into the magnitude, frequency and duration of CETEs, which respectively are characteristics explaining how extreme CETEs are, how often CETEs occur and how long CETEs last (van der Walt and Fitchett, 2022). To calculate these indices, we used the NetCDF datasets pre-processed as per section 2.1 to run the R Climpack package indices calculations (Herold and McComb, 2021). For our calculations, all days within the years of 1979-2021 were used for the calculations for which monthly results were the output, and we subsequently extracted only the June-August months for our analysis described under section 2.3.

Table 2. Details of the ET-SCI cold temperature indices used for this study (adapted from Herold and McComb, 2021).

| Index (abbreviation) | name | Index description | Units | Time scale |
|-----------------------------|-------------|---|--------------|-------------------|
| Coldest day (TXn) | | Lowest daily TX value | °C | Monthly |
| Coldest night (TNn) | | Lowest daily TN value | °C | Monthly |
| Cold days (TX10p) | | Percentage of days when TX <10th percentile | % | Monthly |
| Cold nights (TN10p) | | Percentage of days when TN <10th percentile | % | Monthly |
| Cool days (TNlt2) | | Number of days when TN <2 °C | Days | Monthly |
| Frost days (FD) | | Number of days when TN <0 °C | Days | Monthly |
| Hard freeze days (TNltm2) | | Number of days when TN <-2 °C | Days | Monthly |
| Ice days (ID) | | Number of days when TX <0 °C | Days | Monthly |

Data analysis

For the performance evaluation of the ERA5-based reanalysis datasets against the NOAA CPC reference dataset, our analysis steps followed Roffe and van der Walt (2023). For a time-series view of the reliability of the ERA5-based datasets, we also utilised the NOAA CPC reference dataset to define nominally homogeneous thermal regions derived from a k-means clustering algorithm (Kruger and Sekele, 2013), however, we based this on the 1979-2021 TN climatological values for June-August to consider winter thermal regions to align with our focus on CETEs. Based on the highest average silhouette width across 2-15 cluster groups, we defined three thermally homogeneous regions (Appendix Figure A1).

Towards assessing the datasets based on a time-series view, each thermal region is treated as a homogeneous region although heterogeneities can exist due to differing elevations for instance (Figure 1c). Regardless of any heterogeneities, notable similarities are evident, therefore it is relevant to utilise these regions for the performance evaluation described below. Prior to this, it is important to understand the characteristics of each thermal region. Due to lower average elevations and the influence of the warm Indian Ocean and Agulhas current, thermal region three represents the warmest thermal region with mean TN for June-August for 1979-2021 ranging from ~7-19 °C (Figure 1c). For thermal region one, which occurs over more northern latitudes and is characterised by dry and warm conditions, mean TN ranged from ~3-13 °C (Figure 1c). Due predominantly to higher average elevations, thermal region two represents the coldest region, where mean TN ranged from ~ -3-7 °C (Figure 1c).

For the assessment of the ERA5-based datasets in representing the selected indices (Table 2), we started by plotting the winter

climatological values for 1979-2021 utilising the nominal grid resolution of each dataset (Table 1). Thereafter, we utilised the CDO command line to extract the NOAA CPC grid to re-grid the monthly indices values that were derived from the ERA5-based datasets for comparison to the NOAA CPC reference dataset (Bhattacharyya *et al.*, 2022); a bilinear interpolation approach was utilised (Liu and Weng, 2018; Schumacher *et al.*, 2020).

Using the re-gridded data, we considered all monthly values to calculate the non-parametric Spearman correlation coefficient (i.e., r values) to assess the degree to which the datasets correspond interannually (Kalognomou *et al.*, 2013; Bhattacharyya *et al.*, 2022; Steinkopf and Engelbrecht, 2022). Statistical significance for this, and all analyses, was determined using p values, with the alpha level set to 5%. Thereafter, we used all monthly values to calculate biases as the reanalysis minus reference dataset (Kalognomou *et al.*, 2013; Deng *et al.*, 2021; Bhattacharyya *et al.*, 2022). We also assessed whether the biases were statistically significant, indicating grid cells where the reanalysis dataset grid cells were statistically different from the NOAA CPC reference dataset. For this, we applied the non-parametric Mann-Whitney-Wilcoxon test for the means of two independent samples (Gleixner *et al.*, 2020). As a final spatial analysis, we also assessed the ERA5-based datasets on their representation of temporal trends, utilising the non-parametric Mann-Kendall trend test and Sen's slope estimator (Gleixner *et al.*, 2020; Bhattacharyya *et al.*, 2022). In addition to the spatial analyses, we assessed the reliability of the ERA5-based products over the thermal regions (Figure 1b), considering the annual average winter values for the CETE indices via time series plots (Kalognomou *et al.*, 2013; Donat *et al.*, 2014).

Results

Representation of CETE climatological patterns and biases for June-August 1979-2021

For each of the CETE indices applied herein, it is notable that, despite differing spatial resolutions, the ERA5-based datasets depict relatively similar spatial patterns (and relatively consistent magnitudes) to the NOAA CPC reference dataset for the winter period CETE climatological patterns for 1979-2021 (Figure 2-3). This already reflects some reliability and confidence in the representation of CETE characteristics by the ERA5-based datasets applied herein.

Considering this for each of the indices, for TX_n being the coldest day magnitude, lower values, ranging from 6 to -2 °C, are evident for higher elevation regions, while as elevation decreases, higher TX_n values up to 30 °C are evident (Figure 2). Across all the datasets, a similar spatial pattern of lower (higher) magnitudes, of 0 to -12 °C (8-20 °C), at higher (lower) elevations is depicted for TN_n which is the coldest night temperature, however, lower TN_n values extend farther north in the NOAA CPC dataset (Figure 2); this already suggests that the ERA5-based datasets are characterised by a warm bias for lower, cooler TN_n values.

The pattern of more widespread cooler temperatures in the NOAA CPC dataset, but not the ERA5-based datasets, is also reflected in the climatologies of the frequency indices of TNlt2 (cool days frequency), FD (frost days frequency) and TNltm2 (hard freeze days frequency), however, overall there is similarly a spatial pattern of lower (higher) frequencies,

up to 36 days (as low as zero days), at higher (lower) elevations (Figure 3). For the ID (ice days frequency), Lesotho and some additional southern escarpment regions are the main areas with ID, up 3 days, across all datasets, and for the ERA5-based datasets higher values are evident over Lesotho due to finer spatial resolutions (Figure 3). Over some central and northwestern regions of Namibia, the NOAA CPC climatology reflects an average of 0.5 ID days, but the ERA5-based datasets do not capture any ID (Figure 3). Coupled with a warm bias for lower TN_n values, the climatologies for these frequency indices similarly reveal a warm bias with fewer occurring CETEs.

For the percentile frequency indices of TX10p (cold days frequency) and TN10p (cold nights frequency), all datasets similarly demonstrate no clear spatial pattern, with values consistently between 10-11% (Figure 2). Notably, however, the ERA5-based datasets are characterised by more widespread values above 11% over much of the northern and central study area regions, suggesting a skewed distribution with more lower winter TX and TN values relative to the median.

Despite generally consistent climatologies in terms of magnitudes and spatial patterns, the ERA5-based products were characterised by notable biases for all the indices (Figure 4-5). The spatial pattern of the biases for each index is similar across the ERA5-based datasets, while the same can be said for the spatial pattern of statistically significant (insignificant) biases which reflect where the reanalysis datasets might not be (are likely) reliable due to being statistically different (similar) to the reference dataset (Figure 4-5).

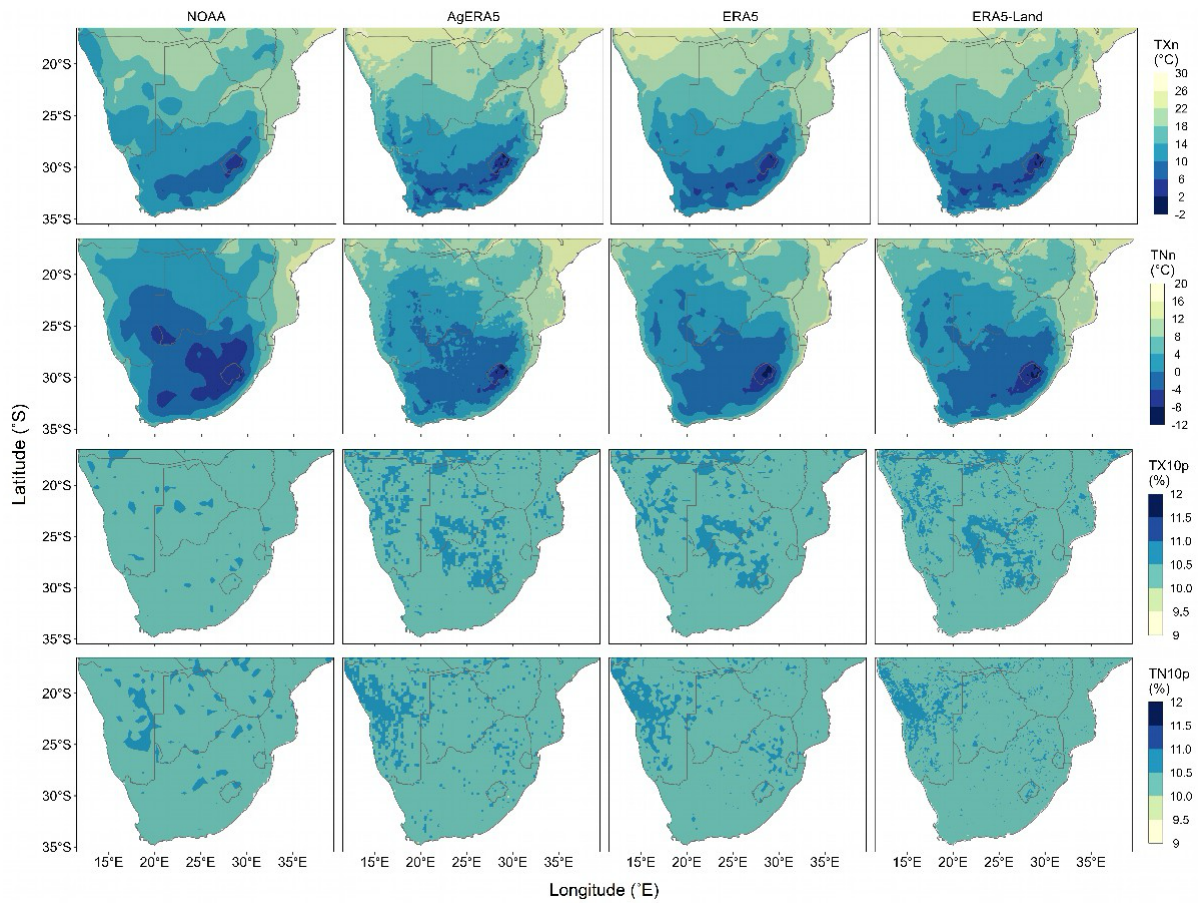


Figure 2. Maps depicting the climatology of the coldest day temperature (TXn), coldest night temperature (TNn), cold days frequency (TX10p) and cold nights frequency (TN10p) for winter (June-August) for 1979-2021 for the NOAA CPC and ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land), mapped using nominal resolutions of the datasets.

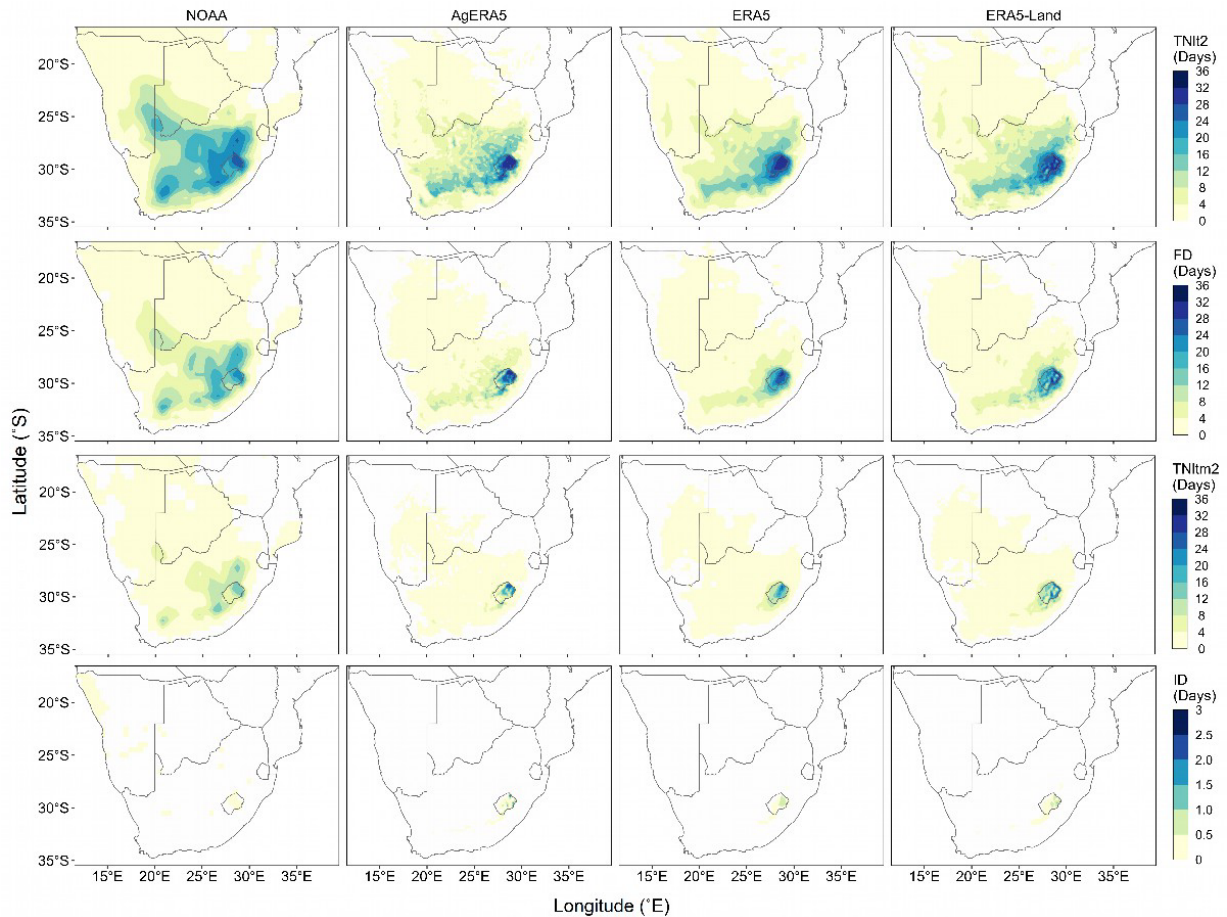


Figure 3. Maps depicting the climatology of the frequency of cool days (TNI2), frost days (FD), hard freeze days (TNI2m2) and ice days (ID) for winter (June-August) for 1979-2021 for the NOAA CPC and ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land), mapped using nominal resolutions of the datasets. White values depict a zero value for the respective index.

For the magnitude indices of TXn and TNn, a large proportion of the study region is characterised by statistically significant biases, while overall the biases range from roughly -8 to 8 °C (Figure 4). For TXn (TNn), there is a predominant cool (warm) bias overall (Figure 4). For TNn, the spread of grid cells with warm biases is more widespread, covering almost all of the study region, with the highest biases up to approximately 12 °C over central northern areas (Figure 4). Conversely, for TXn, central northern and eastern regions have a warm bias up to roughly 4 °C, while remaining regions have a cool bias of approximately -4 °C (Figure 4).

For the TX10p and TN10p, biases predominantly range from roughly -20 to 12% and overall, there are very few statistically significant grid cells (Figure 4), which is likely due to the relative nature of percentile thresholds as opposed to fixed thresholds. Over northern central regions the ERA5-based datasets typically under-estimated the proportion of values with TX and TN below the 10th percentile, whereas for remaining regions, these datasets typically over-estimated the proportion of TX and TN values above the 10th percentile (Figure 4),

For the remaining fixed threshold indices, most grid cells are characterised by statistically significant biases, which more predominantly

range up to -4 days (Figure 5). This reflects a general warm bias in the ERA5-based reanalysis datasets because fewer days had TN or TX values less than the fixed threshold for the TNlt2, FD, TNltm2 and ID indices (Table 1).

Even the time series plots reflect a general (somewhat systematic) warm bias in the ERA5-based datasets for the CETE indices (Figure 6-7). This is such that the TXn and TNn

magnitudes for the ERA5-based datasets are generally ~1-2 °C higher than the NOAA CPC dataset – this bias is more pronounced for TXn (Figure 6). For the remaining frequency and duration indices, this bias is such that ERA5-based datasets are generally characterised by fewer days (up to 2-3 days at most) meeting the criteria of the respective index (Figure 7), while no clear pattern is evident for the time series for TX10p and TN10p (Figure 6).

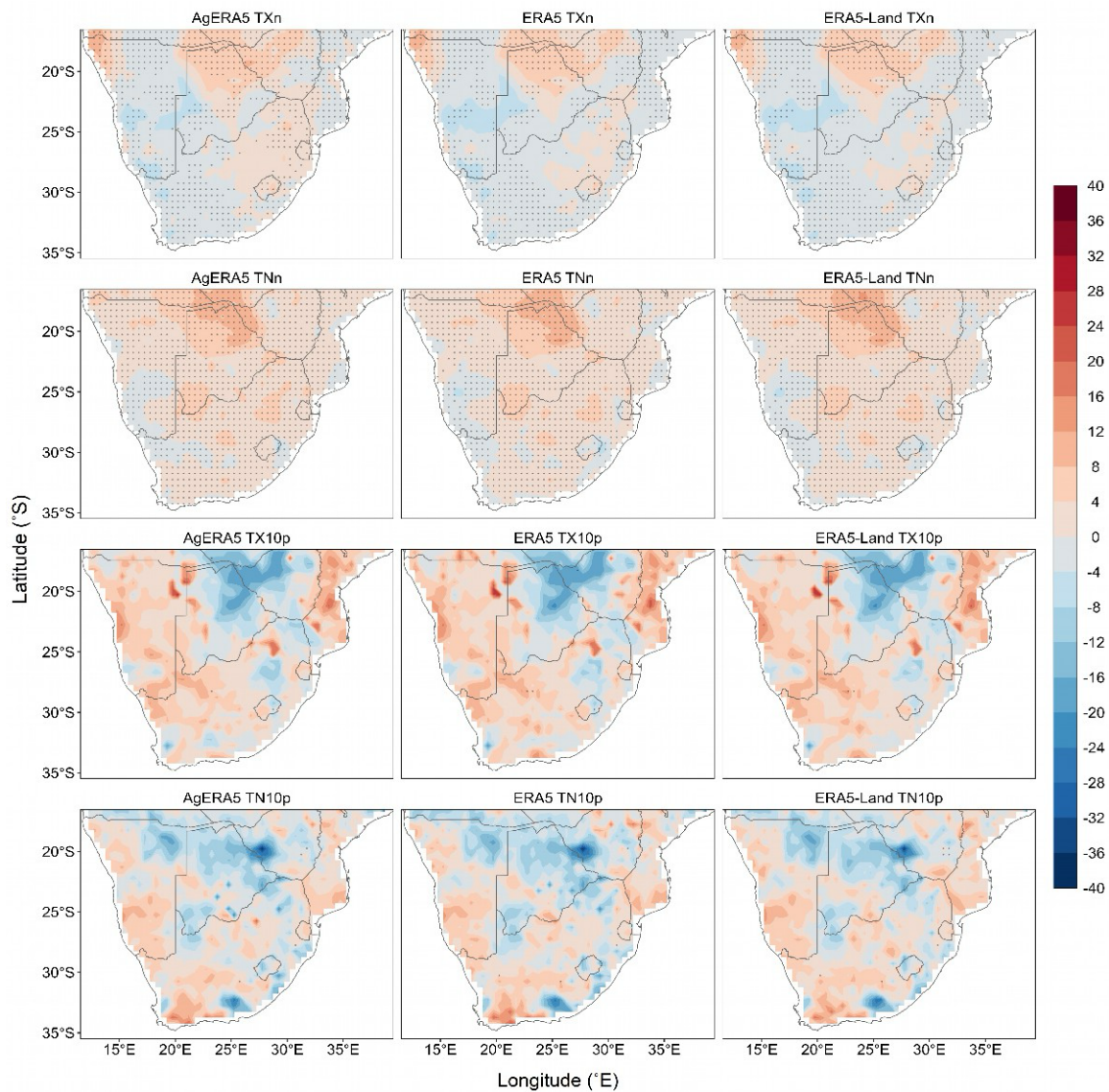


Figure 4. Bias maps comparing the NOAA CPC reference dataset to the ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land) for the June-August monthly values of the coldest day temperature (TXn; units = ° C), coldest night temperature (TNn; units = ° C), cold days frequency (TX10p; units = %) and cold nights frequency (TN10p; units = %) for 1979-2021. Stippling depicts statistically significant biases at the 5% alpha level.

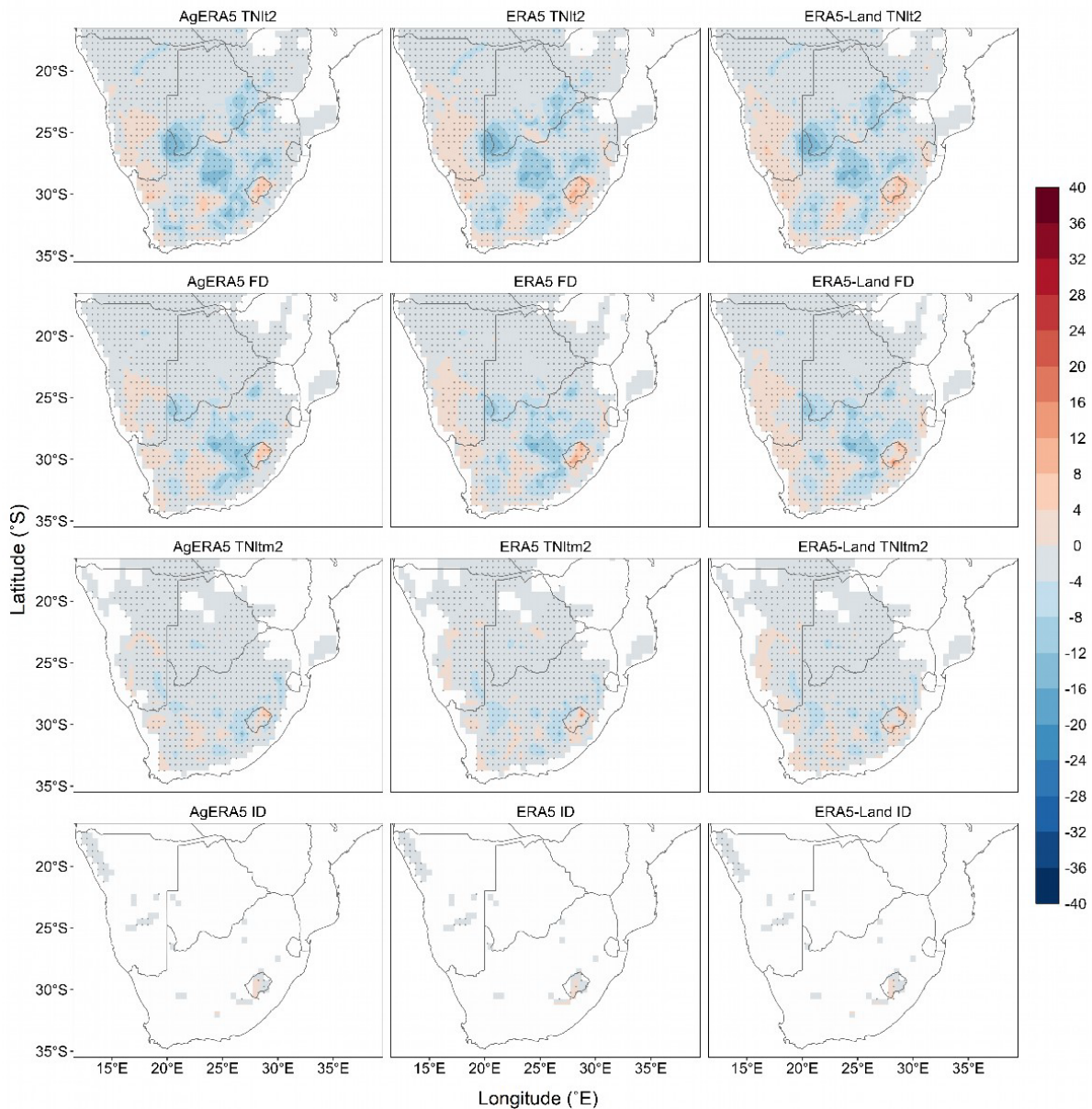


Figure 5. Bias maps comparing the NOAA CPC reference dataset to the ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land) for the June-August monthly values of the frequency of cool days (TNlt2; units = days), frost days (FD; units = days), hard freeze days (TNltm2; units = days) and ice days (ID; units = days) for 1979-2021. Stippling depicts statistically significant biases at the 5% alpha level.

Representation of CETE interannual variability and temporal trend patterns for June-August 1979-2021

The time series plots provide insight into whether the ERA5-based datasets reliably and accurately capture interannual variability (i.e., year-to-year changes) patterns for each of the indices (Figure 6-7). In many instances,

relatively good correlation values between roughly 0.50-0.93 reflects that these datasets perform well despite above-reported biases, while in other instances, lower correlations <0.50 suggest their performance is somewhat poor, indicating potential inconsistencies in performance (Figure 6-7). For the magnitude indices of TXn and TNn, it is evident that the ERA5-based products perform very well for

most thermal regions as most correlations were >0.69 and statistically significant, while overall all these ERA5-based time series consistently track the NOAA CPC time series, capturing interannual variations quite well (Figure 6a-f). For thermal regions one and three for TXn, the performance of the ERA5-based datasets was notably poorer, particularly from the late 1990s, and this is especially the case for thermal region one which had very low correlations of 0.05-0.06 (Figure 6a, c). For the TX10p and TN10p indices, it is noteworthy that the ERA5-based datasets performed generally well as all correlations were statistically significant and >0.80 (Figure 6g-l). For all remaining duration/frequency indices, excluding ID, the ERA5-based products performed generally well both in the correlation values (which

range overall from 0.30-0.93) as well as the visualised time series consistency (Figure 7a-i). There are notable biases evident with many instances of over-estimation, however, the ERA5-based products time series were generally consistent in tracking the NOAA time series and correlations were almost always statistically significant (Figure 7a-i). The performance of the ERA5-based products was consistently weakest for thermal three, while for the ID index, the performance was poor in general (less so for thermal region two), particularly because the ID conditions did not occur frequently, and for thermal regions one and three, these conditions did not occur in the ERA5-based products (Figure 7j-l).

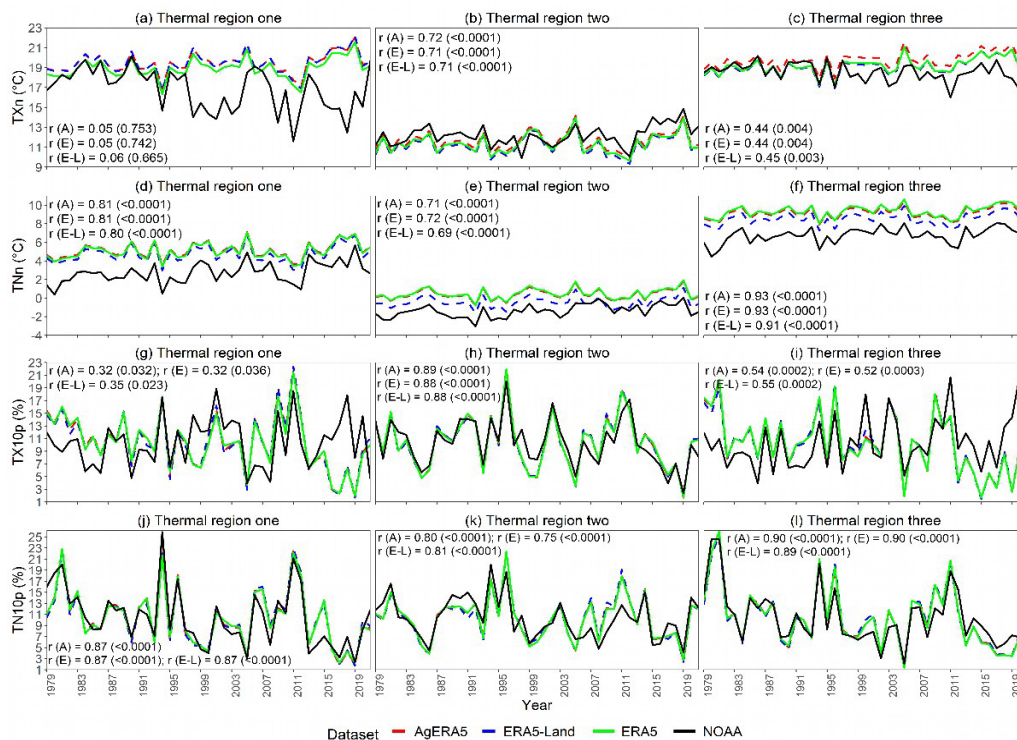


Figure 6. Plots depicting the annual average coldest day temperature (TXn), coldest night temperature (TNn), cold days frequency (TX10p) and cold nights frequency (TN10p) values for each dataset per thermal region for 1979-2021. Spearman correlation coefficient values (i.e., r values) and p values (in brackets) are provided for each reanalysis dataset (i.e., A, E and E-L represent AgERA5, ERA5 and ERA5-Land, respectively) compared to the NOAA CPC reference dataset. P values <0.05 show statistically significant correlations at the 5% alpha level.

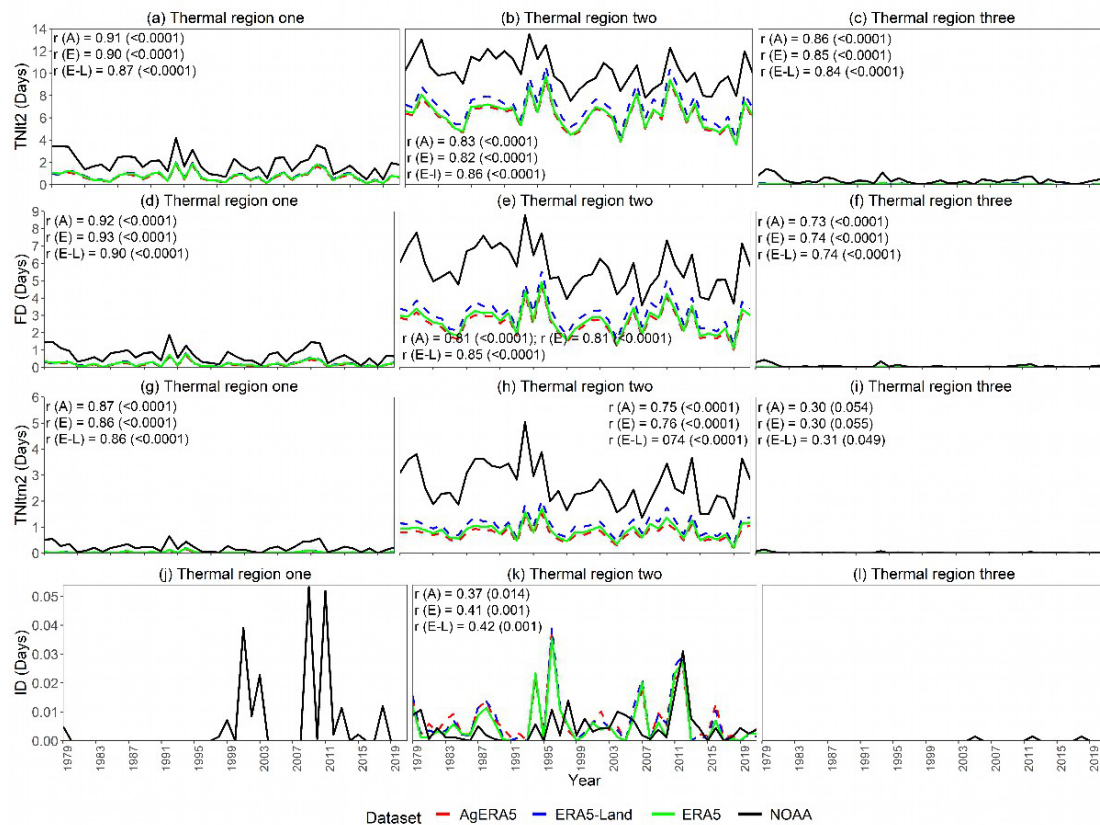


Figure 7. Plots depicting the annual average frequency of cool days (TNlt2), frost days (FD), hard freeze days (TNltm2) and ice days (ID) for each dataset per thermal region for 1979-2021. Spearman correlation coefficient values (i.e., r values) and p values (in brackets) are provided for each reanalysis dataset (i.e., A, E and E-L represent AgERA5, ERA5 and ERA5-Land, respectively) compared to the NOAA CPC reference dataset; for ID, this is only provided for thermal region two as there was insufficient data otherwise. P values <0.05 show statistically significant correlations at the 5% alpha level.

While the time series plots demonstrate generally good interannual variability performance, with some notable weaknesses, it is evident that a grid cell view reflects that this consistency, in terms of interannual variation patterns, extends across most grid cells (Figure 8-9). Most correlations are statistically significant and positive, with values >0.3 (Figure 8-9). Considering this, it is important to highlight that there are very few negative correlations (some negative correlations are evident for TX10p for far

northwestern areas). This reflects that the ERA5-based datasets are reliable in terms of interannual variability patterns since they temporally track the NOAA CPC dataset well, such that when the NOAA CPC dataset index value increases so does the ERA5-based dataset index value. Also, because we used all monthly index values for the correlations, our results reflect that the ERA5-based datasets are also effective and reliable in capturing intra-annual variation patterns.

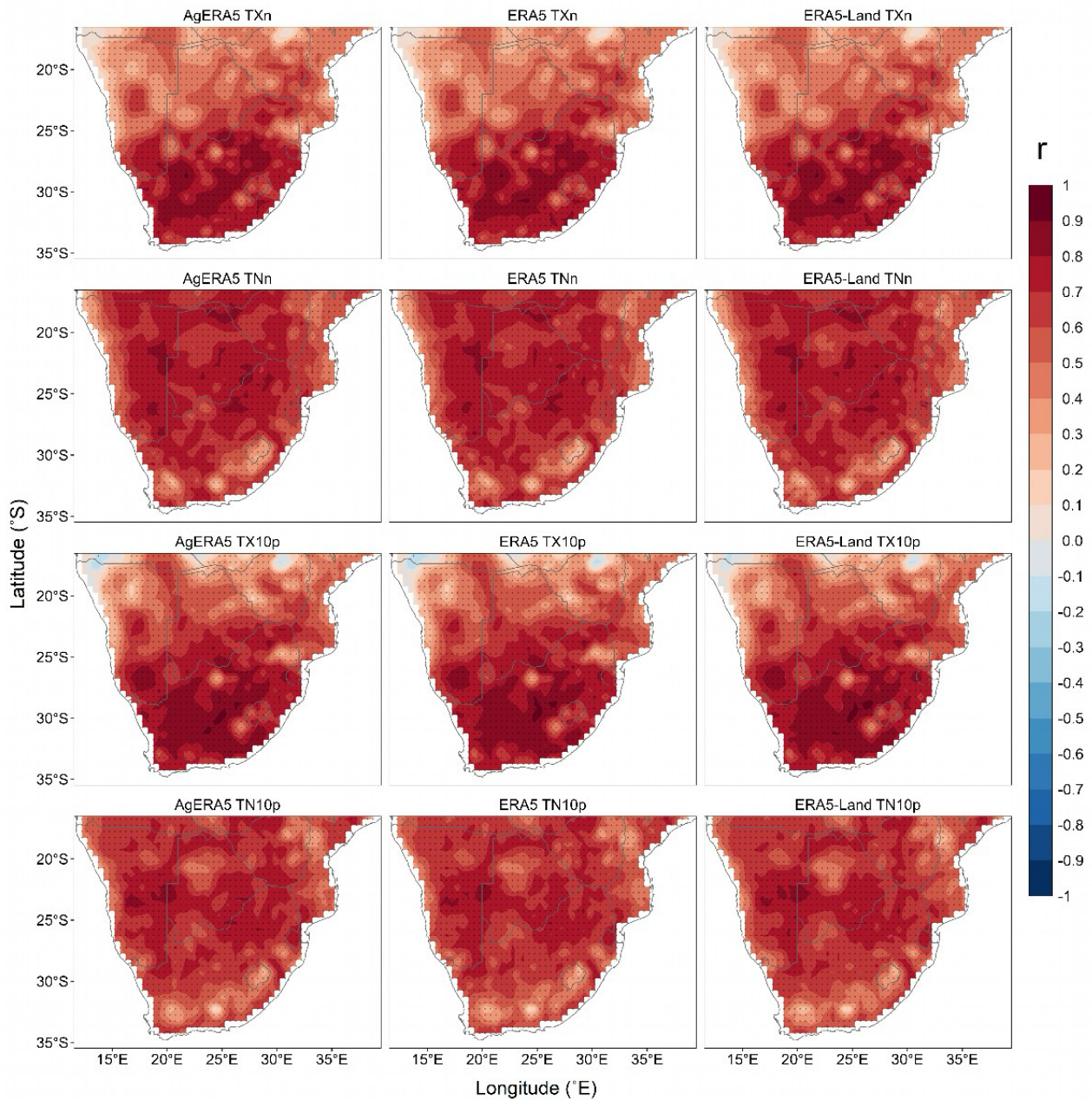


Figure 8. Spearman correlation coefficient maps comparing the NOAA CPC reference dataset to the ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land) for the June-August monthly values of the coldest day temperature (TXn), coldest night temperature (TNn), cold days frequency (TX10p) and cold nights frequency (TN10p) for 1979-2021. Stippling depicts statistically significant correlations at the 5% alpha level.

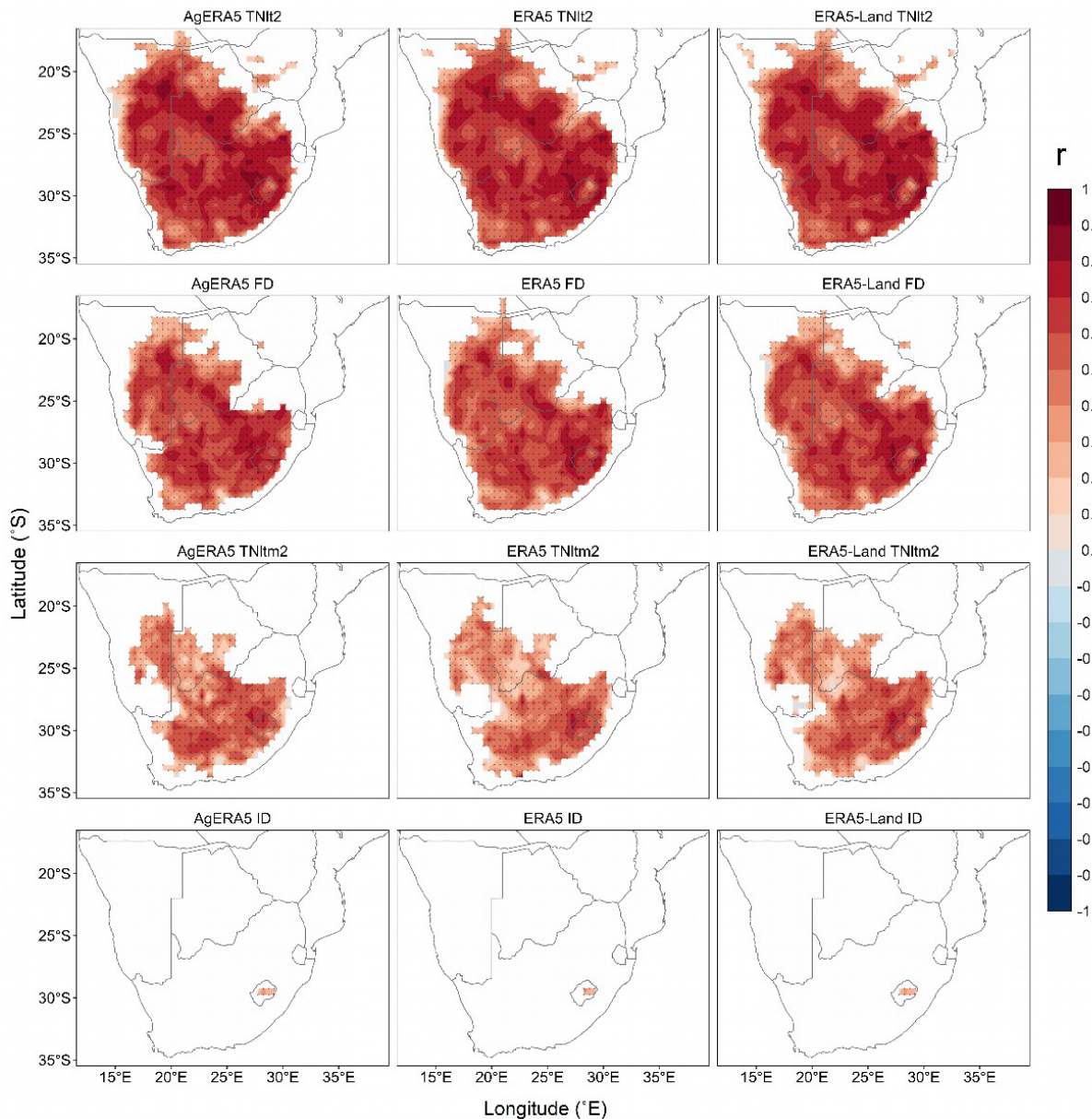


Figure 9. Spearman correlation coefficient maps comparing the NOAA CPC reference dataset to the ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land) for the June-August monthly values of the frequency of cool days (TNlt2), frost days (FD), hard freeze days (TNltm2) and ice days (ID) for 1979-2021. Stippling depicts statistically significant correlations at the 5% alpha level. White values depict a zero correlation value or where no correlations were calculated due to insufficient data available.

As further consideration of the temporal reliability of the ERA5-based datasets, we also visually assess whether the datasets accurately capture observed temporal trends. Overall, there is relatively good performance as the ERA5-based products are characterised by similar trend directions and magnitudes in

many instances (Figure 10-11). There are, however, many notable discrepancies to highlight. For the TXn (TX10p) index, the ERA5-based datasets did not reliably replicate the negative (positive) trends, up to 0.4 °C/decade (2 %/decade), observed over northern regions (Figure 10). For the TNn

(TN10p) index, there were some negative (positive) trend areas, with trends up to 0.2 °C/decade (2 %/decade), scattered across the study region that were not captured by the ERA5-based datasets (Figure 10). For the remaining indices, the ERA5-based datasets evidently were characterised by the same trend

directions, however, the spatial extent and pattern of trends were not always consistent with the NOAA CPC reference dataset (Figure 11).

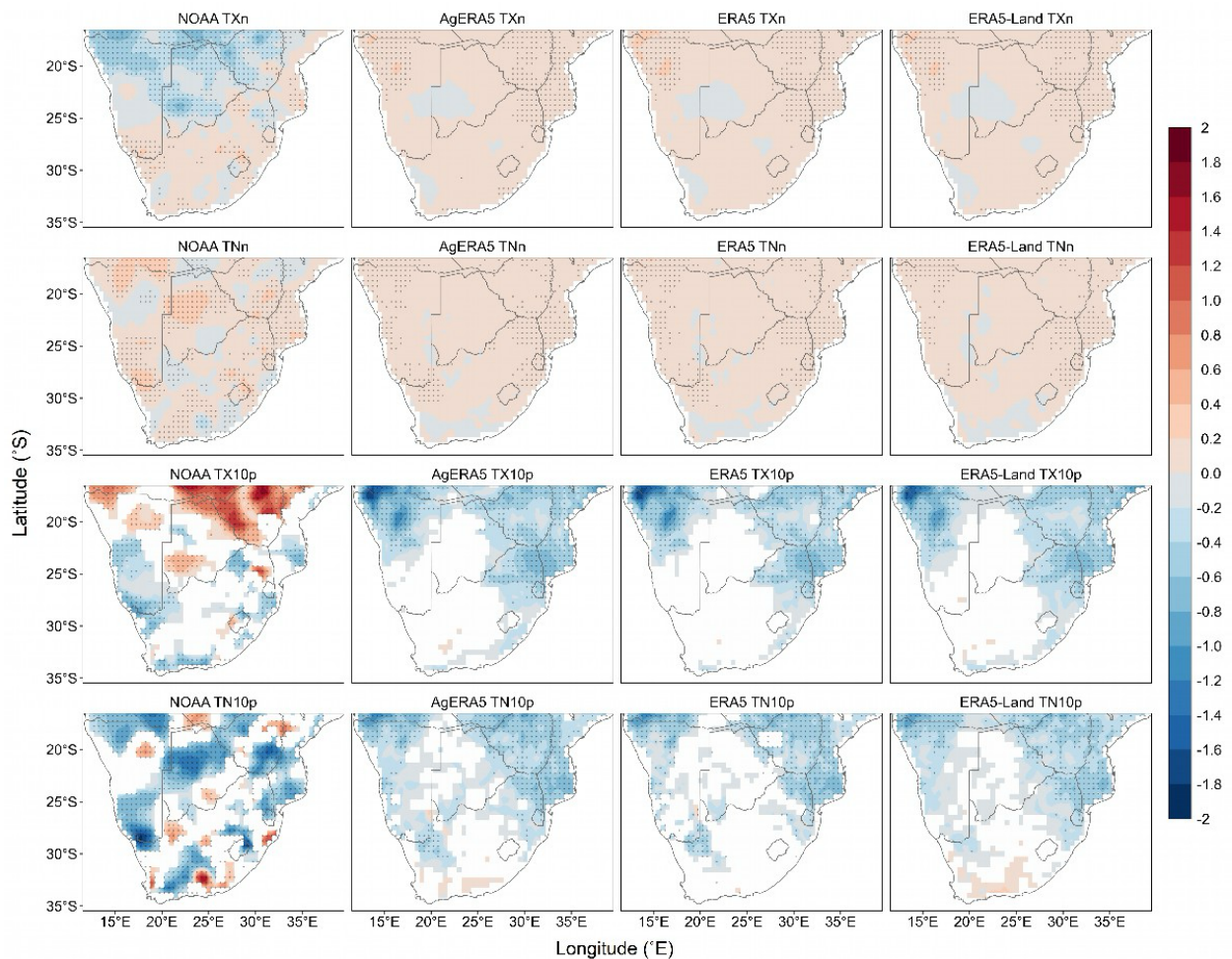


Figure 10. Temporal trend maps for the NOAA CPC reference dataset and the ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land) for the June-August monthly values of the coldest day temperature (TXn; units = ° C/decade), coldest night temperature (TNn; units = ° C/decade), cold days frequency (TX10p; units = %/decade) and cold nights frequency (TN10p; units = %/decade) for 1979-2021. Stippling depicts statistically significant trends at the 5% alpha level. White values depict a zero trend slope value.

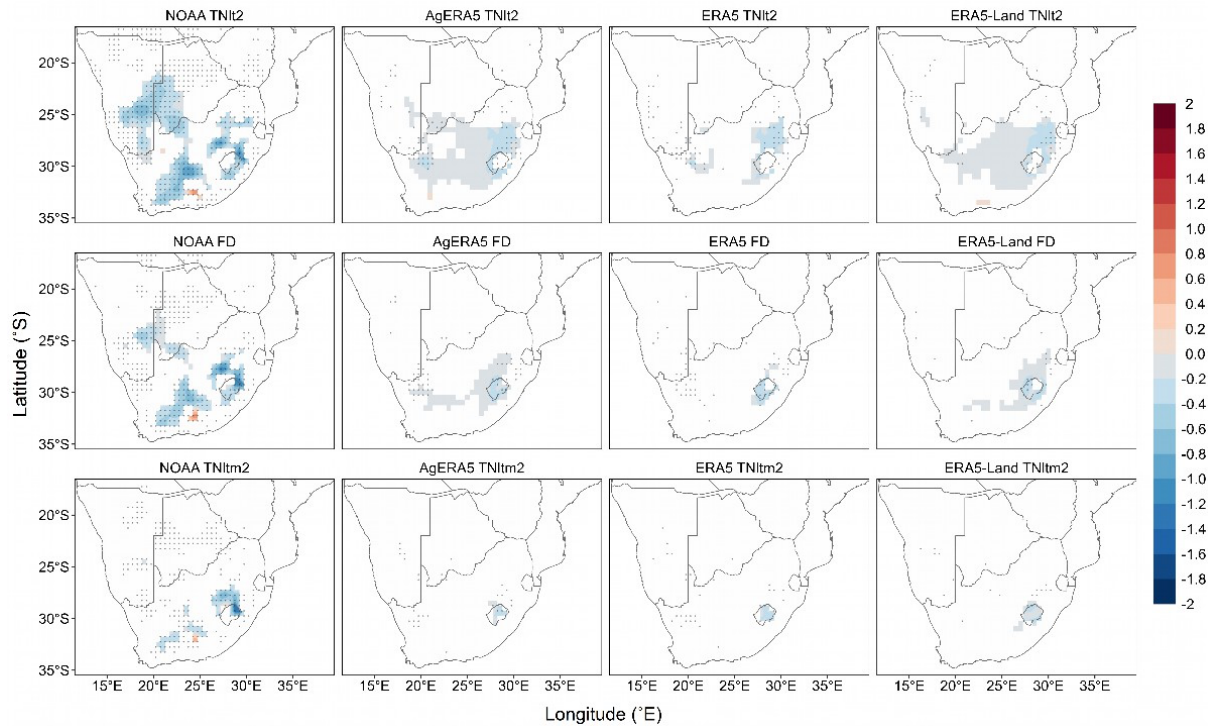


Figure 11. Temporal trend maps for the NOAA CPC reference dataset and the ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land) for the June-August monthly values of the frequency of cool days (TNI2; units = days/decade), frost days (FD; units = days/decade) and hard freeze days (TNI2m2; units = days/decade) for 1979-2021. Stippling depicts statistically significant trends at the 5% alpha level. White values depict a zero trend slope value or where no trends were calculated due to insufficient data available. For the ice days (ID), no trends were calculated due to insufficient data.

Discussion and conclusion

As a proxy for missing SAT measurements across a region where weather station records of SAT are typified by data gaps and monitoring station networks are generally sparse and unevenly distributed (Harris *et al.*, 2020), it is unsurprising that there have been many instances whereby at least one of the ERA5-based reanalysis datasets have been applied to study ETEs over southern Africa (Bradshaw *et al.*, 2022; Engdaw *et al.*, 2022; Meque *et al.*, 2022; Mbokodo *et al.*, 2023; Simanjuntak *et al.*, 2023; van der Walt *et al.*, 2023; Chikoore *et al.*, 2024). Although it is well accepted that these datasets generally perform well over southern Africa, in existing literature (e.g., Roffe and van der Walt, 2023; Kruger *et al.*, 2024) they have not been comprehensively validated for all SAT characteristics. Therefore, our study has extended existing literature to provide insight into whether the ERA5-based datasets reliably characterise CETEs during southern African June-August winter periods within 1979-2021.

Towards determining whether these datasets are reliable to apply for various CETE-related studies over southern Africa, our results have shown that they generally perform quite well in characterising CETEs in terms of their climatologies, interannual (and intra-annual) variability patterns and temporal trends. Consistent with findings of similar studies (Gleixner *et al.*, 2020; Schumacher *et al.*, 2020; Keller and Wahl, 2021; Velikou *et al.*, 2022), their performance over southern Africa varies in space and time, with poorer performance over regions with less dense station networks. Therefore, we acknowledge that there are some notable discrepancies between the ERA5-based datasets and the

NOAA CPC reference dataset, and these must be acknowledged when the datasets are applied for CETE studies. Despite this, we recommend applying the ERA5-based datasets for various CETE studies over southern Africa. Such studies will be important for many reasons, but in the context of our changing climate and the fact that we still experience significant CETEs over southern Africa, further studies will be extremely important for a range of decision-makers. These decision-makers can be informed by a range of studies, such as understanding various aspects of the frequency, duration and magnitude of CETEs in relation to their impacts on various sectors, including agriculture (e.g., frost impacts on crop yields and livestock health), energy (e.g., CETE occurrences in relation to energy demand) and public health (e.g., CETE occurrences in relation to public health planning and responses against hypothermia and frostbite).

In discussing our results, it should be noted that the ERA5-based datasets generally performed consistently compared to the NOAA CPC reference dataset. The results presented demonstrate the ERA5-based climatologies of the CETE indices are very consistent, in terms of magnitude and spatial patterns, with those derived from the NOAA CPC reference dataset (Figure 2-3). Despite the study region, similar studies consistently reflect that ERA5-based climatologies of various SAT indices are reliable compared to observed climatologies (e.g., Gleixner *et al.*, 2020; Schumacher *et al.*, 2020; Engdaw *et al.*, 2022; Velikou *et al.*, 2022; Roffe and van der Walt, 2023). Although mean conditions are generally well represented, it is notable that we detected biases for all of the CETE indices (Figure 4-5). Similar to findings from

previous studies (e.g., Deng *et al.*, 2021; Keller and Wahl, 2021; Velikou *et al.*, 2022; Roffe and van der Walt, 2023), indices representing magnitude values or based on fixed magnitude thresholds were generally associated with statistically significant biases, reflecting herein that the ERA5-based datasets have significant uncertainties for the TXn, TNn, TNlt2, FD, TNltm2 and ID indices (Figure 4-5). This result is not surprising since Roffe and van der Walt (2023) demonstrate that magnitudes in the lower tail-end of the SAT distribution are not fully consistent between the NOAA CPC and ERA5-based datasets, and for mean winter temperatures, there was also generally a warm bias; despite this, for the indices applied, their results showed that the ERA5-based datasets performed better for the coldwave indices compared to the heatwave indices. The biases detected herein similarly predominantly reflect that the ERA5-based datasets over-estimate temperatures in the lower tail-end of the SAT (and TN and TX) distribution over southern Africa, and consequently, these datasets under-estimate (over-estimate) the frequency (magnitude) of CETEs. From a thermal region view, this was similarly evident for most of the indices, while it is noteworthy that the ERA5-based datasets performed best over thermal region two (Figure 6-7), which is expected as it is comparatively characterised by a denser, more reliable weather station network in the NOAA CPC dataset (Roffe and van der Walt, 2023).

While the bias and climatology results are important to acknowledge, it is the temporal performance, in terms of interannual (and intra-annual) variability patterns and trends

that can best inform whether the ERA5-based dataset could be applied for decision-making purposes for CETEs. For this, it should be highlighted that the correlation and trend results reveal overall good, but varying performance (Figure 6-11). The ERA5-based trend results were not always consistent, in terms of direction, with the NOAA CPC dataset results. This is a result that has similarly been detected in many studies (e.g., Gleixner *et al.*, 2020; Bhattacharyya *et al.*, 2022). It is also an important weakness to highlight as this reflects that the ERA5-based datasets alone are not necessarily reliable for trend analysis. Used alone, these datasets could provide misleading conclusions, leading to poor decision-making. For instance, over northern regions the ERA5-based datasets do not capture the decreasing trends reflected by the NOAA CPC dataset for TXn. Application of only the ERA5-based dataset results for decision-making could be problematic for livestock farmers for instance as this could mean less consideration of extremely cold day-time conditions for livestock management practices, and if not accounted for farmers could be uninformed and face livestock losses. This result highlights the value of consistently utilising station records as well as the ERA5-based datasets – coupled application of these datasets can therefore be important to reduce uncertainties in conclusions derived from both datasets, providing better insight on and confidence in the spatial patterns of vulnerabilities to CETE variability and trends. Despite this, our correlation results revealed that the ERA5-based datasets reliably represent interannual (and intra-annual) variability patterns, adding confidence to the temporal

performance of these datasets. Importantly, although spatially and temporally interannual variability patterns were similar in the datasets, caution must still be placed on the actual magnitude values of an index since our results show notable biases for most of the indices. Nonetheless, many studies report good performance in this regard (e.g., Gleixner *et al.*, 2020; Schumacher *et al.*, 2020; Engdaw *et al.*, 2022; Velikou *et al.*, 2022; Roffe and van der Walt, 2023).

While there are many strengths to note, we have reported on some notable weaknesses associated with the representation of CETEs in the ERA5-based datasets applied herein. Despite this, we are not cautioning against the application of these datasets for CETE studies over southern Africa, and we instead opt for application of both datasets where possible. This is because the ERA5-based reanalysis datasets can be complimentary to the station records as they provide spatial detail that is lacking from weather station records, and they are not typically associated with homogeneity and data gap issues which are somewhat common for weather station records. Although there is still room to assess the performance of the ERA5-based datasets, such as for hot ETEs characteristics, the results presented herein and in other studies over southern Africa (e.g., Roffe and van der Walt, 2023; Kruger *et al.*, 2024) provide a body of evidence in support of applying the ERA5-based datasets to characterise mean and extreme temperatures over southern Africa. Though, with any application, we cannot stress enough that uncertainties must always be acknowledged. If, for instance, these datasets are applied for advisory information

for decision-makers, acknowledging uncertainties will be crucial for enabling informed, robust, transparent, and effective decision-making processes. In the context of the current study, a decision-maker would benefit, for instance, from knowing if the year-to-year fluctuations in CETEs are not always well captured by the ERA5-based datasets - this could lead to potential inaccuracies in predicting years with heightened CETE characteristics if their decisions are based entirely on one or all the ERA5-based datasets. Thus, any user of the ERA5-based datasets over southern Africa should proceed with caution.

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Appendix A

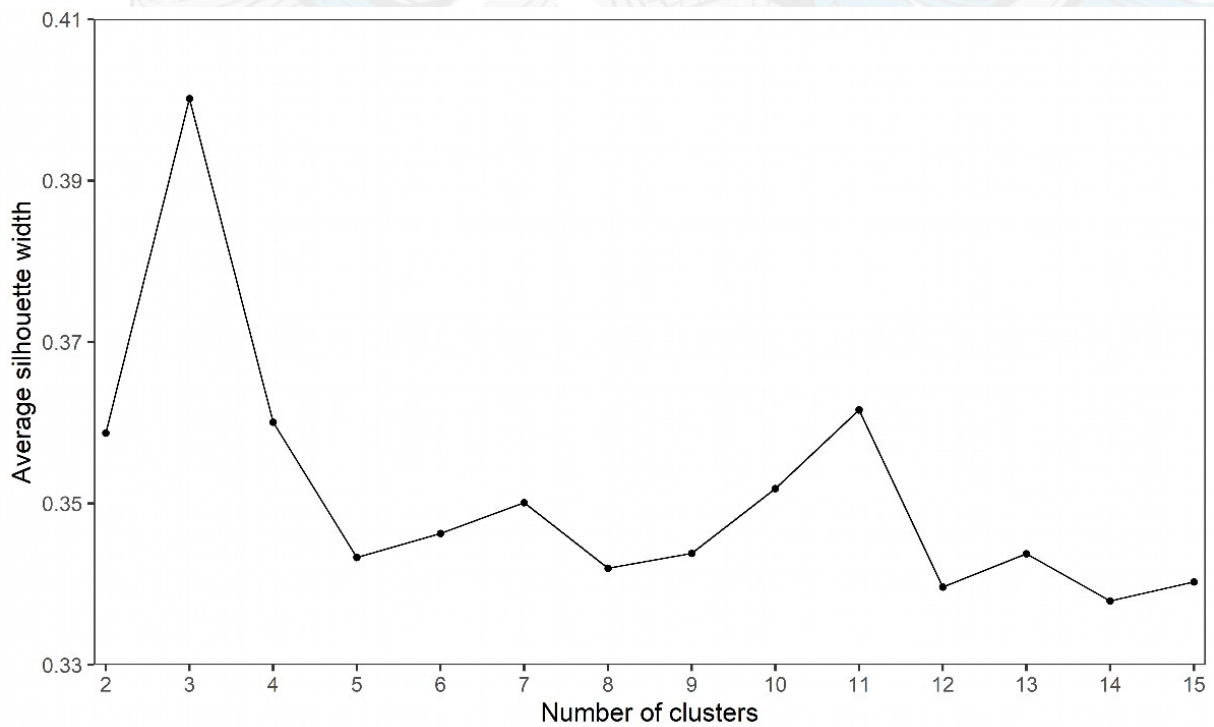


Figure A1. Average silhouette width values for 2-15 cluster groupings for the k-means clustering application (discussed in the main text) for average daily minimum temperatures for June-August for 1979-2021.

ABSTRACTS

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Urban Gentrification Post-Covid 19 and the Maboneng Precinct, Johannesburg

The outbreak of the COVID-19 pandemic in 2020 and the global recession that followed has sparked two new debates over the future of gentrification in Anglo-American cities, namely de-gentrification versus disaster gentrification. In the one debate, gentrification declines or “dies a sudden death” and a post-gentrification city emerges, while in the other, “capitalism exploits the situation” and new mutations of gentrification start to develop. In South Africa the recession, subsequent to the COVID-19 pandemic, has also brought about new patterns of urban change in the inner city. This paper explores whether these two debates have relevance within the context of South Africa by drawing on the case of the Maboneng Precinct in the inner city of Johannesburg. Once known for crime-and-grime, this post-industrial space has been recognised by international media as one of the coolest neighbourhoods in the world because of its trendy restaurants, boutiques and art galleries. However, there has recently been a shift in the character of the neighbourhood with some fearing the precinct’s demise. However, some residents view the recent changes in a more positive light and instead perceive it as a new “incarnation” of the neighbourhood. Therefore, could a form de-gentrification be emerging, where Maboneng becomes a more inclusive space reflecting the needs and aspirations of the community, or will a form of disaster gentrification emerge, where gentrification mutates and takes place even more aggressively in the precinct?

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Towards an eSports Environment Index (EEI)

eSports, or electronic sports, are multiplayer video game competitions where individuals or teams of more than one player, compete against each other. The high-stress competitive environment in which players find themselves are highly reliant on split-second decision making, optimal problem solving, hand-eye coordination and low reaction times. These mental and physical traits can be affected by the thermal comfort of the individual leading to inefficiencies in play. The thermal comfort of any individual is highly influenced by their surrounding environment and a person's indoor setting is no different. An eSport athlete is in a sedentary position while experiencing highly stressful situations and relying on mental attributes to win important matches. The aim of this study is to develop an index to assess the thermal comfort of a gamer's surrounding environment for optimal competitive performance to take place. This index would be named the eSports Environment Index (EEI). To complete this aim, an online questionnaire will be distributed through multiple social media streams to determine what South African's gaming environments look like. Questions relating to the layout of the room, what room they game in as well as the presence of any ventilation or air conditioning are located in the questionnaire. Alongside this, questions relating to clothing worn during gaming sessions are also an important consideration as clothing is a key function of individual thermal comfort. Analysis of the questionnaire results will be done to determine which variables need to be considered for the index. Other indices already created in academic literature will be used as reference points to determine the weighting of important variables specifically in indoor settings. Following this, clothing and the sedentary nature of the gamer will be taken into consideration as these can strongly influence sweating and the heat balance of the body, therefore affecting thermal comfort and performance. Finally, the index will be tested using outdoor temperature readings across the country to output index scores in specific urban centres. Another questionnaire will be released to determine whether these outputs are seen to be accurate in determining the possible indoor environments that these gamers are experiencing. According to these results, the EEI will be reassessed to determine changes and testing will then be redone following the same process as what was previously completed. Conclusions will then be drawn as to what effects certain environmental conditions may have on gaming and performance, and the utility of the index will be used as a way to assess whether a given environment is optimal for performance. Alongside this, recommendations in improving the environment or individual thermal comfort will also be given to finalise the research.

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What counts as urban spatial transformation in South Africa? Breaking down a multidimensional process

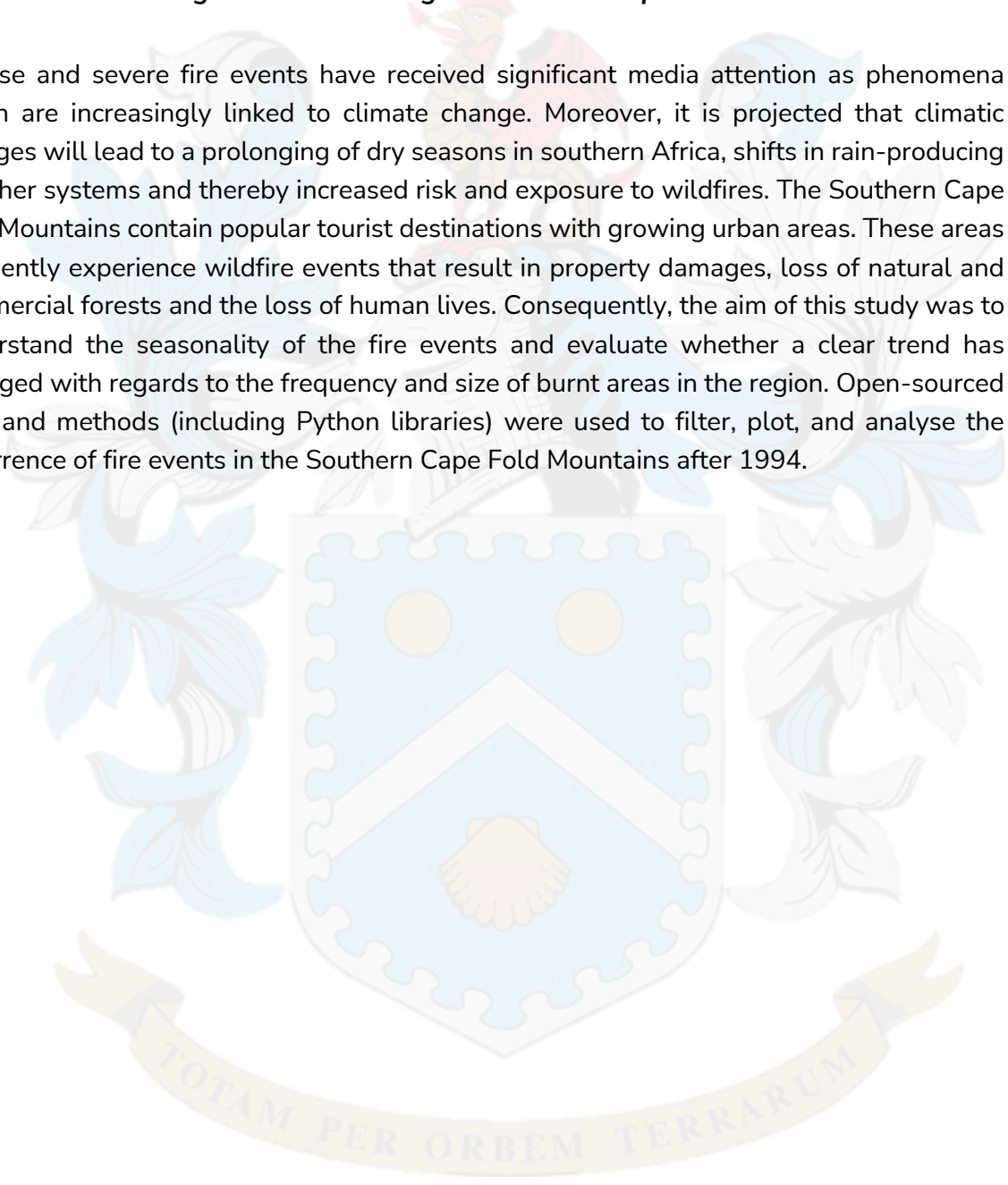
Given apartheid's goal of creating racially segregated cities, the transition to democracy was accompanied by an expectation that cities could be re-organised to make them more just and equitable. This review paper counterposes different kinds of spatial change to reflect on the multiple meanings of urban spatial transformation: racial desegregation, income desegregation, improvements to working class residential spaces and improved connectivity. It argues that each of these forms of spatial transformation has distinct implications for spatial justice. It reflects, too, on the limits of trying to 'fix' society through spatial reorganisation.

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Assessing wildfire risk along the Southern Cape Fold Mountains

Intense and severe fire events have received significant media attention as phenomena which are increasingly linked to climate change. Moreover, it is projected that climatic changes will lead to a prolonging of dry seasons in southern Africa, shifts in rain-producing weather systems and thereby increased risk and exposure to wildfires. The Southern Cape Fold Mountains contain popular tourist destinations with growing urban areas. These areas frequently experience wildfire events that result in property damages, loss of natural and commercial forests and the loss of human lives. Consequently, the aim of this study was to understand the seasonality of the fire events and evaluate whether a clear trend has emerged with regards to the frequency and size of burnt areas in the region. Open-sourced data and methods (including Python libraries) were used to filter, plot, and analyse the occurrence of fire events in the Southern Cape Fold Mountains after 1994.



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Internet of things for just urban transitions: Putting Humans at the Centre

Internet of Things (IoT) has been a new paradigm enhancing the collective connectivity of humans, goods, and services across scales including real-time transferability of data and information. This study is three-fold, 1. There is a limited justification for how IoT can advance just urban transitions 2. IoT and human-centeredness approaches are lacking 3. Research on the quality and safety of IoT hard infrastructure is limited therefore leaving a lacuna in literature on e.g. Telecommunication towers, fiber-optic cable, terrestrial microwave, twisted pair, and satellite transmission management in relation to IoT service satisfaction, urban safety, and spatial development. This study banked on an extensive literature review to achieve the first and second parts, the third part was achieved through the assessment of IoT hard infrastructure quality, safety, and efficiency to keep up with the provision of IoT services in affluent and township settlements of Johannesburg, South Africa. Findings from this study show that IoT advancement is leaving out the human face in its innovation and technological advancement, and the provision of IoT-enhanced facilities is seen to be more standard in affluent areas compared to township settlements. This signals that IoT managers in urban areas are profit-oriented, invariably township settlement dwellers will continue to struggle to keep up with civilization. Also, the IoT focus has majorly been on smart devices, cloud storage, big data, and artificial intelligence with less attention on IoT hard infrastructure maintenance. Hence, there are reported cases of network failure in terms of communication, and use of Apps (to access information, bank transactions, weather forecasts, travel arrangements, etc.). It is on this note that the management of engineering infrastructures which anchors the network equipment, enhancing effective communication and connectivity between cities and persons need attention. As we leap into just urban transitions, there is a need to reform technological advancement with the human face through the co-creation and co-production of knowledge, in addition, IoT stakeholders should focus more on the hard infrastructures that facilitate connection and transmission of information by climate-proofing these infrastructures including attention to quality and safety to avert failure which could lead to urban disasters.

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Earth Observation for Estuarine Biodiversity Monitoring in the Western Cape Province of South Africa

Estuarine biodiversity is often low due to natural stressors such as inundation and salinity. However, estuaries across South Africa have relatively high plant biodiversity and provide critical ecosystem services. Ecosystem extent mapping in these systems is often limited by the available remote sensing data parameters, for example, spatial, spectral, and temporal resolution, resulting in products that exclude meaningful distinctions in habitat across the intertidal zone. The remote sensing methods and limitations for mapping tidal marsh ecosystems to monitor biodiversity are research gaps we seek to address. In this study, we demonstrate a methodology for rapidly developing training data and applying the developed algorithm regionally and across time to improve the mapping and monitoring of coastal ecosystems, focusing on predicting the species richness of coastal wetlands. We demonstrate the potential of high-resolution satellite data classified with convolutional neural networks to capture crucial intra-seasonal variability and classify plant functional communities. The model achieved an internal overall accuracy of 90.46% and an area under the curve (AUC) of 0.85. We predicted coastal wetland extent for ~57 estuaries in the Western Cape Province. We achieved detailed high-resolution extent results for two IUCN ecosystem functional groups, MFT1.3 salt marsh and reedbeds and M 1.1 Seagrass meadows. We additionally demonstrate the importance of separately mapping salt marsh and reedbeds to identify species richness across the coastal wetlands. We collected vegetation plot data for Langebaan and Swartvlei estuaries as part of the NASA BioSCape field campaign which we incorporated into our analysis as training data for species richness classification and verification of our ecosystem extents. We will discuss the potential of the imaging spectroscopy collected by NASA BioSCape to improve our ability to monitor biodiversity in estuarine environments of South Africa.

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Prospects and challenges for climate smart communities in rural southern Africa

This study sought to determine the prospects for and challenges of climate smart communities with a special focus on rural southern Africa. The study undertook a systematic review and content analysis in order to derive valid insights on the prospects and challenges for climate smart rural communities in southern Africa. As such, the study reviewed 68 academic publications in the period 2005 to 2023. SCOPUS was the principal database used to search articles for the study. Emerging from the study is that the rural communities are exposed to the effects of extreme weather events majorly due to their dependence on the natural environment for livelihood. The study revealed existing efforts towards the transition to climate smart communities. Attention is given to operational performance of local and public institutions in promoting adaptation and resilience. Literature underscores the role of stakeholder participation and partnerships to achieve effective adaptive capacity building in the backdrop of climate change. There are bright prospects for a climate smart rural southern Africa although several barriers have to be overcome to achieve this desired state.

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A geographical study of some of the lesser known coastal lakes of Maputaland, KwaZulu Natal

The coastal lakes of Maputaland are not only extremely rare ecosystems in South Africa but also provide critically important water resources for local communities in one of the poorest and least developed regions of the country. Most are located with the iSimangaliso Wetland Park, a World Heritage site unique in Africa and of global importance for the sheer diversity of wetland ecosystem types. However, there are very few rivers and most surface waters are groundwater fed. Water resources have been identified as one of the key constraints to economic development within the region and in recent years, declining groundwater levels and reduced water levels in South Africa's largest lake, Lake Sibaya, have become an increasing cause for concern. Some parts of Maputaland are experiencing rapid land use change and potential conflict between poor rural communities and conservation organisations, while the region is characterised by temporally and spatially variable rainfall and hydrology. Hence determining the impact of human activities such as abstraction, expanding forestry and land cover change on ecological status and water levels of the region's lakes is a major challenge, especially in the context of a changing climate. Furthermore, there are a number of lakes in the region about which almost nothing is known (at least to science, as published research), in terms of morphology (bathymetry), hydrochemistry, ecological state and environmental pressures. As part of a wider, multi-proxy palaeolimnological study to reconstruct lake levels, atmospheric contamination and environmental change in the region, here we present preliminary data on the limnology of six lakes spaced along 143km of the Maputaland coastline from the Mozambique border to Lake Bhangazi South at Cape Vidal. Subsequent comparison with meteorological and documentary evidence will allow the separation of the relative roles of climate and landcover change in influencing lake water levels and contamination through the Anthropocene.

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Measuring Quality in South African Safari Tourism

Arguably, safari tourism is an essentiality for the conservation of Africa's iconic wildlife and the sustainability of savanna ecosystems. For sure, it is the encounter value that brings a guest within close proximity to an exotic beast ---often perceived as dangerous --- and an opportunity to take selfies with wildlife in the background, which are forwarded to friends and family via social media at day's end. Yet, this experience can come with a great social cost, for indigenous people have often been dispossessed of their lands, which now may be administered by absentee investors uninterested in their welfare. Two decades of fieldwork in the "Safari-Belt" countries of East Africa and Southern Africa has revealed considerable uneven quality in safari lodges, not only with reference to game-viewing, dining, and service, but also with regard to the manner in which owners and investors treat employees and contribute to the amelioration of social problems plaguing local communities. Beyond the issue of social justice, there is good reason for safari operators to address these matters, for although they show a desire for enjoying lodge amenities, American travelers, who make up more than 17% of South Africa's tourists, express an increasing level of concern for the people who dwell within the vicinity of the parks and reserves where they vacation. Unfortunately, travelers' review scores, which are often relied upon by tourists for selecting safari experiences, are often inadequate and unreliable; a legitimate means of assessment has yet to be endorsed. Given that, I developed a Safari Quality Score (SQS), which incorporates within its rubric measures of elements relating to the actual safari experience as well as the individual lodge's social justice initiatives. In an assessment of South African safari lodges, Tanda Tula in the Timbavati Reserve has achieved the highest SQS. This paper discusses the creation of the SQS and offers examples throughout South Africa of lodges that have achieved certain scores.

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Community engagement pathways using citizen science to enhance participation in water quality monitoring: participation in water quality monitoring: insights from Eastern Cape region, South Africa

There is an increased demand of local citizen engagement in science contributing to the development of evidence-based policies at local, national, and international development scales. In recent years, a steady growth of geosciences related citizen science projects aiming at building knowledge, awareness, and resilience to environmental issues such as geohazards has been realised. This project considers the Citizen Science approach to enhance participatory citizen science and community engagement methodologies, facilitating skills development in water monitoring within the selected Eastern Cape Karoo communities. Growing concerns of water quality in the Eastern Cape region of South Africa, whether it is fit for local community domestic use and the existing unknowns of the role played by climate change in the hydrology of the river basins, are emerging challenges – not only in the Eastern Cape but at national, regional and global scale. In societies with Citizen Science experience, it is important to note that the collaborative participation with local citizens and engaging the relevant stakeholders, are potential avenues to accelerate data needed to make effective water management decisions. It is therefore important to advance the global agenda for water quality resource monitoring, by meaningfully engaging and building the capacities of local citizens, where local water management can first be realized.

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Creative Destruction and Built Environment Heritage in Makhanda, South Africa

Heritage conservation is recognised as an important component of sustainable development but is often considered a lower priority compared to other development imperatives, and societal issues. The prioritization of economic and urban development threatens urban heritage through a process known as creative destruction. This research uses the concept of creative destruction to explore the interplay between market forces and urban planning and management practices on the heritage conservation of the city of Makhanda in South Africa. Makhanda has a rich and varied cultural heritage landscape, including many individual buildings and streetscapes. A qualitative approach, including semi-structured key informant interviews and secondary sources was employed. The study found that municipal dysfunction and other urban management challenges result in difficulty in enforcing legislation and policy, and thereby threatens heritage conservation. The fates of three buildings within the historic urban fabric of the city are explored in terms of the impacts of neoliberal urbanism occurring within this context. The research contends that for heritage management to be successful, there needs to be a balanced approach through improvements in stakeholder relationships, governance, institutional capacity, knowledge sharing and community involvement in decision-making processes.

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Counter-urban migration amongst creatives in South Africa in response to COVID-19: Zoom towns and creative cities

Cultural and creative industries (CCIs) and creative workers are seen as quintessentially urban (Florida, 2002), but this is not the case in reality (Bell and Jayne, 2010; Gibson, 2010; Markusen, 2013). South Africa's creative geography is dominated by two metros, Johannesburg and Cape Town (SACO, 2022). However, studies have revealed a creative turn in rural policy and the formation of CCIs clusters in these spaces (Gregory and Rogerson, 2018; Drummond and Snowball, 2019). With improvements in technology and the rise of remote working, in part associated with and accelerated by COVID-19, a counter-urbanization trend may exist amongst some freelance creative workers. This is linked to issues of affordability and lifestyle re-evaluation (Hracs et al., 2011; Alacovska et al., 2021). In particular, the pandemic has given rise to the phenomenon of 'Zoom towns' – small towns in picturesque settings with an attractive range of lifestyle amenities linked to nature. Taking an economic geography perspective and using a mixed methods approach, this research examines the location decisions of creative workers in South Africa and the implications for non-metropolitan spaces and creative cities. A GIS analysis of property transactions data in potential Zoom towns and major metros is combined with key stakeholder interviews and a survey of freelance creative workers to unpack the motivations behind relocation decisions. Results show that career stage, lifecycle, and creative occupation influence locational decision-making. This research also helps to address both the urban bias and global north bias in the research around creative work.

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Creative spaces in non-metropolitan areas: The cultural economy of Mahikeng and surrounds

This paper investigates the development of the cultural and creative economy in a non-metropolitan space in the Global South. The geographical focus is Mahikeng in South Africa's North West province. The research adopts an historical approach. Through a reading of the archives of the Mahikeng Mail for the period 1974-2023 a longitudinal database was derived, consisting of approximately 3000 performance events. The data was disaggregated and analysed using the six cultural domains proposed by UNESCO. This allowed for the construction of a narrative which uncovered the rise and fall of a local cultural economy, which was deeply affected by political, social and economic change, accompanying the Bophuthatswana period and subsequent re-incorporation into South Africa. The results disclosed the dominance of the domain of Performance and Celebration throughout the fifty-year study period. The development of the Mahikeng cluster was state-led and with critical government support for the overall development and health of the cultural economy and of its various domains. The cluster did not continue to prosper after the state was transformed resulting in the withdrawal of support and funding in the post-apartheid period which caused the onset of the decline in the Mahikeng cultural economy.

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Reflecting on South Africa's changing urban spatial development patterns since 1994

South Africa commemorates 30 years of post-apartheid democracy in 2024. One of the policy priorities of the overall post-1994 policy framework is the transformation of apartheid spatial patterns at both a national and urban level. The objectives of this paper are thus twofold. Firstly, to provide an overview of the trajectory of the spatial development policy framework since 1994. Secondly, to consider the role and influence of this changing policy framework on the overall national spatial urban development pattern. The paper considers the key trends in the transformation of the spatial planning and policy framework during various distinct phases since 1994. It provides a comparative temporal analysis of the key global events influencing spatial development, the main spatial planning policy shifts and priorities, and the resulting influence on the national and urban spatial pattern during these various phases. Based on the experiences and trends of the last 30 years, the paper concludes with the implications for future urban spatial development patterns and associated spatial planning practices.

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Gold in Africa – the distribution of wealth, power and misery

Gold has been the most sought-after metal for the longest period in history. Gold has been used as measure of value, treasure, bullion, coinage and as backing for currencies by many countries, kingdoms and empires through the millennia. Originally gold was used as ornaments by the more affluent members of societies, but later it became the standard on which the wealth of nations was built. The distribution of gold deposits is very erratic and has determined the distribution of development and welfare of the exploited and the exploiters for over 5000 years.



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Enquiry-based fieldwork in geography promotes metacognitive skills: lessons from case studies

The South African Geography Curriculum and Assessment Policy Statement supports the enquiry method of asking geographical questions. By combining two of Geography's four Big Ideas: place as well as the human and environment interactions with the pedagogy of geographical fieldwork (DBE, 2011), we can prove that the powerful tools of enquiry: observation; description; analysis and explanation; evaluation and prediction; decision making and personal evaluation, judgement and response will be part of that learning strategy. This research uses an interpretive case study design and grounded theory to evaluate how fieldwork promotes the development of learners' metacognitive skills.

The metacognition observation form and evaluation tool, constructed from literature and best practice, and combined with the researcher's personal content knowledge, was tested by conducting a pilot study. These tools assess the effectiveness of enquiry-based learning in the field where the various skills and actions have been linked to the cognitive, affective, social and kinaesthetic domains which promote metacognitive learning. The study suggests that a local, place-based environment such as the school grounds or precinct, will allow enquiry-based learning to take place and help develop learners who are able to think critically, problem solve and acquire geographical literacy and the subject-specific skills.

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Biometeorological futures for Southern Africa: Applying regional climate model outputs to human comfort indices

A range of biometeorological indices have been developed to quantify and classify the impacts of local meteorological conditions on human comfort, health, and enjoyment. In recent years, these indices have been validated for application in Southern Africa, and human biometeorological conditions have been quantified using historical climate data. Where these data span periods of more than three decades, progressive changes in biometeorological suitability can be quantified. However, the rapid acceleration of climate change limits the accuracy of extrapolations into the future. This study presents the first calculations of Biometeorological index outputs using bias-corrected regional climate model outputs for Southern Africa.

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The demographic challenges of implementing Bus Rapid Transit in the spatially fragmented city of Cape Town

Cities in countries of sub-Saharan Africa are facing a mobility crisis, which stems from an increased demand for mobility amidst dramatic demographic, urban and economic transitions. Inefficient land use patterns, neglect of the transport sector, dominance of the informal sector, and affordability constraints, have rendered the current public transportation systems ineffective to meet this demand. In response, many cities in sub-Saharan Africa have adopted a transit approach based on BRT-TOD (transit-oriented development using bus rapid transit) to spatial restructuring in an effort to address the disconnect between transportation systems and the fragmented urban form. The rationale behind BRT-TOD is to integrate urban form and all modes of transport into a seamless integrated transport system where all modes will function at their optimum capacity. The study followed a mixed method approach involving deductive and inductive reasoning, arguing that the mismatch in BRT ridership is not caused by the problematic spatial structure of South African cities. Rather, it is characteristic of an inappropriate design response to improve the country's transport system amidst an inherently fragmented urban form. To accomplish this, the study used qualitative and quantitative data, employing a cross-sectional secondary data analysis to the case study of the MyCiTi BRT's trunk routes T01-T04 operations in City of Cape Town, South Africa. It hypothesises that land use regulations that are adopted to reverse the effects of distorted land markets, run the risk of achieving the exact opposite, when market forces react to such interventions. This comes at a great public cost. In South Africa, as is the case in other cities of sub-Saharan Africa, distorted land markets and fragmented labour markets have left unique footprints in terms of density, demand and diversity patterns. These patterns hold implications for policies that aim to change them.

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Transformation in South African National Parks Tourism

National parks are an integral part of the South African tourism economy, due to the country's diverse landscapes and unique wildlife. Nature has also been integral in South African national identity as conceptualizations of the country are often closely linked to its natural features, most notably wildlife. However, despite the fall of the apartheid government in 1994, nature spaces and protected areas remain largely white recreational spaces. Significant barriers remain in terms of access to national parks by Black South Africans, both in terms of physical and financial inaccessibility but also, importantly, social and psychological access. Within the framework of access theory, this paper seeks to demonstrate the opportunities for and challenges to developing safari tourism amongst Black South Africans. The work is based on surveys of Black South Africans who visited Kruger National Park in order to determine their motivations, experiences and challenges faced in order to enhance safari tourism among Black South Africans in the future. This is important for many reasons including the increased need to grow domestic tourism, due to increases global crises which can impact global travel patterns. In addition engagement with nature spaces has shown to have numerous benefits, both in terms of environmental awareness and also psychologically. Thus, these experiences are important due to the fact that Black South Africans, particularly young Black South Africans, are the current and future leaders of the national parks systems and the custodians of protected areas and therefore must be more inclusive.

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Leveraging the visual arts in teaching urban geography: Reflections from the University of Pretoria, South Africa.

Historically the visual arts have played an important role in illustrating landscapes. Similarly, in geography, representations of landscapes form a crucial part of the discipline. South Africa has a rich collection of visual art depicting urban life during the colonial and apartheid eras, as well as contemporary urban life. This study underscores the value of incorporating visual arts in teaching urban geography in South Africa. In 2023 a post-graduate urban geography module was facilitated within a gallery space at the Javett Art Centre at the University of Pretoria. The students critically engaged with art depicting urban life during apartheid and also each produced a creative piece illustrating the contemporary South African city. This study draws on teaching reflections, teaching and module evaluations, written student reflections, and semi-structured interviews with representatives from the Javett Art Centre. The results indicate that the shift from a traditional classroom setting to a gallery space stimulated and created an opportunity for students to critically engage and deepen their understanding of the various socio-political complexities of urban South Africa. The opportunity to produce creative pieces offered a nuanced and emotive understanding of student's lived experiences in urban South Africa. An interdisciplinary approach in leveraging the arts for teaching urban geography helps disrupt linear modes of thinking, forging new pathways for students to understand the complexities of urban environments.

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Surface indices over the Drakensberg Basalts: Implications for landscape evolution of the Great Escarpment

The Drakensberg basalts constitutes the uppermost portion of the passive continental margin (PCM) known as the Great Escarpment in southern Africa. Coinciding with the breakup of Gondwana, this region formed as a large igneous province roughly 183 Ma. This study uses geomorphometric and surface indices to offer novel insights into the landscape evolution of the region and assess the influence of tectonics, incision, and denudation. Utilising a moving window, the following geomorphometric indices were derived from a 30 m pixel digital elevation model (DEM): hypsometric integral, surface roughness, relief anomaly, and the surface index. Differences in relief and incision were assessed using 3km swath topographical profiles. High incision and erosion rates determined by the surface indices suggest that the escarpment and valley sides experience higher rates of erosion. However, the Drakensberg Basalts have been dated to show low rates of denudation and weathering at high altitudes. Based on the results, highly elevated but low relief regions were identified together with areas characterised by high rates of erosion or deposition. The results from the indices suggest that the escarpment and incision depth and rates are maintained and controlled by the underlying sandstone formations and location of dolerite sills or dikes. The results also support a tilted uplift mechanism that resulted in a rearrangement of drainage basins and a shift in the drainage divide until its pinned location.

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De-migrantizing as methodology: rethinking migration studies through immobility and liminality.

This paper discusses the trend of de-migrantization in migration studies, which involves shifting focus from migrants to broader concepts like immobility to gain deeper insights. By examining immobility through the concept of liminality—viewing it as a transitional or transformative phase—this approach seeks to understand migration without solely focusing on the movement of people. The research utilizes 165 interviews with distance education students from Zimbabwe, Namibia, and Nigeria at the University of South Africa to explore how studying immobility can provide new methodological perspectives in migration studies. The study explores immobility as a potential tool for de-migrantization, offering insights into when, where, and how migration studies can be conducted without emphasizing migrants as a distinct category.

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Exploring Shifts in the Threshold for Reporting on Extreme Temperature Events over the Past Century in South Africa

The coming century is predicted to warm at an unprecedented rate due to anthropogenic climate change which will impact the occurrence of extreme temperature events (ETEs). Climate change is expected to increase heat wave events at a rate of 30 extra days of excess heat per degree Celsius of global warming. Extreme temperatures can cause a variety of health concerns from cardiovascular to respiratory diseases and in extreme cases can lead to morbidity (illness) and mortality (death). Urban populations, the elderly and children are the most prone to negative effects from ETEs, which means that South Africa's increasingly urban population will be at higher risk. However, very little is understood about the threshold that has been used historically to classify ETEs. Modern definitions for ETEs also range drastically from percentile-based to absolute temperatures. Moreover, there has been speculation that people are becoming more sensitive to ETEs due to modern lifestyles and relative insulation from outdoor temperatures. However, the relative sensitivity of people to ETEs has not been widely studied to determine whether there has been an increase or decrease in sensitivity to extreme temperatures. Understanding the change in the threshold for reporting on ETEs in South Africa and how that threshold has changed through time will be key to future public health preparedness. This study will explore how newspaper reporting on ETEs in South Africa has classified ETEs. This data will be compared with South African Weather Service (SAWS) daily temperature data to determine the temperature threshold used to classify ETEs and explore the change over time. This will also be used to explore whether human sensitivity to extreme temperatures has increased or decreased over the past century. SAWS data will also be used to determine what type of temperature increase or decrease was considered an ETE, by exploring the temperatures of the week preceding the ETE. This can account for seasonal acclimatisation to heat and cold, for example, a heat wave at the beginning of spring may be classified as major compared to a similar heat wave at the end of summer. Preliminary research has found that newspaper reporting can give extremely detailed data about daily maximum and minimum temperatures for ETEs at very specific locations, which can be used to cross-check SAWS weather data. Additionally, this gives a very clear threshold that was used in the newspaper reporting which will be able to indicate either an increase or decrease in the threshold for an ETE. An additional qualitative component of this study will explore how or if newspaper reporting on ETEs has changed over the past century. This historical climatology approach to studying extreme temperatures will indicate whether climate change has increased the

threshold for ETEs or instead made humans more sensitive to extreme climate which will be key to understanding and preparing for an increase in hot ETEs under climate change.



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Creative Destruction and the Reivention of Heritage Spaces: the creative class, third places and the prisons of Makhanda, South Africa

Built environment heritage is recognised as integral to the identity of cities and communities, and its conservation is, therefore, a key component of sustainable development and, more particularly, the SDGs. Economic shifts and the changing focus of capital and profit generation enterprises can present a challenge to heritage conservation through the process of creative destruction. Creative destruction includes a range of forces that can destroy, reimagine, or repurpose the built environment alongside these economic shifts. This paper explores the creative destruction processes at play in the small city of Makhanda, South Africa which has a considerable array of buildings and streetscape dating back as far as the early 1800s. Its particular focus is the reimagining of three heritage spaces. These three former prisons date back to the early 19th century and have been reimagined alongside the changing market. This paper argues that their current reincarnation is aligned with the creative classes, third places and the education scene within the city. The paper proposes that this reimagining gives new purpose to the buildings, opens them up to public, builds narrative value and presents little threat to the built environment. This is, in part, because heritage is utilised in and aligned with the place-making and -branding of the businesses themselves, and not as a challenge to them. It is argued that these can be used as a blueprint for further development in the city.

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Rose-tinted spectacles: perspectives on garden festivals, place identity and political ecology in Raymond Mhlaba Local Municipality

Gardens and gardening are an often overlooked aspect of geography, but gardens involve a design process much like that of the design of a building or a neighbourhood. Even in the most naturalistic garden, design involves the transformation of the natural environment. Therefore, while gardens include natural features, they are artificial in their construction and are therefore seen as 'hybrid spaces' (Head and Muir 2006). Like urban planning or architecture, gardening can be understood as a cultural expression and gardens as a symbol of the gardener's identity and sense of belonging (Kimber 2004). There is a body of ethnographic literature that explores the gardens of immigrant communities and the role gardens play as an expression of cultural identity and connection to one's homeland or illustrate belonging in an alien land (Bhatti and Church 2004; Morgan et al. 2005; Head and Muir 2006) The act of gardening is an act, therefore, of place-making. The present research utilised in-depth, semi-structured interviews with gardeners in the small towns of Bedford and Hogsback to explore place-making through gardening and investigate the myriad representations of place, identity and belonging within gardens It contextualised this investigation within South Africa's history of colonialism and white minority rule, and more recent democratic transformation to provide a possible political dimension to the understanding of these spaces. The political ecology perspective was employed to understand the power dynamics inherent within the expressions of cultural identity and belonging of white settler communities within the national context of a renegotiation of power, identity and belonging.

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Novel Optimal Spectral Subset Picker (OptiSpecPicker) Algorithm for Classification and Regression Problems in Remote Sensing Inspired by the Wine-Making Process

The development and exploration of new algorithms are needed to solve challenges such as collinearity and dimensionality. In the current study, we propose a novel feature selection algorithm, i.e., Optimal Spectral Subset Picker (OptiSpec), based on the wine-making process to enhance the efficiency and performance of classification and regression of remote sensing data. The proposed OptiSpecPicker feature selection algorithm is a hybrid filter-wrapper method, thus leverages the capabilities of individual assessment of features and their relationships to response variables while also evaluating their combined effect on model accuracy. Inspired by the wine-making process, which involves steps such as (1) vine selection, (2) picking the grape varieties, (3) sorting the grapes by quality, and (4) blending to create the wine, the novel OptiSpecPicker algorithm first evaluates the information content (or quality) of each variable in relation to the response using information theory, sorts the features according to their individual importance, iteratively (recursively) evaluates, using a machine learning classifier or regressor, the various feature combinations starting with the most important variable and adding new (i.e., next important) variable until there is no more improvement in accuracy in n consecutive iterations (i.e., patience parameter u). This process prioritises quality variables (i.e., those with high information content), implements an automated and objective cut-off decision, and the stopping criterion (no consecutive accuracy improvement) improves the efficiency of the algorithm. When tested in a species discrimination problem using simulated EnMAP hyperspectral data, the algorithm showed better accuracy compared to RFE and entire Spectral data. In a regression problem of estimating biophysical and biochemical parameters of crops using Sentinel-2 spectral bands and vegetation indices ($n = 22$), the OptiSpecPicker feature selection algorithm showed a similar performance to the RFE while performing better than the entire Spectral data.

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What makes the ideal Environmental Assessment Practitioner? An empirical approach to identifying key knowledge areas and employability skills

Graduate unemployment is a growing concern in South Africa's economic landscape. Not only is the economy shrinking, but employers are becoming more discerning regarding who they employ. Employability skills are becoming increasingly important for industry and most universities have now made a point of including employability skills in the curricula presented. This is particularly relevant to recent graduates trying to gain entry into the Environmental Assessment Practitioners (EAP) field. This paper aims to identify those knowledge areas and employability skills most sought after by industry. Data was collected from online job recruitment platforms. This data was then triangulated with questionnaires distributed to environmental experts, such as EPAs, government officials and environmental specialists. SPSS was used to analyse the data using frequency and significance tests. NVivo was further used to identify themes and narratives from the questionnaire data. Twenty-two Knowledge Areas were identified with Environmental Impact Assessment (77.8%) and Environmental law (72.7%) being the most frequently requested in job advertisements analysed. Sixteen Employability Skills were identified, with Interpersonal and communication skills listed in 76% of the job advertisements analysed, followed by Written Skills (74%). Ten Emotional Intelligence attributes were identified with "being able to work independently" occurring in 67.1% of the job advertisements followed by "being willing to travel" (51.4%). Ethical and professional conduct only occurred in 20% of the advertisements. Preliminary findings indicate that certain knowledge areas and employability skills are expected to become an EAP. However, some knowledge areas and skills, such as GIS and Ethical conduct, were surprisingly low on the ranking. GIS is considered a scarce skill and EAPASA places emphasis on Ethical and Professional conduct. In the next phase of the study further analyses should bring light to the grey areas observed when addressing the disparity observed in the data collected from the online advertisements and the questionnaires.

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Epistemologies of urban justice in Bantu Africa, through a critical urban geography and African studies transdisciplinary lens.

This paper investigates the epistemological nuances of a central question in urban geography, urban studies and planning, namely “urban justice”, in the context of Bantu Africa. There are variations of this concept, such as spatial justice, as the justice discourse by Marxist political economists and urban sociologists took a spatial turn. Lefebvre’s poetic provocation “the right to the city” is used by urban activists globally. Scholars grapple with what it means to be a “just city” and how we might facilitate “just transitions” amid a climate crisis, neoliberal political economies, multiculturalism and surging precarity. Yet, while we try to address the material outcomes of what is perceived as unjust, few urban scholars venture into the epistemological framing of justice as a defining factor in finding solutions for more just cities. African philosophy and legal scholars argue that the nexus between the conception of justice in African traditional thought cannot be separated from philosophical, spiritual, moral, and legal principles embedded in African societies. For instance, Wiredu moves away from Kant's understanding of the self where the self is not seen as separate from the world and extends itself to the world as it is socialized. Rather the self is an extension of the world and becomes through communication and socialization. Critical geography scholars that engage identity and relationality in urban justice debates have not considered a more fluid and relational conception of the self. Therefore, I argue the epistemological roots of justice as theorized in the global North (West) are distinct from those in Africa. Understanding how African societies, collectively and separately, theorize and practice justice in individual, inter-personal, social and legal ways will give greater insight into what a just and sustainable African urban environment might constitute. In this paper I develop a theoretical framework for a larger Southern urban research project on urban justice in Bantu Africa, using a methodology of ‘theory unbundling’ as per the teachings of postcolonial, Southern urban scholars.

POSTER

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Spatial Validation of Government Infrastructure Expenditure Project within the Gauteng Province

In today's dynamic socio-economic landscape, effective allocation, and utilization of government funds for infrastructure projects are critical. This study focuses on spatially validating government infrastructure expenditure projects within the Gauteng Province, leveraging Geographic Information Systems (GIS), Google Earth Pro Imagery, and land-use land cover (LULC) change assessment techniques. The research is conducted in collaboration with the Office of the Premier's GIS department. The methodology employs the Gauteng Provincial Government (GPG) IRM B5 Report, which catalogs all infrastructure projects conducted by the government over the past 30 years. Projects are categorized into two stages: initial documentation and project construction and development. This categorization enables the validation of the spatial location of these projects. High-resolution spatial imagery is utilized to track the construction life cycle of projects and assess land cover changes for "new and constructed" projects. The objective of this study is twofold. Firstly, it aims to incorporate GIS and remote sensing technology into government decision-making processes. Secondly, it explores how these methods can be employed to track project life cycles and spatially observe project and fund locations for enhanced service delivery analysis. By integrating GIS and remote sensing techniques with government infrastructure project data, this study contributes to a more transparent and accountable allocation of resources. It also facilitates informed decision-making regarding infrastructure development initiatives. This research serves as a valuable framework for future studies seeking to optimize government resource allocation and enhance service delivery through spatial analysis and technology integration.

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Spatial trends of the shadow economy: African Migrant Street traders in South Africa

The shadow economy includes people who operate entirely outside the tax and regulatory system or who are known to the authorities but do not correctly report their tax obligations. Over the years, most countries have witnessed a growth within this sector of the economy. Estimating the size of the shadow economy is difficult and has posed estimation challenges to scholars and policy makers. The study investigates the major driving forces behind the size and growth of the shadow economy in South Africa. Furthermore, it looks at the spatial trends which emanate within major cities of South Africa. The presence of informal economic activities, often referred to as the shadow economy, plays a significant role in shaping urban spaces and socio-economic dynamics. The increase of African migrants into South Africa has led to the emergence of vibrant informal trading networks, with street trading serving as a crucial livelihood strategy for many migrants. Despite its economic importance, street trading by African migrants is often marginalised and viewed as a problem to the shadows of formal urban spaces. Understanding the spatial dimensions of this phenomenon is crucial for policymakers striving to create inclusive and sustainable cities. The study makes use of secondary data, it reviews various publications from government in the form of policy documents, publications from various organisations as well as technical reports. By providing insights into the spatial dynamics of the shadow economy, the study offers valuable recommendations for enhancing the socio-economic integration of African migrant street traders while fostering sustainable urban environments.

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Water access and climate change adaptation in urban northern Lesotho

Water plays a significant role in determining the ecological environment, public health, and social and economic development. Therefore, access to clean water and proper sanitation is a crucial part of sustainable development, as well as environmental protection. Since water is vital to local communities, these natural resources need to be well managed, equally so, the community needs to have access to these resources and manage them appropriately. Lesotho is often described as the water tower of southern Africa and portrayed as a country rich in water resources, however, this is in contrast to the everyday reality of many people in Lesotho, who have to walk long distances to access water, or those who experience malfunctioning water service delivery or polluted water sources. This paradox between the one hand abundance of water and the other scarcity of water is a concern that needs to be resolved. This study focuses on exploring water access and adaptation to climate change in the Urban Northern Lesotho. A qualitative approach was used to collect data from the local community and relevant government officials. Using semi-structured individual interviews and focus groups. 44 interviews were conducted in the 4 main villages of Maputsoe, as well as 8 focus groups, 2 in each village, with a total of 39 participants. The data was then analysed using thematic data analysis. Results show that climate change, unsustainable water management, overpopulation and economic growth and unsustainable water infrastructure negatively affect water access. Despite the available piped water infrastructure, the majority of households in Maputsoe run out of water several times a month. As a solution, most people buy water from people with borehole taps or go to community boreholes as they always have water. With each household and village, water access and use differ depending on the water supply sources, rainfall and economic situations and this in turn affects the sufficiency of water uses.

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The impact of southwest Indian Ocean tropical cyclones on transient weather conditions in Réunion

The landfall of tropical cyclones can leave people isolated and vulnerable to extreme environmental conditions yet the less severe impacts on weather are under-documented (Lenzen et al., 2019; Molua et al., 2020; World Health Organization, 2024). Tropical cyclones are well-researched, especially concerning broad atmospheric and oceanic dynamics associated with cyclogenesis (Kossin et al., 2014; Bell et al., 2020; Chand et al., 2020). However, at a local level in Réunion, there is a lack of documentation on how the passage of a tropical cyclone impacts less extreme, transient weather conditions (Matyas, 2014; Tory and Dare, 2015; Doyle et al., 2017; Leroux et al., 2018). Réunion itself does not experience a high frequency of tropical cyclones making landfall compared to its neighbours. Yet, the seasonal movement of these storms near the island would have an impact on the local weather, though the extent of this influence remains uncertain (Lin and Chan, 2015; Duan and Li, 2022). These impacts may exert influence on sectors such as agriculture, tourism, accessibility and general living conditions (Kossin et al., 2014; Wang and Toumi, 2021). This study aims to determine the impact of passing tropical cyclones on the transient weather conditions in Réunion. This will be achieved by firstly, identifying the tropical cyclones that have had storm tracks within 500km of the borders of Réunion using the Historical Hurricane Tracks database from the National Oceanic and Atmospheric Association. Secondly, exploring the meteorological conditions in Réunion compared to the weeks prior and subsequent of a tropical cyclone using data on the meteorological conditions in Réunion is provided by Meteo France for the period 1991-2021. Finally, determining how the storm-size and distance from Réunion influence the level of meteorological impact experienced.

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Remote sensing analysis of land use land cover changes and the DPSIR framework of Greater Giyani in Limpopo

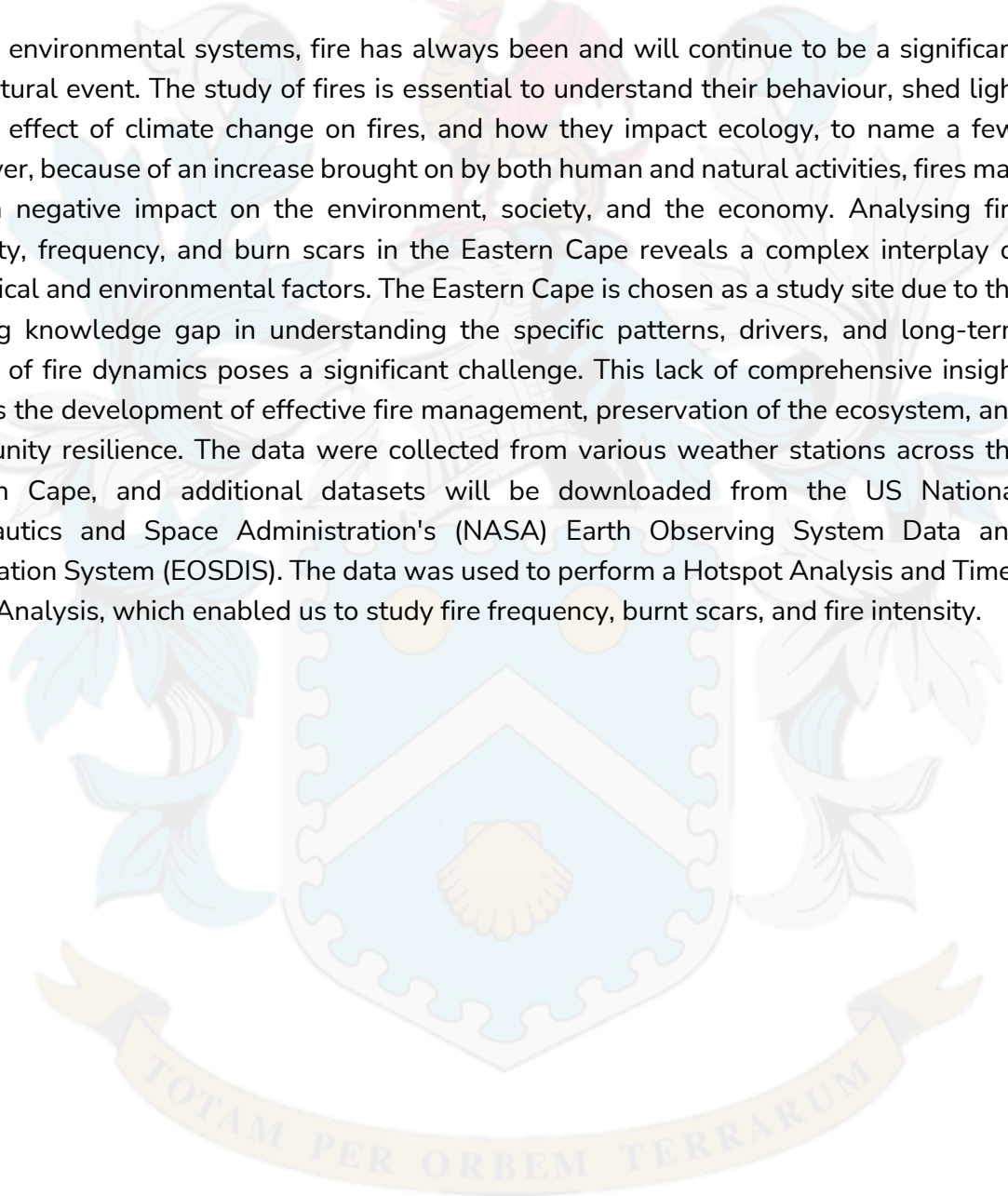
The Greater Giyani Municipality (GGM) has experienced extensive land use and land cover changes (LULCC), but data and documentation detailing this transformation of the GGM are limited. The aim of this study was to assess the observed changes in LULC that occurred between 2000 and 2020 in the GGM region in Limpopo. Four images from Landsat 4-5 Thematic Mapper (TM), and Landsat 8 Operational Land Imager (OLI) were acquired, Image classification for each of these imageries was done through supervised classification using the Minimum Distance Classifier. To analyse and present LULC changes in the area, an adapted Driver-Pressure-State-Impact-Response (DPSIR) framework was used. It was observed that vegetation was the major LC category with 48.10%, 42.13% between 2000 and 2007 respectively. The rate of decrease in vegetation was recorded between the period of 2014 and 2020. For this period, the built-up area has increased from the first period of 2000 to 2020 by 5.61% in 2000 and 13.08% respectively, while bare land increased throughout the 20 years, with 44.98% in 2000 to 61.06% in 2020. The LULC changes in GGM are driven by demographic, technological, political, economic, cultural, and environmental factors. These factors must be considered in future planning policies and regulations to minimize negative environmental consequences while retaining socioeconomic benefits.

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The pyrogeography of the Eastern Cape in a changing climate

Within environmental systems, fire has always been and will continue to be a significant and natural event. The study of fires is essential to understand their behaviour, shed light on the effect of climate change on fires, and how they impact ecology, to name a few. However, because of an increase brought on by both human and natural activities, fires may have a negative impact on the environment, society, and the economy. Analysing fire intensity, frequency, and burn scars in the Eastern Cape reveals a complex interplay of ecological and environmental factors. The Eastern Cape is chosen as a study site due to the existing knowledge gap in understanding the specific patterns, drivers, and long-term effects of fire dynamics poses a significant challenge. This lack of comprehensive insight hinders the development of effective fire management, preservation of the ecosystem, and community resilience. The data were collected from various weather stations across the Eastern Cape, and additional datasets will be downloaded from the US National Aeronautics and Space Administration's (NASA) Earth Observing System Data and Information System (EOSDIS). The data was used to perform a Hotspot Analysis and Time-series Analysis, which enabled us to study fire frequency, burnt scars, and fire intensity.



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Impacts of Climate Swings in the Water Balance over the South African Sugarcane Belt

Floods occur due to hydroclimate dynamics, the built environment, and human activities. In some instances, these features coincide to bring about compound floods. Rainfall-bearing mechanisms such as tropical cyclones, cut-off lows, and NW cloud bands are responsible for heavy and/or persistent rainfall that causes floods over the South African Sugarcane Belt (SASB). Climate impacts on surface water levels were investigated over the SASB between 1980 and 2022. In this study, the percentiles of rainfall and temperature were calculated to characterise the seasonal climate of the study area (23-31°S and 28-33°E). Palmer Drought Severity Index (PDSI) and Standardized Precipitation Evapotranspiration Index (SPEI) were the main indicators of floods in this study. The wavelet transform from the KNMI Climate Explorer was used to determine the flood return period and the field correlations revealed the statistical links between rainfall, temperature, annual sugarcane yield, and surface water levels over the SASB. In addition, correlation analysis was employed to explore the teleconnection patterns between local and remote climate features and their impacts on water resources in the study area. PDSI remains a good proxy of soil moisture and its year-to-year fluctuations in the study area, but SPEI can be supplementary on multiple timescales for better water resource management. Less than a 2-year flood return period was observed over the South African Sugarcane Belt. Stronger statistical links ($r \geq +0.6$) for SPEI, annual sugarcane yield, and surface water levels over the irrigated region were observed while the $r \geq +0.4$ was predominant across the entire SASB. El Niño and positive Indian Ocean Dipole were related to enhanced temperatures and dry weather conditions. High temperatures favor dry weather conditions and further diminish surface water levels which then compound together to suppress the annual sugarcane yield in the study area.

Prof J Melkon (John)

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Balancing Geopolitical Interests and Great Power Competition in Africa

The African continent, rich in resources and strategic significance, has become a focal point for great power competition. The United States, seeking to maintain its influence and promote its values, faces the challenge of balancing its geopolitical interests with the growing influence of other major powers, particularly China and Russia. This lecture explores the strategies the United States can employ to navigate this complex landscape and foster positive outcomes for both the continent and its own interests. By focusing on economic investment, military partnerships, and cultural engagement, the United States can mitigate the risks of great power competition and build lasting relationships with African nations. This approach will not only advance American objectives but also contribute to the continent's development and prosperity.

Dr A Mngeni (Asabonga)

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Assessing Water Quality: A comprehensive Monitoring study in Mthatha River

Less than half of the rural population in South Africa has access to safe and reliable water source, and over 12 million people lack access to clean water. A vital component of environmental health, water quality affects both the sustainability of ecosystems and human well-being. Regular surface water sampling in the Mthatha River is part of the monitoring program, which assesses the river's chemical, biological, and physical properties. This study provides a thorough evaluation of the Mthatha River's water quality using a large-scale monitoring program. By employing a combination of physical and biological markers, the research seeks to clarify the current state of water quality, pinpoint potential sources of contamination, and evaluate the effectiveness of current control measures. Water parameters (pH, ammonia, electrical conductivity, phosphates, faeces, and E- coli) were measured in this study using samples taken from eight sampling stations in the Mthatha River between 2012 and 2022. Significant variations were observed in all the water parameters examined across the sampling stations. In addition, e-coli has no seasonal variations, even though pH, phosphates, ammonia, and faecals showed variations throughout the sampling seasons. Furthermore, composition of water parameters varied significantly across both seasons and location. The results suggest that different sites have varied levels of water quality, with certain areas showing indicators of pollution from urban growth, industrial discharge, and agricultural runoff. Water quality characteristics are dynamically altered by anthropogenic activities and seasonal variations. The knowledge gained from this study is crucial in helping stakeholders, managers of water resources, and policymakers to create plans that will effectively manage and conserve water quality of Mthatha River. It is feasible to reduce pollution sources and protect water resources for current and future generations by putting targeted measures into place and encouraging community involvement.

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Characterising extreme cold events in the Limpopo River Basin, southern Africa: 1979-2021

Scientific evidence from across the globe agrees on the warming trends of our planet. Despite this, there is still a significant occurrence of events characterised by extremely low temperatures (ELT). These events, especially when not planned for, can have dire impacts on society. Their impacts are vast and can range from infrastructure damage, to negative effects on human health, and they can cause challenges for the agricultural sector. Most research on these events is concentrated over the global north, with very few focused on the global south. Among the regions where there has been limited research focus is the Limpopo River Basin (LRB), southern Africa. The LRB is characterised by a developing economy, it has many outdoor tourism attraction sites, and it is a region with a large concentration of subsistence and commercial agricultural activities that occur year round. An understanding of ELT events in this region would consequently be beneficial. Therefore, this study aims to firstly investigate the spatiotemporal characteristics of ELT events over the LRB using daily minimum temperatures derived from ERA-Land hourly temperatures for June-August 1979-2021. For this aim, 302 ELT events were identified when at least 30% of the LRB was characterised by minimum temperatures below the 10 th percentile of all June-August minimum temperatures. Subsequently, a second aim is to utilise selected ERA5 atmospheric circulation fields to develop a synoptic classification to characterise atmospheric circulation patterns associated with the identified ELT events. Although still ongoing, the results from this study would eventually provide novel insight on the occurrence of ELT events and associated atmospheric conditions specific to the LRB. In turn, such information would be invaluable towards characterising the impacts of these events on human health and agricultural activities.

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Spatial mobility of people pursuing the services of traditional and biomedical health practitioners in uMkhanyakude District Municipality

South Africa has a pluralistic health system in which biomedical health care services coexist with traditional health services. Many treatment options are available which include seeking help from both biomedical and traditional medicine. The literature reports that a large proportion of African people make use of the dual health care system in which both biomedical and traditional medicines are used depending on the type of illness. While there are many studies which focus on the use of traditional and biomedical medicines, there is a need for more information on the geographical analysis of the spatial mobility of people to biomedical and traditional health practitioners. This study aims to provide knowledge by determining the spatial patterns of people who utilise these services in the study area. Both qualitative and quantitative methods were used in the study. The selected health care facilities included 2 hospitals, 10 residential clinics and 64 facilities of traditional health practitioners. The total sample of 360 patients was drawn from these facilities. Questionnaires and interviews were used to elicit data from the respondents. The study found that many patients of biomedical health practitioners came from the local areas near the health care facilities and the patients of traditional health practitioners came from various areas outside their local areas within the Province of KwaZulu-Natal. The patients of traditional health practitioners incurred higher travelling costs and spent more time travelling to the health care facilities.

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***Spatio-temporal assessment of land-use patterns impacts on river water quality:
A case study of the Komati River system, Mpumalanga Province, South Africa***

The decrease in water quality has become a global environmental problem due to the increase in climate change, human activities and land-use in watershed areas, which significantly alter the water cycle. Nearly one-third of the world's land area has changed in the last 60 years and humans have impacted around 75% of the land. Therefore, it has been globally confirmed that human land use is one of the primary contributors to the changes in water quality resulting in water insecurity and pollution. This study aims to assess water quality of the Komati River in relation to the spatiotemporal land-use distribution patterns. Physiochemical parameters; pH, temperature, electrical conductivity, salinity and total dissolved solids will be determined on site. Nutrients dynamics will be assessed in various location of the studied river system. A distribution map indicating concentration of various parameters will be generated in ArcGIS platform. The supervised classification based on different land use classes i.e., (i) water, (ii) settlement, (iii) forest, (iv) agriculture and (v) bare land will be done based on the collected data. Generally, the results of this study will demonstrate the capabilities of Remote sensing and GIS in assessing the impact of land-use on river water quality.

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Estimation of the daily soil temperature from meteorological data using Machine Learning Approaches in South Africa

Accurate and reliable soil temperature (ST) information is critical to inform efficient planning and decision-making for precision agriculture and various other related applications. However, in-situ measurements of ST at the high temporal and spatial resolution required for agricultural applications are time-consuming and costly. Therefore, this study aimed to investigate the possibilities of using machine learning approaches as alternative and cost-effective tools for the estimation of ST from readily available meteorological data in South Africa. Four machine learning models comprising multiple linear regressions (MLR), artificial neural networks (ANNs), random forests (RF) and decision tree (DT) were developed and tested for estimating daily ST at six soil depths (viz. 10, 20, 30, 40, 60 and 80 cm) from meteorological data acquired from seven stations, representing diverse climatic conditions of South Africa. Data were randomly split into two parts and the first 80% of the dataset was used for training while the remaining 20% was utilized for validation of the models. The results showed that ST at various depths can be estimated reasonably by different generic machine learning models, with average Nash–Sutcliffe Efficiency (NSE) values ranging from 0.74 for DT to 0.87 for RF models and root mean square error (RMSE) values less than 2.79 °C for all models. Among the evaluated models, RF models had the greatest estimating accuracy across different soil depths and climatic conditions, with average NSE values ranging from 0.87 to 0.95. This study indicated that the performances of climatic-specific models were better than the aggregated ones. Therefore, it is recommended that machine learning approaches, particularly RF models are developed for specific climatic conditions where possible for better ST estimations. Due to the range of climatic conditions at which these models were developed and validated, they can be applied with caution in other regions with similar climatological and pedological properties.

Prof S Narsiah (Sagie)

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The evolution of Neoliberalism during the democratic era in South Africa

This year marks 30 years of democracy in South Africa. It may be closer to 40 years if we consider 'the long decade of democracy' (c1985-1996) when South Africa embarked on a journey which broke decisively with the apartheid order. The 1990s were characterized by a number of seminal moments during which South Africa claimed a legitimate position in the global order politically, economically and culturally. The global order shaped and re-shaped the nascent South African state. The character of the global order of the period was what is termed neoliberal. South Africa embraced neoliberalism unequivocally during the formative years of democracy. In this paper I will trace how neoliberalism has evolved over period of 30-40 years or so. Following Marx I engage the concepts of centralization and concentration to analyze the evolution of neoliberalism as class power in South Africa. I argue that neoliberalism in its South African incarnation has been extremely destructive. The implications for the continuation of neoliberal practices will bookend the paper.

POSTER

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Pandemic penalties and resilience: Decomposition of change in the quality of life of an urban population in South Africa

The COVID-19 pandemic and the attendant lockdown measures involving the closure of many nonessential economic activities resulted in adverse socioeconomic impacts on many households around the globe. In South Africa, the complexity of the pandemic implications was worsened by the fact that the already existing inequalities. Many people, especially those employed in the informal sector, in small-to-medium enterprises (SMEs), lost their source of income, thus were disproportionately impacted. The South African government introduced the Social Relief of Distress (SRD) to mitigate a pandemic poverty catastrophe. Nonetheless, the quality of life significantly declined during the pandemic period. This study was therefore designed to investigate if the decline in the quality of life was proportional across the population. The analysis was based on two quality-of-life surveys conducted in 2017/18 and 2020/21 in the Gauteng province of South Africa. The Kitagawa-Oscar-Blinder (KOB) regression-based decomposition technique was employed to investigate inequalities in the change of the quality of life index on a sample of 38 505 respondents described in terms of population group, household headship type, sex, household dependency ratios, household income level, employment status, neighbourhood type and neighbourhood satisfaction. The results showed significant inequalities in the quality of life index. Some areas experienced notable decreases in the quality of life index while others realised increases. Pandemic penalties were associated with Black African and Coloured population groups, low-income households, living in a low-income neighbourhood and households headed by a female. The study concludes that the COVID-19 pandemic arguably entrenched inequalities in South Africa.

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Chair: M. Ramutsindela

Panel: A. Nel, M. Mgubane & E. Mogende

Ecological Futures: Political Ecology in/for South(ern) Africa

An overt focus on political ecology (PE) hardly features in reflections of histories and trends of human geography in South Africa and the region. Yet the politics of environmental change runs deep in our historical and contemporary urban and rural landscapes, and will continue to shape our ecological futures. In this context, PE offers significant scope for both constructive readings of existing work in human geography with implicit political-ecological themes, and theorisation of features of Urban and Rural Geographical realities and futures. In this Session, we develop two entry points into PE as a theoretical and methodological approach to human geography in the country. The first relates to how geographers in South(ern) Africa have researched themes relevant to the scope of PE, and where they placed those themes in their scholarship. We seek to understand how PE has been used or otherwise as an analytical framework. The second is about the potential the country and the region offer to PE research and how this could be harnessed to advance critical socioecological inquiry and to contribute to the discipline in and for the Global South more broadly. We consider the Session a starting point for a long-term engagement on PE in the region.

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Indigenous indicators for predicting natural hazards: a compliment for meteorological seasonal climate and weather forecasts

Knowledge and awareness, and in this case indigenous ways of predicting hazardous events is fundamental for reducing the risks and impacts of disasters particularly for indigenous and rural communities. More importantly, historical trends and the ability to observe hazard early warning indicators is invaluable for these indigenous communities. This is so because the capacity of a community to prepare for, respond to, and recover from disasters is normally limited by knowledge including both indigenous and western scientific knowledge. This paper assesses the indigenous knowledge-based indicators for predicting hazardous events that can be used to complement meteorological seasonal and weather forecasts for the rural communities of the Joe Morolong local municipality in the Northern Cape province of South Africa. The study assumed a qualitative approach, gathering data through focus group discussions with the community and virtual platforms with key informants with a total of 109 participants taking part in the study. Respondents were able to provide indicators that they use in their context for predicting hazards. These include observing the vegetation, the moon, clouds, birds, and wind speed and direction amongst others. The paper enhances and fosters the complementarity between indigenous knowledge systems and Western knowledge systems for reducing the risks and impacts of disasters.

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Topological relationality and regional planning: Insights from selected rural municipalities, KwaZulu-Natal (South Africa)

This study investigated the integration of topological relationality in planning approaches and practices in selected rural municipalities in KwaZulu-Natal. Modernism, which underpins urban planning in South Africa, has fragmented urban spaces. This has qualities of topographic logic, which defines places and regions as discrete, defined by their positions and elevations, with a focus on places' local details. But topological relationality adds another dimension to the conceptualization of places and regions. It realizes places' connectedness, complexity, and continuous transformations. So, within this context, the problem of this study established the extent to which planning approaches and practices in selected municipalities have incorporated topological relationality. Therefore, this study analyzed the policy and strategic documents of the municipalities of interest. However, the study's findings showed that municipalities were more inward-looking. Organizational, governance, and issues of redress arising from the past dominate. Processes for positioning municipalities as part of the national and international web of economic interrelationships are not part of the strategic direction of municipalities. Hence, this study recommends the incorporation of topological relationality, as places exist in a dynamic environment where socio-political and economic relationships operate contemporaneously.

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The Intersections of International and Local Capital Relations: The case of the North-South Urban Development in the Durban Metro, South Africa

Urban development in the Durban Metro (which falls under the Ethekewini municipality), South Africa, shows the North-South divide pattern of development. Large capital investments in the residential, commercial, and transportation sectors are beginning to set the northern part of Durban, also known as the north coast, apart from the southern part, which appears to be lagging. This has happened within the context of accusations of the Ethekewini Municipality's inability to render the necessary services. So, this study investigates the intersections of international and local capital relations and their role in producing the skewed form of urban development in the Durban Metro. Secondly, this study determines if the Ethekewini municipality has diminished its role in providing the necessary goods and services for collective consumption, thus creating a gap that private capital is filling. Finally, this study understands if the Ethekewini municipality has normalized the individualized, private provisioning of services with the resultant effect of the north-south urban divide in development. This study uses qualitative methods of research. This involves collecting and analyzing data on the nature of investments in the Durban Metro. From this process, the GIS analysis will produce maps showing the levels of investment in the study area. Finally, this study interviews the Ethekewini municipality about its role in providing goods for collective consumption. This study makes an invaluable contribution to the urban development body of knowledge because it shows how the market fills the gap in ineffective institutions.

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The Role of Ecotourism in Promoting Sustainable Economic Development in South Africa

This study investigates the role of ecotourism in fostering sustainable economic development in South Africa, a country renowned for its rich biodiversity and unique cultural heritage. With the dual challenges of preserving its natural environment and promoting economic growth, South Africa presents a compelling case for the potential benefits of ecotourism. The research aims to elucidate how ecotourism can serve as a sustainable development strategy that benefits both the environment and the economy. Employing a mixed-methods approach, the study combines quantitative data analysis with qualitative interviews and case studies from four protected areas in KwaZulu-Natal. This methodology enables a comprehensive examination of ecotourism's economic, environmental, and social impacts. The analysis focuses on key indicators such as income generation, job creation, environmental conservation efforts, and community involvement in ecotourism projects. Findings reveal that ecotourism significantly contributes to local economies, particularly in rural and remote areas, by providing sustainable livelihoods, enhancing local capacity, and fostering entrepreneurship. Additionally, ecotourism initiatives have been instrumental in promoting environmental conservation through community-based projects, wildlife protection, and habitat preservation efforts. Importantly, the study highlights the critical role of policy frameworks and stakeholder collaboration in maximising the benefits of ecotourism. The significance of this research lies in its contribution to the understanding of ecotourism as a viable tool for sustainable economic development in developing countries, with South Africa serving as a model. It offers valuable insights for policymakers, tourism developers, and conservationists seeking to balance economic development with environmental sustainability. By highlighting successful practices and identifying challenges, this study provides a roadmap for optimising the benefits of ecotourism in South Africa and similar contexts globally.

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Stamping Ground: student walksheds, walking patterns and walkability in Makhanda, Eastern Cape

Walkability is an important research topic in the Global South where many people in urban settlements walk because of transport poverty. University students are a subset of the urban population in Makhanda who experience transport poverty and largely rely on walking to navigate the city. The purpose of this study is to investigate and understand the student walkability, walking patterns and walksheds with specific focus on students who reside in the Rhodes University, CBD (Central Business District) (Central), Westhill and Sunnyside areas. These specific areas were chosen because, in terms of student residents, these are the most densely populated residential areas in the city, but are also the epicentre of student activity. This research intends to explore the existing walkability within these four study sites through a visual survey using common measures of walkability, digital mapping as well as student perceptions of walkability. Additionally, this research seeks to understand student walking patterns and walksheds within Makhanda through participatory mapping of their typical daily trajectories and interviews. The quantitative data collected through visual surveys, digital mapping and participatory mapping will be spatially analysed using GIS (Geographic Information Systems). It is hoped that the findings of this research will help to understand whether or not the walkability of these areas adhere to the needs of its student population and will, thereby, given direction to planning strategies to support walking practices. It is important to note whether these walking routes are safe, accessible and comfortable for the walking population. As there is currently little research done in South Africa on student walkability and walking patterns, this study aims to create a pathway to future comparative analyses.

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Heat stress: considering climatic components beyond suitability for tourism in the southern hemisphere

The climate of a destination is a motivator for destination choice, promoting particular expectations of weather during travel. Over the past 40 years, several tourism climate indices have been developed and applied to an array of touristic activities and geographic settings, highlighting climatic suitability on a spectrum from ideal to unsuitable. Although these indices include thermal comfort as an input variable, they do not express the shift to thermal stress when specific thresholds are exceeded. This is primarily due to the cumulative nature of climate indices where thermal stress may be occurring but is obscured when climatic suitability is classified as ideal because other input variables may be suitable. Therefore, using a case study from Réunion Island, the study looks at the incidence with which heat stress is indicated in comparison to already calculated total index scores for a period of 30 years for four climate indices, namely the Tourism Climate Index (TCI), Holiday Climate Index (HCI) for both beach and urban attractions and the Camping Climate Index (CCI). These results will determine whether sufficient warnings about heat-related risks are provided to tourists, particularly in potentially seeking medical assistance outside of their home country. Lessons from this case study pose important insights for other contexts that experience warm temperatures such as South Africa, Namibia and other southern African tourism destinations.

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***Exploring the risk of heat stress in high school pre-season sports training,
Johannesburg, South Africa***

There is growing concern over the increased risk of heat stress induced by the changing climate, with increased global temperatures expected to exacerbate conditions. Heat stress in school sports is a critically understudied research area in South Africa (SA). As demonstrated by several studies conducted in the global north, the stress elicited by meteorological conditions on students participating in physical education lessons and after-school sports activities could have serious consequences on their health. This paper represents the first research in the region to investigate the risk of heat stress to school students during physical activity. Meteorological data were collected at a school in Johannesburg between March and July, which encompasses the seasons of late summer, autumn, and winter. These were inputted into four heat stress indices: Humidex, Heat Index, Wet Bulb Globe Temperature, and the Universal Thermal Climate Index, together with the measured Wet Bulb Temperature to determine the level of risk of heat stress during physical education lessons and after-school sports activities between March and July. Of the 2700 index scores calculated over this period, 56% indicate some level of heat stress, with almost 6% indicating a high and very high level of risk. Heat stress is calculated to be most likely to occur between 11h00-15h00, and the danger of pre-season training, which takes place in the summer months, is demonstrated by these results. Additionally, this research finds that heat stress is far more likely on artificial surfaces than on natural grass. The findings of this research intimate that school stakeholders should consider the implications of heat stress when considering timetabling and policy-making in the interests of safeguarding their students.

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Analyzing the City of Johannesburg's governance in the shift to sustainable energy integration

The transition to decentralized, low-carbon energy systems has become a necessary component of sustainable urban development. This study examines the governance of the shift to renewable energy generation and integration at the local level in the City of Johannesburg, utilizing the Transition Management framework to explore strategic, tactical, operational, and reflexive dimensions of governance activities. At the strategic level, both national and municipal policies are aligned towards renewable energy adoption and market decentralization, with the City of Johannesburg setting a goal to achieve 35% renewable energy by 2030. Tactical-level analysis reveals the necessity for regulatory reforms to facilitate the integration of small-scale embedded generation into the city's distribution network. At the operational level, City Power's initiatives aim to generate 500 MW by 2030 through investments in renewable energy and power purchase agreements. Insights into reflexive activities highlight significant gaps in local monitoring systems, emphasizing the need for improved registration and tracking mechanisms for renewable energy installations. This research identifies weakness in current governance and provides valuable insights for policymakers and urban planners in Johannesburg and other cities navigating similar energy transitions

POSTER

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Quantifying the effects of an El Niño event on savannah grass using MODIS and Sentinel-2 MSI images

Savannah rangelands provide forage for wild and livestock grazers, making them important for biodiversity conservation and food security. El Niño events frequently result in failure of the seasonal rainfall in the semi-arid savannah areas of southern Africa, causing reductions in rangeland grass biomass. Although the negative effects of El Niño events on the grass are expected, they are seldom quantified. This study quantified the effects on the length of the grass growing season and grass biomass using MODIS (MODerate resolution Imaging Spectroradiometer) and Sentinel-2 MSI (Multi-Spectral Imager) images of savannah rangelands near Mahikeng, South Africa. The late start of the 2023/24 rainy season, and low amounts of rain, thereafter, led to widespread speculation of an El Niño event. Therefore, monthly rainfall totals in the 2023/24 (El Niño) rainy season (September 2023 – May 2024) were numerically compared to those during the 2020/21 (non-El Niño) season (September 2020 – May 2021). To quantify the effect on the grass growing season, the 250 m resolution 16-day enhanced vegetation index (EVI) layer in the MOD13Q1 Terra MODIS product was used. MOD13Q1 images for each month in the analysis periods were downloaded from the open access site Earth Explorer®. EVI values at indicative, open grass sites were plotted against time. A consistent increase in EVI values indicated the start of the growing season, while a consistent decrease indicated the end. To quantify the effect on grass biomass, Sentinel-2 MSI images at the peak phenology stage, which usually occurs annually during the February – March period, were used. Above-ground grass biomass samples were collected from open grass sites with no grazing, in widely scattered 10 m × 10 m plots that matched the MSI pixel size. In each plot, a 1 m quadrat was tossed randomly three times. After each toss, the grass inside the quadrat was cut to the soil level, and the UTM (Universal Transverse Mercator) coordinates of the plot centre recorded. The collected grass samples were air-dried and then weighed. The average biomass weight from the three quadrat tosses was then recorded for the respective plots. The pixel locations of the respective biomass values were then located on a sampling date near-concurrent MSI image. The image, with corrections for atmospheric effects, was downloaded from the European Space Agency's Copernicus Open Access Hub®. The grass biomass values were correlated with soil adjusted vegetation index (SAVI) values computed from the image. A numerical model for predicting the grass biomass from the SAVI values was then developed using a random sample of 67% of the field biomass values and validated using the remaining 33%. A historical, atmospheric effect corrected MSI image of the area acquired at

the peak grass phenology stage in 2021 was then download and SAVI values computed from it. Using the developed statistically significant numerical model, grass biomass values at the respective sampling sites during the 2020/21 rainy season were then predicted, for comparison with the 2024 biomass. The results will be presented during the conference.



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Evaluation of ERA5-based reanalysis products for cold temperature indices over southern Africa

Over southern Africa, unusually cold events continue to occur despite robust warming trends for surface air temperatures – such an unusually cold event occurred as recently as 10 July 2023 when many interior regions of South Africa experienced unusual snowfall. Although less frequently, such unusually cold events will still occur despite continued warming over the region. In turn, these events, therefore, have the power to surprise us and be particularly impactful in many ways, such as negatively impacting winter cropping activities, livestock health, and human health, while also exacerbating the region's energy poverty. Thus, continued research on these events is extremely important. For a data-sparse region such as southern Africa, one of the valuable research avenues is exploring the strengths and weaknesses of reanalysis datasets in representing cold temperature indices. Hence, for the period 1979-2021, this study explores the performance of three ERA5-based reanalysis products (i.e., AgERA5, ERA5 and ERA5-Land) for the spatiotemporal representation of winter period (i.e., June-August) cold indices, focusing on indices of the number of cool days and nights and frost, ice and hard freeze days, and the magnitude of the coldest day and night temperatures. Compared to the National Oceanic and Atmospheric Administration Climatology Prediction Centre (NOAA CPC) gridded observation-based temperature reference dataset, results show that the ERA5-based reanalysis products performed generally well. These reanalysis products adequately reproduced the spatial patterns of the cold indices, and temporally they reliably reproduced interannual variability patterns for the indices. Moreover, relatively low biases were evident. These results highlight that the ERA5-based reanalysis products are useful to apply for further research considering, for instance, the agricultural and human health impacts of unusually cold events over southern Africa; importantly, however, their weaknesses must be acknowledged.

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The map work content knowledge gap among geography teachers: empirical evidence from the University of Johannesburg in-service teacher training in Gauteng, South Africa

People have downplayed the importance of mapwork in geography teaching, but the consistent poor performance in mapwork among matriculants in South Africa raises questions about the level of content knowledge (CK) competence in mapwork teaching among the geography teachers. In this context, the study investigates the CK competence gap in mapwork among geography educators from Gauteng Department of Education schools who participated in the mapwork in-service teacher training at the University of Johannesburg, South Africa, in 2017, 2019, and 2021, respectively. The Department of Geography, Environmental Management, and Energy Studies (GEMES) undertook the study with 52 educators in 2017; 109 educators in 2019; and 65 educators in 2021, giving a total of 226 participants. We used descriptive and inferential statistics to analyse primary data from the survey's questions, utilising the Statistical Package for Social Science (SPSS) version 16. We conducted the principal components analysis (PCA) for the Likert scale questions. The results of this study show a relationship between the number of years teaching and CK competency, which is a function of years of field experience and gives teachers the understanding necessary to comprehend curriculum, pedagogy, and mapwork content delivery. While the study did not find a correlation between age and factor ratings, we argue that the younger age groups of recent graduates have highly developed 21st-century skills that improve their GIS and remote sensing capabilities compared to older teachers. The study, together with the reviewed literature, demonstrates that there is a relationship between geography instructors' CK competence, specialisation, and prior geographic knowledge. We argue that employing non-specialised geography teachers results in subpar performance due to their inability to provide effective instruction, as evidenced by their poor performance in map calculations. The use of preservice teachers with no pre-existing geography background, contributes to a poor grasp of basic mapwork theory, evident in their inability to read and interpret features in mapwork questions. We advocate for continuous geography teacher development programmes offered at the university level to keep up with the CK dynamics in geography theory and mapwork instruction.

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Financial Capital, 'Living Annuities', and the Financial 'Rip-off' of Pensioners – A Preliminary Analysis

Considerable geographical research in South Africa has focused, over time, on the primary sector (e. g., agriculture, forestry, fishing, and mining capital), the secondary sector (principally manufacturing capital), and the tertiary sector (including commercial and trade capital), but less so on the quaternary sector (e. g., finance, real estate, and insurance [or financial capital]). In consequence, this paper focuses on the insurance sector, and in particular, on a case study of the financial returns earned from an investment in a private pension fund with one of South Africa's leading financial houses. The paper highlights the 'smart' presentation of information to clients via quarterly newsletters, apparently designed to deceive clients into thinking that their different financial fund investments are geared towards serving their best interests. In addition, this paper highlights how legislative regulations, unfortunately, impact negatively on the clients' best interests in South Africa. Moreover, this paper sheds light on how an attempt to address the challenges that pensioners experience has, to date, been ignored at the state and party-political levels. In essence, this case study shows that financial capital (and in particular, insurance capital) is "ripping-off" the contributors to pension funds, and in particular, pensioners. These developments are occurring at a time when massive payments are made to leaders in financial institutions, and against the background of a South African study which showed, in February 2023, that only 7.2% of respondents with a retirement or pension fund contended that they were "well-prepared" financially for retirement.

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Community-based Disaster Management Plans in a Petro-Metropolis: A Case Study of the South Durban Basin

Disaster Management has become critical for South Africa's environmental future – given the country's high propensity for extreme weather events and the hazardous nature of its many industrial hotspots. The South Durban Basin (SDB), located in the KwaZulu-Natal province of South Africa, is one of the most volatile and toxic industrial complexes in the world. It contains two of the country's major petrochemical plants – the Engen refinery and SAPREF, which is the largest crude oil refinery in the country. Consequently, there have been numerous industrial accidents such as fires, explosions and odours – with more than 180 refinery-related incidents recorded between 1998 - 2022. Such incidents remain on the increase despite the existing institutional frameworks of local government, including the Offsite Emergency Plan for the South Durban Basin (2011), the Community Response Guide for Emergencies (2015), and the eThekweni Disaster Management Level II Plan (2021) – all of which have been ineffective. Given the spatial vulnerability of the South Durban residents, community-based organizations such as the South Durban Community Environmental Alliance (SDCEA) and Merewest Community Forum (MCF) have resorted to developing their own community-based disaster management plans (CBDMPs) to mitigate, prepare, respond and recover from petrochemical accidents, after decades of fighting for environmental justice. This paper will assess the CBDMPs of SDCEA and MCF in response to the refinery accidents, and demonstrate the inefficiency of the eThekweni Municipality's disaster management governance as an infringement on the community's rights to live in a safe environment – enshrined in Section 24 of the South African Constitution.

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Vulnerability of women's livelihoods to climate change in rural areas: The case of northern KwaZulu-Natal

Climate change has severe consequences for the rural livelihoods of numerous women worldwide. However, women are not passive actors; they actively seek ways to adapt to the impacts of climate change. In this study, we utilise the sustainable livelihoods framework to explore the socioeconomic effects of climate change on women. We examine the vulnerabilities associated with these effects, the resources and strategies employed to support rural livelihoods, and the potential outcomes of these livelihoods. Our research involved an online survey conducted with seventy-four female participants from the uMkhanyakude District Municipality. The results indicate that the primary manifestation of climatic changes has been in the form of drought episodes. Consequently, the impacts of climate change have been felt in various livelihood-supporting systems, including water, agriculture, livestock production, and health. Moreover, our study reveals that the participants heavily rely on their willingness to engage in collective action and utilise social networks to adapt to climate-related shocks. The findings also highlight the importance of natural and financial assets for the participants. By effectively utilising their asset portfolios, the participants achieve sustainable livelihood outcomes, such as reduced health implications, improved food security, enhanced economic security, and poverty reduction. This research underscores the significance of women's empowerment in enhancing their resilience against the adverse effects of weather-induced shocks. It also has implications for a better understanding of livelihoods within a rural, gendered context. Lastly, this research provides input to the global sustainable development agenda, particularly United Nations Sustainable Development Goal number 13.

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Are mopani worms a mechanism for mopane tree (*Colophospermum mopane*) conservation? An evaluation of the villages around Giyani, Limpopo Province, South Africa

Colophospermum mopane provides many benefits including mopani worms, firewood, timber for construction, and medicine. Despite *C. mopane* playing a significant role in the lives and livelihoods of communities within their range, they are destroyed because of unsustainable harvesting practices coupled with lack of management practices. Assessment of people's attitudes has become significant in studies dealing with the conservation of biodiversity. This study aims to assess the attitudes of local communities in and surrounding Giyani in Limpopo Province in South Africa towards the mopane tree and to determine if their attitudes relate to obedience to traditional rules and regulations. Interview-administered questionnaires were used to systematically select 161 households in Muyexe village and 82 households in Nsavulani village. The questionnaire evaluated the biographical data of respondents, knowledge of mopane woodlands, importance of mopane trees and mopani worms, and their attitudes towards mopane tree conservation. The overwhelming majority of respondents in both villages had positive attitudes towards mopane trees for ethical reasons. Respondents were also positive that mopane trees should be protected for future generations. The positive attitude of most respondents relates to obedience to rules and regulations that do not allow cutting of wet *C. mopane*. Respondents only cut dead or dry mopane woodlands for fuelwood. Cutting or harvesting was done on a subsistence and sustainable basis. The communities have shown that they are guardians of *C. mopane*. The study concluded that mopani worms serve a mechanism for *C. mopane* conservation in Muyexe and Nsavulani villages in South Africa. The positive attitudes of local communities, and obedience to the customary rules and regulations is a positive sign not only for ethical reasons, but also for long-term mopane woodlands conservation. This approach encourages the long sustainability of mopane woodlands in the study area.

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Mapping Festival Adaptations to COVID-19

COVID-19 affected the creative economy, and especially live performing arts and festivals, very negatively. Studies that focus on the adaptation strategies of festivals and live events during COVID-19 tend to follow a case study approach using in-depth, qualitative analysis of individual, or a small number of festivals. There has been much less research at the national level, quantitatively analysing the determinants of those festivals that survived and those that did not. With this in mind, a database of South African cultural festival responses to COVID-19 (2019-2022) was created using desktop searches. Using 2019 as a base year, 223 cultural festivals were held in South Africa. This dataset was then mapped using GIS to display the festival adaptations to COVID-19. Festival responses included cancelled, in-person, virtual and hybrid. GIS mapping results showed that there has been a shift in festival responses to the pandemic over time. Initially, virtual adaptation strategies were the most common given that lockdown regulations in South Africa were particularly strict. However, in 2021, lockdown measures began to ease and so festivals were able to move more towards hybrid and live responses. Despite this, approximately half of all festivals found in 2019 were cancelled over the period and some did not survive. To determine the factors that influenced festival survival during this period, an econometric model was created. Results showed that the main factor determining survival was pivoting to a digital festival adaptation strategy. Being based in a metro, or having status as a "flagship" national festival were not (on their own) as good predictors of survival as using innovative online strategies, which were more important for festival resilience.

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Indoor radon levels, geology and climate: The Pilanesberg Alkaline Ring Complex

Elevated indoor radon gas levels can cause serious health issues, the most prevalent being lung cancer. Unfortunately, the measurement of residential indoor radon-in-air levels is expensive, labour- and time-intensive. The underlying geology of an area can be used to estimate radon exhalation rates, while climatic conditions, especially temperature and wind, can mitigate or enhance indoor radon gas levels. Recently published research developed and tested a novel framework to rapidly identify the most probable areas of high indoor radon levels, potential targets for indoor radon measurements. The study utilised GIS tools to superimpose overlays of geology, temperature, and wind to identify possible radon hotspots in South Africa. One of the hotspots identified when only considering the underlying geology, was the Pilanesberg Alkaline Ring Complex. Interestingly, the hotspot was mitigated to such an extent by the climatic conditions that it was no longer considered a hotspot during the final analysis. Recent measurements of the actual geology of the Ring Complex indicated very high levels of radioactivity. These high levels of radioactivity are associated with possible high levels of radon exhalation, and thus high indoor radon levels. This necessitates a re-evaluation of the earlier framework to allow for possible small-scale variation and to further refine the framework. Comprehensive indoor measurement in the area is planned to verify the real indoor radon levels, vs the predicted levels.

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Toponymy and its contribution towards tourist route development: A case study of Route 62, Western Cape

The origin of naming towns, settlements, places of interest, as well as natural and cultural features are rooted in the study of the linguistic evolution (etymology) of place-names referred to as a toponymy. For several decades, South Africa's socio-political arena has altered the spatial-temporality of events and phenomena shaping the name-giving process of places across the Western Cape. Place identity, uniqueness and meanings are often attached to geographic phenomena, therefore the aim of this study is to analyse the relationship between toponymic association of small town names and the development (and marketing) of enroute tourist product and services consumption along Route 62. Route 62 is a renowned South African tourist route between the town of Worcester in the Boland and Oudtshoorn in the Little Karoo, allowing visitors to traverse through diverse physiographic and cultural landscapes. These landscapes provided a basis for the toponymical characteristics (and historical changes) along the route and its hinterland. The methodology for the study was underpinned by a systematic literature review of the relationships between toponymy and tourist route development, followed by an ethnographic inquiry and participant observation during site visits and whilst analysing oral histories and archival material. Furthermore, representatives of tourist establishments along and off Route 62 vividly expressed how the appropriation of place names along the route is associated with popular tourist culture related to natural and cultural heritage importance. Development initiatives of district- and local municipalities associated with Route 62 are silent on toponymy as a potential contributor and pathway to tourism development in small towns. The study yielded results that allude to contested, but also socially-acceptable name-uniqueness that directly and indirectly influence visitation patterns along the route.

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***Neglect of municipal infrastructure and the response of civil society in
Phalaborwa, Limpopo province***

The maintenance and the rehabilitation of municipal infrastructure are formidable challenges facing many local municipalities in South Africa. Infrastructure is crumbling because of years of neglect, resulting in the under-provision of basic municipal services. This research investigates the state of municipal infrastructure in the town of Phalaborwa, Limpopo province. Data was sourced from municipal documents, various government, consultant and non-profit organisation reports, academic literature and online media. In addition, semi-structured interviews were conducted with several key municipal, business and civil society respondents. It was found that infrastructural neglect and municipal financial problems were the foremost reasons for the severe service delivery issues experienced by residents in Phalaborwa. This, despite the assistance of two large mining companies in the form of projects linked to their corporate social responsibility (CSR) mandates, assistance with projects outside its CSR mandates and availing their artisans for the repair of municipal infrastructure. Ratepayers' associations have tried for years to hold the Ba-Phalaborwa Local Municipality accountable, but to no avail. A new civil society forum, Let's Change Ba-Phalaborwa, was constituted in early 2022. The forum has a seven-pillar strategy to remedy the infrastructural situation, including taking the local municipality to task while also extending an offer to provide expertise. Will an accountability-partnership approach between civil society and the municipality fix the situation?

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Progress on using GIS and RS in mapping and monitoring the biodiversity of inland waters for reporting to the Global Biodiversity Framework of 2030

South Africa, as a member of the Convention on Biological Diversity (CBD) is expected to report progress on the conservation and management of ecosystems to the Global Biodiversity Framework's (GBF) targets by 2030. Several topics are of main interest: mapping of extent and percentage of types, identifying rare or unique ecosystems, modelling ecological conditions to inform interventions, and assessing the protection level targets. Two of South Africa's three National Biodiversity Assessments (2011 and 2018) indicated that wetlands are highly threatened and poorly protected. Reporting to the United Nations' Sustainable Development Goal (SDG) 6.6.1a also requires that natural dynamics of wetlands should be distinguished from those resulting from anthropogenic and/or climate change trends. We will present the value of Geographical Information Systems (GIS) and remote sensing (RS) in mapping inland water (i.e. rivers, estuarine and freshwater wetland) biodiversity in South Africa and Africa, as well as challenges faced in the reporting of the extent and percentage changes to the GBF and SDG 6.6.1a. We present progress made on various inland water ecosystem types with respect to: (i) red listing of forested wetlands based on the use of geospatial data and the International Union for Conservation of Nature (IUCN) criteria for red listing of ecosystems; (ii) quantifying changes and trends in palustrine wetlands for the Maputaland Coastal Plain, showing various rates of declines in all six palustrine wetland types; (iii) biodiversity mapping for African rivers and assessment of extent and percentages of types, their ecological condition and levels of protection; and (iv) progress on assessing trends for lacustrine wetlands for the whole of South Africa.

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Progress in mapping trends in the Advance Fire Information System (AFIS) burnt area product across 22 years using geospatial data and tools

The Advanced Fire Information System (AFIS) of the CSIR has recorded data from the Moderate Resolution Imaging Spectroradiometer (MODIS) at a 500 m spatial resolution for the past 22 years. The monthly number and extent of these occurrences have been assessed to determine the overall and seasonal trends across Eswatini, Lesotho and South Africa. We also assess the occurrences across an updated Fire EcoType (FET) map aligned to the most recent National Vegetation Map as well as provide a breakdown of fires across the several natural land cover classes. Overall, the results showed a minimal decline in the number of fires across the study area for the 22-year period. The numbers were lower during the most recent decadal drought of 2015/6 across the study area, associated with a reduction in the fuel load available for burning. The monthly data showed strong seasonal signatures. In general, the highest number of times a pixel has burnt over the time period, resulting from veldfires in natural areas, occur in August each year, while the highest extents are observed, on average, in August and September. Veldfire profiles vary across the 14 FETs though, with the Fynbos, compared to the Grasslands that burn at the end of the dry season (August). We intend to present progress in the seasonal trends at the time of the conference.

The assessment provides valuable information on natural variation in veldfires, as a natural process, in natural land cover areas of South Africa. We will discuss the feasibility of distinguishing between natural and anthropogenic or climate change impacts, using the overall and seasonal trend analysis for the 22 years.

POSTER

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Fine-resolution analysis of the spatiotemporal characteristics of heatwaves in the Maloti-Drakensberg region, southern Africa: 1979–2021

Consistent with global patterns, heatwaves have increased in frequency, duration and intensity across southern Africa; under enhanced global warming this is projected to worsen. Heatwaves have many adverse impacts, but in biologically unique mountainous regions, like the Maloti-Drakensberg region, impacts on ecological processes and hydrological cycles are particularly dire given their highly sensitive nature. Despite this, extreme temperature changes and interannual variability patterns remain understudied in mountainous regions, owing largely to remoteness and inaccessibility. This is especially true for the Maloti-Drakensberg region. Hence, using heatwave indices developed by the World Meteorological Organization (WMO) Expert Team on Sector-Specific Climate Indices (ET-SCI), we explored spatiotemporal patterns for the seasonal average number, length and magnitude of summer (November–March) heatwaves for 1979/80–2020/21 using the AgERA5 reanalysis. Although higher elevation regions typically experienced more frequent, longer-lasting heatwave events with higher interannual variability levels, on average the Maloti-Drakensberg region experienced 1.4 heatwave events, lasting for 6.5 days with a magnitude of 3.5°C^2 . Interannually, the El Niño–Southern Oscillation influenced variability of heatwave characteristics, with positive (negative) heatwave number and length anomalies predominantly detected during El Niño (La Niña) phases, while for heatwave magnitudes no clear pattern was evident. These heatwave aspects were predominantly characterised by increasing trends, however, few regions exhibited statistically significant trends. Overall, trends averaged 0.003 events/year, 0.03 days/year and 0.02°C^2 /year for the mean number, length and magnitude of heatwaves, respectively. These results highlight that the Drakensberg-Maloti region is vulnerable to an increasing frequency, duration and magnitude of heatwaves, however, implications thereof require further study.

Prof CD van der Merwe (Clinton)University of Pretoria (clinton.vandermerwe@up.ac.za)***Teaching the Anthropocene in the Geography Curriculum Assessment and Policy Statement (CAPS) - myth or reality?***

The Curriculum and Assessment Policy Statements (CAPS) embody the modern curricula of a post-apartheid democratic South Africa. Initiated after apartheid ended in 1994, CAPS came to life through broad public consultation involving students, parents, teachers, subject advisors, and curriculum specialists, coinciding with Nelson Mandela's election as South Africa's first democratically elected president. The South African education system adopted CAPS in 2012, aiming to enhance the consistency and evolution of the knowledge and skills students acquire over their 12 years of schooling in any subject area. This paper delves into the representation and instruction of the Anthropocene within the Geography curriculum of the Further Education and Training (FET) phase, which caters to students in grades 10 to 12, ages 16 to 18, covering all geography-related topics. Through a detailed examination of the CAPS documents, this paper aims to uncover the depth and breadth with which the Anthropocene is addressed in Geography. The goal is to ensure that South African students emerge as critical thinkers and responsible, empowered citizens, ready to navigate the challenges of the 21st century and beyond.

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Resilience and Preparedness to Tropical Cyclones across Southern Africa (REPRESA): Early warning in Malawi and Mozambique

The “Resilience and Preparedness to Tropical Cyclones across Southern Africa (REPRESA)” project aims to assess and enhance the resilience and preparedness of communities in Malawi, Madagascar, and Mozambique to tropical cyclones. This paper presents the findings from research conducted in Malawi and Mozambique, where community-based qualitative and quantitative methods were employed. In Malawi, a sample of 896 participants provided insights into the local perceptions, coping mechanisms, and preparedness strategies for tropical cyclones. Similarly, in Mozambique, data from 1,103 participants were gathered to understand the community’s adaptive capacities and the effectiveness of early warning systems. Preliminary findings reveal significant variations in resilience and preparedness levels, influenced by socio-economic factors, local governance, and access to resources. The research highlights the importance of community engagement in disaster risk reduction strategies and the need for tailored approaches to enhance resilience in cyclone-prone regions. This study contributes to a broader understanding of how communities across Southern Africa can better prepare for and respond to the increasing frequency and intensity of tropical cyclones due to climate change

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'Borrowing' parks: an analysis of organised events and attachment to urban parks, Johannesburg

Urban parks have since the start of planned park developments, been considered the spatial and social 'fixes' to the cultural, political, economic and environmental challenges of cities. This is even more pronounced in dynamic cities of the global South. Steering away from romanticized 'lungs of the city' and 'city escape' conceptualizations, parks are also productive spaces in which a variety of ideals, expectations and needs are enacted and negotiated daily by different 'park actors' and 'park practices'. One such park practice is organized events in public parks as host venues. This research employs the ever-popular parkrun 'move-ment' as its case study. The parkrun has since its inception in 2004 in the UK, 'borrowed' parks and park-like venues to host hundreds to thousands of avid participants and volunteers weekly on Saturday mornings for a 5km walk, jog or run. Today, the parkrun takes place in communities across 22 countries globally. Contextualized within the city of Johannesburg and during the time of the Covid-19 pandemic, this research draws on primary and secondary data from online questionnaires, semi-structured interviews, social media and online desktop research to unpack three unique parkrun case studies, namely the younger Mapetla parkrun and the older Roodepoort and Delta parkruns. The research explores how the parkrun has 'event-tualised' parks and resulted in an indirect (re)discovery and (re)appreciation of parks through the creation of a temporary 'third place' and 'communitas'. For its participants and volunteers, the parkrun carries immense significance and a strong event attachment underpinned mostly by social and community-related benefits. The 'borrowed' park itself becomes synonymous with the parkrun, and park attachment and sense of belonging relates directly to the fostered event attachment and community. Investment in park cleanups, maintenance and positive environmental behaviours are motivated by the need for the sustainability of the event, and the 'borrowed' parks thus enjoy the subsequent knock-on effects of their weekly parkrun influx. This is especially the case for the Mapetla and Roodepoort parkruns. For the Delta parkrun, the park itself serves a greater variety of alternative core functions to the community.

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***Exploring Perceived Relationships between Weather, Climate and Mental Health:
Biometeorological Perspectives of Healthcare Practitioners***

The relationship between climate and mental health has been the focus of a growing body of research over recent decades. Although the findings of this research have been contested, the majority of studies suggests that air temperature, exposure to sunlight, and EWEs exert a statistically significant influence on mental health outcomes. This study explores healthcare practitioners' perceptions of the relationship between climate and mental health, and the ways in which these perceptions influence medical practice. To achieve this, semi-structured interviews were conducted with 50 participants, comprising 10 from each of the following categories: general practitioners, emergency physicians, psychologists, psychiatrists, and social workers. All 50 participants perceived the relationship between climate and mental health to be substantial, but participants' perceptions of the relative importance of this relationship varied. The majority of participants perceived climate to exert a considerable influence on mental health outcomes, while acknowledging that climate likely acts in tandem with socioeconomic and biophysiological factors. A large minority of participants, however, perceived the effect of climate on mental health to be relatively insignificant when compared with socioeconomic and biophysiological risk factors. The findings of this study make it clear that the relationship between climate and mental health has not been integrated into the medical education syllabus. Although the majority of participants perceived the influence of climate on mental health to be considerable, none of the participants considered this influence in their practice. Climate change projections for South Africa suggest that the potentially adverse effects of climate on mental health may increase in severity. Thus, healthcare practitioners could benefit from formal education on these potential impacts, allowing them to identify periods of vulnerability, and to develop holistic treatments, considering the impact of climate on mental health.

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Investigating the Meteorology of Cut-off Lows and their Impacts on Vulnerability and Disaster Risk in Kwa-Zulu Natal, South Africa

Every year, cut-off low (COL) pressure systems produce severe weather conditions and heavy rainfall often leading to flooding, devastation and disruption of socio-economic activities in South Africa. As they occur throughout the year, these weather systems are important rainfall producing systems that are also associated with extreme cold conditions and snowfalls. Sometimes COLs may extend to the surface, creating conditions conducive for extreme rainfall and high floods over South Africa especially when impinged on the coastal escarpment. Slow propagation of COLs appears to be largely modulated by a quasi-stationary high-pressure system, acting as a blocking system. An in-depth review, investigation and forecast of COLs is critical due to their high impacts which affect some parts of the country regularly affecting lives and livelihoods. The study at provides a single most comprehensive treatise, investigation focusing on of 3 recent COLs over the South African domain, in Kwa-Zulu Natal (KZN) province. This study presents a comprehensive investigation into the meteorology and societal impacts of COLs in KZN. The study analyzes historical data to characterize COL climatology in KZN, including frequency, intensity, and duration. Investigate the atmospheric factors that contribute to COL development and persistence over KZN. Assess the vulnerability of KZN communities to COL impacts and this involves spatial analysis of hazard zones, socio-economic vulnerability factors, and an evaluation of existing early warning systems. The study also aims to improve understanding of COLs in KZN and their societal consequences. The findings develop recommendations for enhanced forecasting, early warning systems, and disaster risk reduction strategies to improve community preparedness and resilience to these extreme weather events.

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State of transhumance in the Maloti Drakensberg region of South Africa: the case of Namahadi Catchment Area

Climate change and climate variability have measurable impacts on socioecological systems. Transhumance in the Maloti Drakensberg region is one of the oldest but less known land uses in this area. This increases its vulnerability to climate change and infringement by other land uses and land covers. This study aims to bring to the fore the current state of transhumance in the area. Qualitative observations, ethnographic observations, and unstructured interviews were used to understand the structural, organizational and functional properties of the system. The results showed the existence of the generic structure of vertical transhumance. Despite the relatively small size of the transhumance landscape, is constituted by different types of transhumances, ranging from family, collective, and individual transhumance. Nevertheless, the deteriorating ecological integrity of the landscape poses threat to the resilience of transhumance. It has led to abandonment of camps and the shift in time of movement between seasonal camps. As much as the use of mini ethnography provided valuable information on transhumance system from the herders, more still needs to be done to incorporate transhumance in land use land cover dynamics. This will also raise awareness about vulnerability of transhumance and its contribution to geospatial-related studies. Ultimately, the study could not cover the socio-economic elements of transhumance and its potential contribution to sustainable livelihoods. This opens opportunities for future multidisciplinary and interdisciplinary studies involving transhumance system.