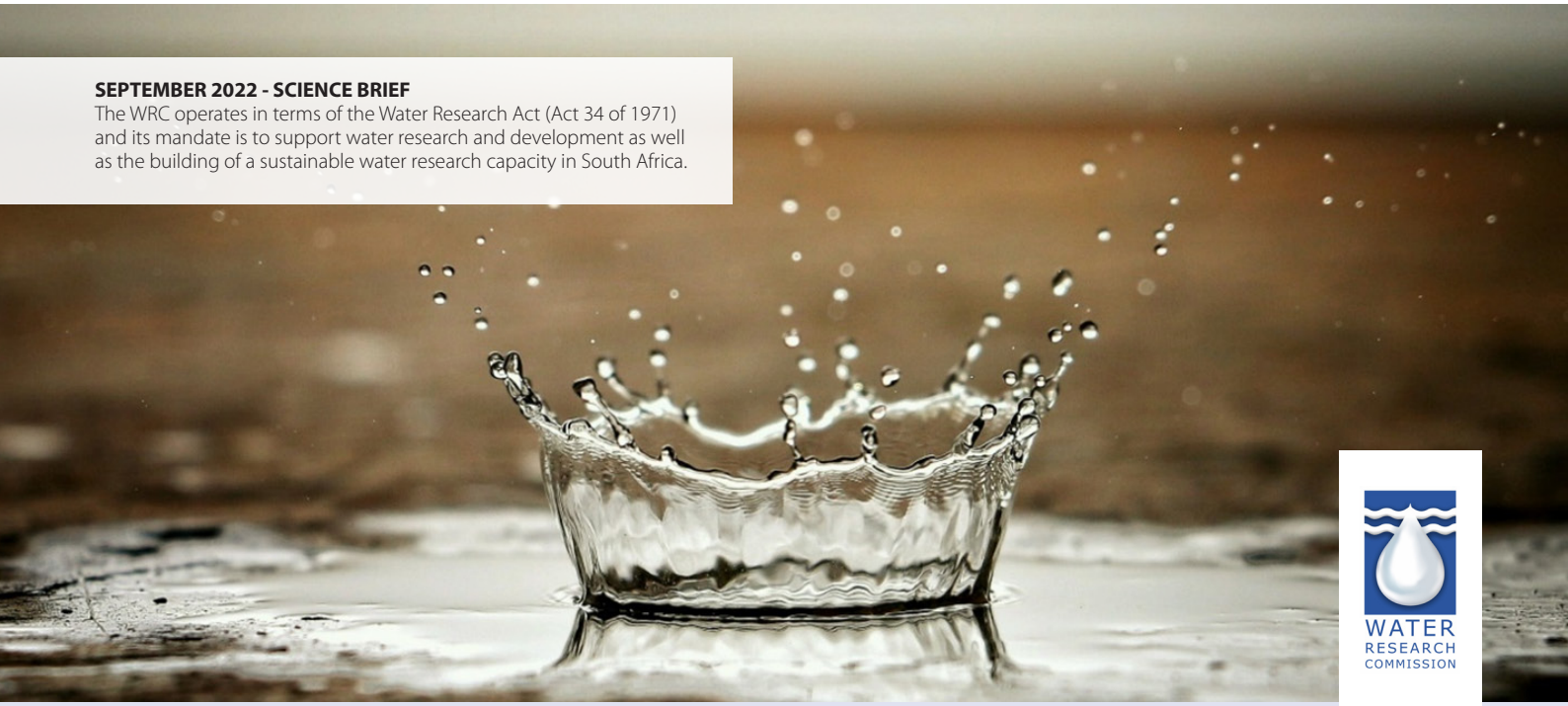

SEPTEMBER 2022 - SCIENCE BRIEF
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

CLIMATE CHANGE AND THE WATER FUTURES: AN OVERVIEW[1]

Brilliant Petja, John Ngoni Zvimba, Sylvester Mpandeli and Luxon Nhamo

Water is one sector witnessing depletion and degradation due to the increasing frequency and intensity of extreme climate-related events such as droughts, heatwaves, and flooding. These events have been consistently increasing with the corresponding change in climate. These developments have compromised the water and sanitation initiatives to achieve sustainability in the sector by 2030. This chapter provides an introductory context and highlights the brevity and enormity of climate change in South Africa, highlighting common areas of interest and the need for resilient response to sustain the water sector. The recurrence of droughts caused by the El Niño Southern Oscillation (ENSO) continues to devastate the country, affecting poor households and the environment. Although South Africa is classified as food secure at national level, over 40% of households remain food insecure, a situation that requires immediate policy interventions to enhance resilience and meet the 2030 global agenda on sustainable development. This science brief, therefore, advocates for site-specific diagnoses of climate change impacts starting at a local scale, which will ultimately lead to practical solutions that will increase resilience and adaptive capacity.

[1]This science brief is taken from B. Petja (Ed), Climate change impacts on water resources: Implications and practical responses in selected South African systems (WRC report no. SP. 155/22), Water Research Commission: Pretoria.

Introduction

Climate change is a complex cross-cutting issue and may not be the sole prerogative of one government department. A single sector cannot respond to the consequences of the changing climate alone. For the effective integration of adaptation and mitigation measures, almost every department in government and the entire administrative system (including decentralised levels of government and parastatal entities) should mainstream climate change and integrate it into policies and interventions. Furthermore, a multiplicity of actors is intervening and influencing discussions and actions. Policymakers need to take these features into account and address the governance of climate change as a complex, cross-cutting, multilevel, multi-actor process that is deeply embedded in local realities [1].
The southern Africa region is extremely vulnerable to the impacts of climate change both in terms of the region's water resources and development. The projections into the future show declining trends in rainfall because of the changing climate. This, coupled with projected increasing temperatures translates into a forecast for drier areas. Evidence shows a record increase in natural disasters and extreme weather events [2,3]. Changes in climate and increased variability brings significant implications for production and viability of different sectors. These changes in climate advocate for balanced planning while adapting to the new normal within the context of development. It is important to adequately plan to respond to both droughts and floods while increasing resilience to these extremes. Future infrastructural development needs to include the increase of storage capacity such that more floodwater is captured and stored. This can include underground storage where more water may be stored for future use. This will reduce societal vulnerability to the impacts of floods while reserving these extremely high volumes of water for use in drier periods and also for groundwater recharge. On the other hand, recovery from droughts is a timely process. This bears negative implications for economic activities, such as agriculture, as they may take longer than usual to recover after each drought season. While climate change may bring lots of negative impacts, planning and addressing those impacts in advance will contribute to making the future bearable [4,5]. This publication serves as a toolbox to reflect on the challenges brought on by climate change to water resources and ecosystems. It is aimed as an eye opener and will by no means cover all the climate change issues facing the water sector.

Context

It is important to regularly reflect on the future likely to be brought on by climate change. There is a need to assess each development relying on water, with a particular emphasis on increasing the resilience, adaptive capacity and proactive response of each sector. This may include, among others, strengthening infrastructural capacity. The projected climate future will be covered in detail in chapters two and three. Examining climate change impacts on society and the environment should not only focus on temperature and precipitation, but also on the resultant impacts on socio-economic implications on population shifts, migration, resource needs and development requirements above the ordinary threshold. Water-intensive industry and developments may need to relocate, change water use patterns or explore further alternatives which may affect the locality of current economic hubs. It is critical to establish new protocols for assessing vulnerability of existing infrastructure emphasizing the need to incorporate global climate science into them to improve their resilience. Design of new infrastructure requires in depth consideration of the future climate to encourage sustainability and resilience. It is important to adequately plan to respond continually to both droughts and floods while increasing adaptive capacity. This will contribute to reducing societal vulnerability while encouraging sustainable development.

Rationale for climate change research

Actions and interventions responding to the changing climate require the research sector to identify the likely impacts of climate change and to develop strategies and position the sectors to respond to identified risks and opportunities. Improved observation, process understanding and modelling of the climate system will deliver more robust information on the timing, extent and nature of likely changes to temperature, rainfall, water availability, sea level and extreme climate events. Determining how important climatic variables will change, quantifying their natural variability on multi-decadal or longer timescales, and improving confidence in climate projections will allow for better risk management, reduce the cost of managing the impacts of climate change, and enable exploitation of potential opportunities. Detecting and attributing current changes in the climate will enable informed government decision-making for climate change response. Understanding the sources of uncertainty in projections of future climate change will help quantify likely impacts on communities (including coastal communities), biodiversity, water resources, primary production sectors and major infrastructure. Extreme climate events including tropical cyclones, flooding, veld fires and drought have posed severe impacts on the economy, community and ecosystems over recent years. These events are closely linked to known drivers of climate variability, such as the El Niño Southern Oscillation, with possible contributions from climate change. Understanding how these global drivers have previously behaved, are behaving today, and how they will change in the future, as well as how they are influenced by climate change, will help us forecast and plan for future extreme climate events with greater confidence. Ensuring that climate models capture these processes will underpin the capacity to predict changes with greater confidence and better understand uncertainties about future climate [6] and advice accordingly on the appropriate responses [5,6].

Framework for mitigation and adaptation

It is acknowledged that climate change is a complex and cross-cutting problem that is impacting on all sectors [7]. As a challenge that is affecting all sectors, climate change adaptation needs to be addressed holistically through transformative and circular models that consider the interlinkages of sectors and reduce uncertainties that are associated with linear approaches [8]. Transformational change is critical when responding to societal changes and when shifting from the norm. There are four climate change thematic areas that need to be addressed to achieve resiliency in the water sector [8,9,10]. These include (a) integrated policy and institutional frameworks, (b) adoption of water use efficiency technologies, (c) development of a water adaptation strategy, and (d) adoption of transformational and circular approaches to manage water resources (Figure 1).

The water sector climate change adaptation thematic areas address the drivers of climate change that impact water resources. The implementation of these fundamental themes is envisaged to enhance water and food in the country. Climate change adaptation through transformational, multicentric and circular approaches inform policy- and decision-making on managing resources effectively without transferring challenges to other sectors [11,12]. Responses to climate change in the water sector range from autonomous coping strategies to reactive interventions towards climate variability and extreme weather events, and proactive interventions to long-term changes in climate [10]. Reactive/autonomous adaptations refers to deviations from current production and management practices (such as changes in crop mixes, and crop varieties) in response to changes in local climatic and growing conditions [9]. Proactive interventions, on the other hand, include planned policy and investment decisions to enhance adaptive capacity of target water and agricultural systems, such as investments in efficient irrigation systems and new crop varieties [11]. While reactive/autonomous responses are useful in the short-term, it is proactive interventions that contribute to long-term adaptation and sustainability. One such initiative is to promote and cultivation of indigenous underutilised crops that are suitable for local harsh environmental conditions and do not require a lot of water.

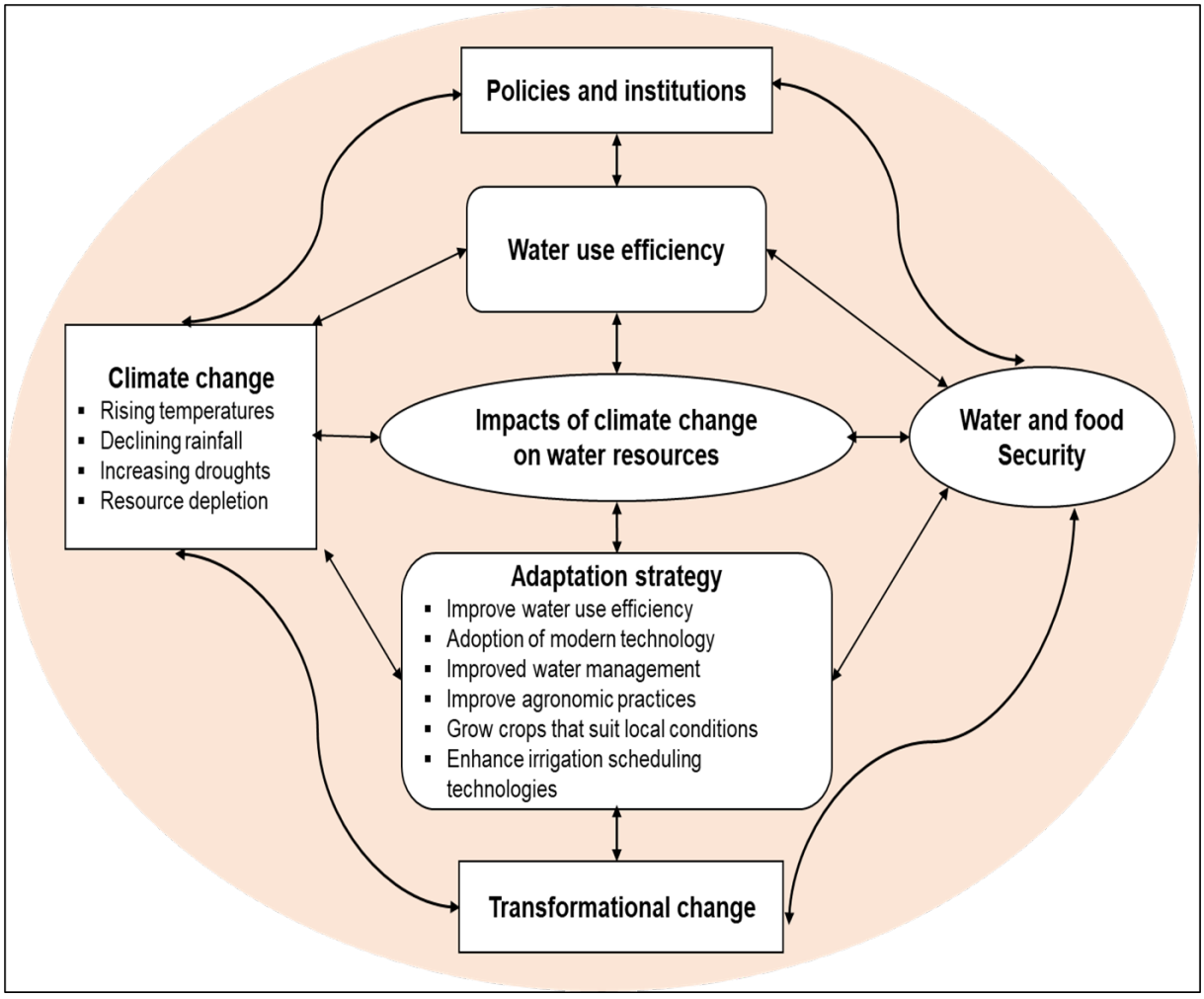

Figure 1. Conceptualised pathways towards climate change adaptation and resilience in the water sector.

Policies on climate change adaptation need to be aligned to governance capabilities such as (a) reflexivity, (b) resilience, (c) responsiveness and (d) revitalisation [11]. Reflexivity is the ability to deal with a variety of problem systematically and continuously as they emerge; resilience is the ability to bounce back to the original basic state of function after a perturbation; responsiveness is the ability to deal with dynamic demands and expectations, and revitalisation is the ability to reignite policies and ensure their continuous application [13,14]. Ideally, these approaches must be flexible to allow upscaling and downscaling, depending on and in response to the prevailing challenges at local and transboundary scales. In addition, adaptive management, which allows for iterative decision, is needed to manage climate change risk and uncertainty. Table 1 provides some of the climate change risks on water and the adaptation strategies.

Implications for local scale response

The South African water sector is expected to be significantly impacted by projected climate change. Such experiences have already been witnessed during the recent El Niño event (2015 – 2016). The entire water services value chain is vulnerable to the effects of climate change, from the raw water source, through to the purification and distribution processes and subsequent wastewater treatment. Increased temperatures will affect existing water treatment infrastructure and conveyance systems. In this regard, storage tanks, flocculation chambers, and the pipeline network used for water distribution may be exposed to increased corrosion as a result of higher temperatures. In turn, an increase in extreme events, such as floods, may damage infrastructure. An increase in temperature will also lead to a concomitant increase in water demand and use despite a decrease in available water at the source due to higher rates of water loss, especially from dams. This will result in an increased level of pollutants in water resources, which will translate to an increase in the cost of treatment, an important area for municipalities to be able to put in place the necessary plans to adapt to these changes. All of these changes will be an added burden to municipalities, who are already having to cope with eradicating service backlogs in support of improved service delivery, ensuring proper operation and maintenance of water and wastewater systems and ensuring water security amid rising demand and dwindling water supplies. To assist with addressing above challenges guidelines dealing with the selection of relevant water sector adaptation technologies and approaches for specific climate change impacts over the short-, medium- and long term have been developed (see, for example, **WRC Report No. TT 663/16,** [15]). The concept for adaptation articulated in these guidelines is to provide solutions that can be applied across various geographical settings and municipal capabilities, thus setting the basis for adaptation to be planned and applied where and when required, especially in the most vulnerable regions and within suitable timeframes.

When municipalities compose their climate change adaptation response, as they are now being encouraged to do, they should consider their specific local circumstances. The options selected should optimise prevailing and anticipated environmental, social, economic and cultural aspects. Options should also be associated with a favourable economic assessment after accounting for the social components for which monetary returns are not expected. In this regard, rural municipalities are considered to have the poorest adaptive capacity, making them more vulnerable to the additional stresses, while large urban municipalities are associated with a higher level of service delivery, thus reducing vulnerability. The Blue- and Green Drop scores also point to the nature of vulnerability in water and wastewater services. A poor score also means that the institution and the service delivery process are highly vulnerable to the impacts of external factors such as climate change. As such, these vulnerabilities have to be dealt with before accounting for climate change. Water sector bylaws and management of restrictions are currently evolving at a slower pace which do not necessarily cater for the threat of climate change to water service provision but rather attempts to respond to disasters already in dire situations. In this regard, plans for implementing climate change adaptation are still failing to make it onto the list of prioritised projects for the municipalities, even though several climate change strategies may have been developed. This often results in failure of cities to respond to disruption in water supply for example in case of extended and unusual drought which are the modern features of the changing climate [15].

Conclusions

The overall vulnerability of South Africa to climate change impacts to the water sector has been fully characterised, and the emphasis now falls on translating findings into adaptation measures and developmental interventions, with the aim of providing site-specific responses. From the overview, it can be noted that climate change can be classified as a permanent problem which needs to be dealt with sustainability. The basis for climate change response is dependent, among others, on adaptive capacity, increasing resilience, improvement of early warning systems, reducing vulnerability, identifying specific impediments and the ability to respond while prioritising proactive planning. It is upon this premise that consequences of climate change can be addressed in an attempt to contribute to a climate resilient society. Considering water as both a constraint and opportunity to sustainable growth and development under a changing climate, the research outcomes therefore need to be robustly mainstreamed into water-related policy practice as well as developmental and adaptation needs while integrating a cross sectoral capacity development and at the same time informing the future sectoral response. This publication therefore talks to the site-specific climate change impacts and attempts to bring forth the strategies that advocates for resilience and sustenance of the water sector in light of the changing climate.

References

1. DEA, Department of Environmental Affairs (2011) Governance of Climate Change in South Africa. Department of Environmental Affairs, Pretoria.
2. DEA, Department of Environmental Affairs (2013). Long-term adaptation scenarios flagship research programme (LTAS) for South Africa: climate trends and scenarios for South Africa. DEA, Pretoria.
3. Kephe, P.N., Petja, B.M., Kabanda, T.A. (2016) Spatial and inter-seasonal behavior of rainfall in the Soutpansberg region of South Africa as attributed to the changing climate. Theoretical and Applied Climatology, 121(1-2), DOI 10.1007/s00704-015-1569-9.
4. Petja, B.M. (2017) Perspectives of development under climate change and the need to invest in a climate resilient future. Development Finance Agenda, 3(4), 14-16.
5. WRC. (2018) Water Research Commission Corporate Plan 2018-2023. Water Research Commission (WRC): Pretoria, South Africa.
6. DCCEE, Department of Climate Change and Energy Efficiency (2012) A Plan for Implementing Climate Change Science in Australia. Department of Climate Change and Energy Efficiency, Commonwealth of Australia.
7. Nhamo, L., Mabhaudhi, T., Modi, A. (2019a) Preparedness or repeated short-term relief aid? Building drought resilience through early warning in southern Africa. Water SA 45(1), 75-85.
8. Mpandeli, S., Naidoo, D., Mabhaudhi, T., Nhemachena, C., Nhamo, L., Liphadzi, S., Hlahla, S., Modi, A. (2018) Climate change adaptation through the water-energy-food nexus in southern Africa. International Journal of Environmental Research and Public Health 15, 2306.
9. Iglesias, A., Garrote, L. (2015) Adaptation strategies for agricultural water management under climate change in Europe. Agricultural Water Management 155, 113-124.
10. Mpandeli, S., Nhamo, L., Moeletsi, M., Masupha, T., Magidi, J., Tshikolomo, K., Liphadzi, S., Naidoo, D., Mabhaudhi, T. (2019) Assessing climate change and adaptive capacity at local scale using observed and remotely sensed data. Weather and Climate Extremes 26, 100240.
11. Nhamo, L., Matchaya, G., Mabhaudhi, T., Nhlengethwa, S., Nhemachena, C., Mpandeli, S. (2019b) Cereal production trends under climate change: Impacts and adaptation strategies in southern Africa. Agriculture 9, 30.
12. Nhemachena, C., Nhamo, L., Matchaya, G., Nhemachena, C.R., Muchara, B., Karuaihe, S.T., Mpandeli, S. (2020) Climate change impacts on water and agriculture sectors in Southern Africa: Threats and opportunities for sustainable development. Water 12, 2673.
13. Magidi, J., Nhamo, L., Mpandeli, S., Mabhaudhi, T. (2021) Application of the Random Forest Classifier to map irrigated areas using Google Earth Engine. Remote Sensing 13, 876.
14. Nhamo, L., Mabhaudhi, T., Magombeyi, M. (2016) Improving water sustainability and food security through increased crop water productivity in Malawi. Water 8, 411.
15. Dube, R.A.; Maphosa, B.; Fayemiwo, O.M. (2016) Adaptive Climate Change Technologies and Approaches for Local Governments: Water Sector Response, WRC Report No. TT 663/16. Water Research Commission: Pretoria.