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National Science and Technology Forum (NSTF)

media release

World Water Day, 22 March 2024

Prof Timothy Dube is revolutionising water management with AI and satellite technology

World Water Day, celebrated on 22 March annually since 1993, is a United Nations (UN) observance highlighting the importance of freshwater. It aims to raise awareness about the 2.2 billion people without access to safe water and encourages action to address the global water crisis.

The National Science and Technology Forum (NSTF) is proud to spotlight the 2024 NSTF-South32 Award winner, Prof Timothy Dube, in honour of this significant day. Prof Dube, a trailblazer in water research, was awarded the prestigious NSTF-Water Research Commission (WRC) Award for his pioneering use of satellite technology combined with machine learning (AI) to monitor water resources in semi-arid regions. His innovative work enhances ecological sustainability and strengthens community resilience, making a profound impact on water management and conservation. As Director of the Institute for Water Studies at the University of the Western Cape (UWC) and an Adjunct Professor at the UN University, Prof Dube continues to push the boundaries of science to address global water challenges.

World Water Day: The core focus for the day is supporting the achievement of Sustainable Development Goal (SDG) 6, which aims for water and sanitation for all by 2030. Each year, UN-Water sets a theme, and in 2025, the theme is "Glacier Preservation," focusing on the crucial role of glaciers in the water cycle. The day raises awareness about challenges posed by melting glaciers and encourages action to reduce carbon emissions and adapt to water flow changes. Mitigating climate change and adapting to the loss of glaciers is essential to protect communities and ecosystems across the world.

Figure 1: Prof Glenda Gray, Prof Dube, Dr Jeniffer Molwantwa (Chief Executive Officer: WRC), Dr Mmboneni Muofhe (Deputy Director-General: Department of Science, Technology and Innovation)

Advancing water resource management through innovation and technology: Prof Timothy Dube is a highly regarded National Research Foundation (NRF)-rated Geospatial Scientist and Senior Lecturer in Environmental and Water Sciences at UWC. He earned his PhD in Environmental Science, specialising in satellite remote sensing, from the University of KwaZulu Natal (UKZN) in 2016. Prof Dube has a strong academic background, having attained his MSc in Geoinformation Science from the University of Twente, The Netherlands, and an undergraduate degree in Geography from the University of Zimbabwe (UZ), where he won two university book prizes.

His research focuses on developing methods to monitor and understand riparian ecosystems (riparian means in and around rivers), their impacts on water resources, land-use changes, invasive species and climate change. His innovative approach is transforming how water resources are monitored, analysed and managed in some of the world's most vulnerable ecosystems, with remarkable accuracy. Prof Dube stated: "Technological advancements enable us to respond to environmental changes in real-time, optimise water usage and develop predictive models for better resource planning". He is an expert in geospatial analytics, satellite remote sensing, and sensor networks, particularly for terrestrial ecosystems, inland waters, and wetlands.

Prof Dube is a lead investigator in the European Union (EU) and European Space Agency (ESA) funded Global Monitoring for Environment & Security project and has contributed to other major projects, such as the TIGER-Bridge African Water and Climate Change Project as the leading Principal Investigator for Africa.

Prof Dube's work has been supported by institutions like the WRC (South Africa – SA) and the Centre for Climate & Earth Systems Science, French Research Platform (CIRAD), and he has provided extensive earth observation training in Southern Africa. He states that his passion for water research was strengthened during a field research trip he had embarked on as an undergraduate student, where he observed a struggling community in a water scarce area.

> "Witnessing the struggles people faced due to limited access to clean water profoundly impacted me," he recalled. "It highlighted the critical importance of water in every aspect of life and would define my career going forward."

He uses artificial intelligence (AI), machine learning, and remote sensing to tackle water scarcity, focusing on non-perennial rivers (N-PRs) in semi-arid regions. In sub-Saharan Africa, two-thirds of rivers are non-perennial, but these waterways have often been overlooked in research. Prof Dube's model estimates water availability in N-PRs with about 85% accuracy, a breakthrough for areas where traditional monitoring methods fail. By using Sentinel satellite data, his team can now detect and monitor water resources more effectively. This work helps improve water management, supports agriculture, mitigates droughts, and aids ecosystem conservation.

Prof Dube declared: "Our goal is to provide decision-makers with the most accurate and up-to-date information possible."

> "By harnessing new-generation Sentinel satellite data, we're able to detect and monitor water resources in ways that were previously impossible, addressing pressing environmental challenges and promoting better water resource management."

He is a registered Natural Scientist with the South African Council for Natural Scientific Professions (SACNASP) and a member of the African Association of Remote Sensing of the Environment (AARSE) and WaterNET. He has authored over 100 international publications and has been recognised globally, with over 1,100 citations and an H-index of 17. He is a dedicated teacher and has supervised numerous MSc and PhD students developing the next generation of hydrology specialists.

> He says: "The integration of AI and machine learning into hydrological modelling presents exciting opportunities to improve predictive capabilities and optimise
> water management strategies."
>
> "It's crucial to equip young scientists with the tools they need to tackle future challenges."

Prof Dube was also nominated for the 11th HOPE meeting with Nobel Laureates in Japan. His research aims to develop satellite remote sensing techniques to address climate change and various water management challenges in Southern Africa.

> He reflects: "The success of this project was technical, but also deeply personal. Witnessing the direct impact of our work on the ground and knowing that our research was contributing to resilient water management practices and resilient communities was profound."

Prof Dube was awarded the coveted NSTF-WRC Award at the prestigious NSTF-South32 Awards, known as the 'Science Oscars of SA' held on 11 July 2024. He relates that winning the award was transcendent for him because it helps bring environmental issues and water management practices at the forefront.

> He concludes: "It highlights the importance of interdisciplinary research in addressing complex environmental issues, amplifying its influence and fostering the broader adoption of innovative solutions to global water challenges."

Advancements in earth observation for water resources monitoring and management in Africa: The development of remote sensing in water resources management (WRM) has evolved significantly, transitioning from traditional methods like aerial photography to advanced satellite systems. These satellite systems offer routine monitoring of water balance components and topographic parameters impacting water catchments. Open data access and the availability of new satellite resources have especially benefited developing countries with limited in-situ networks.

Spatial Water Resource Monitoring Systems (SWRMS) are remote sensing missions dedicated to WRM, providing valuable information about hydrological processes, including evapotranspiration, precipitation, soil moisture, surface water, and water quality. These systems enhance spatial understanding of water resources and allow near real-time monitoring.

The ESA launched the TIGER Initiative to support African water authorities, empowering them to utilise EO technologies for WRM. This initiative helps build capacity and disseminate EO technology for scientific research and WRM programmes in Africa.

Despite the advantages of EO data, challenges remain, such as the overwhelming amount of available data and the complexities in selecting appropriate datasets for specific studies. There is a pressing need for investment for continued investment in EO technologies and data integration to address the gaps in hydrological data, particularly in regions with scarce in-situ monitoring, such as machine learning and cloud computing for improved data resolution and multi-source data integration, to tackle complex hydrological issues in the future.

About the NSTF Awards: The NSTF Awards recognise, honour, reward, celebrate, profile and promote outstanding contributions to science, engineering and technology (SET) and innovation in SA.

About the NSTF: NSTF is an independent non-profit stakeholder body and network – a civil-society forum of over 140 organisations involved in science, engineering, technology (SET) and innovation in SA.

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- Timothy Dube – The Conversation
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About the NSTF

The National Science and Technology Forum (NSTF), established in 1995:

- is a broadly-representative stakeholder body for all science, engineering and technology (SET) and innovation organisations in South Africa
- gathers stakeholders around burning issues of national and global interest, across the public and private sectors, including matters of public policy
- includes a network of professional societies in SET and STEM education (STEM = science, technology, engineering and mathematics) - the NSTF pro*SET* membership sector.
- recognises, awards and profiles the outstanding contributions of individuals and groups to SET and innovation through the prestigious NSTF Awards
- runs and supports collaborative projects and youth outreach, including recognition of top performance in mathematics and science, role modelling, bursary and STEM career information
- runs and supports the STEMulator.org which attracts youth and educators to Explore>Discover>Learn the world of STEM including careers. (Established by NSTF pro*SET)*

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