TERMS OF REFERENCE FOR A SOLICITED WRC PROJECT

THEME:	**Water Quality and Health**
TITLE:	**Title:** Re-imagining the feasibility of the future of water resources quality monitoring in South Africa and transboundary systems using latest technology: A feasibility assessment for accelerating digital transition
TOR NUMBER:	

1. Rationale for the Study

South Africa covers about 1.22million km^2 of land area, with a spread of wetlands, rivers, dams, estuaries and aquifers. South Africa has a very dense monitoring network, however, most of the monitoring stations are no longer generating data. This decline is mainly due to budget constraints affecting sampling and analysis. The resulting data gaps are well documented, including in national reports such as by the Department of Water and Sanitation' State of Water Report, Statistics South Africa, Water Research Commission funded reports and the SDG: 2030 report. These gaps undermine the ability to effectively manage water resources and plan for sustainable development. While monitoring is expensive, it is a prerequisite for reasonable water resources management and planning for development. The old adage which says "if you cannot measure it, you cannot manage it" is increasingly relevant and even more valid in the current context of growing water stress, water resources pollution and demand for timely information. Monitoring across the country as vast as South Africa through traditional approaches based on routine field sampling, transportation of samples and analysis at accredited laboratories needs urgent review in the times of technology. These methods are costly, time consuming and often fail to provide real-time or high frequency data needed for responsive decision-making. The world is migrating towards digital and technology-enabled water quality monitoring approaches, such as those aligned to the Fourth Industrial Revolution, including artificial intelligence (4IR/AI). It is for this reason that monitoring using various forms of innovative tested tools and emerging technologies such as remote sensing, autonomous monitoring platforms, drones, mobile applications, citizen science platforms, environmental DNA (eDNA), and systems such as cyber-physical monitoring networks are of paramount importance as they offer significant opportunities to enhance data collection and analysis. However, these technologies have not been taken up in the water quality monitoring value chain in any significant way. The status quo has to dramatically change if custodians (e.g. the Department of Water and Sanitation) are to meet their mandates and respond to increasing demands for real time data and information in the future. The Water Research Commission is leading the development of big data warehouse (Water Research Observatory) which integrates artificial intelligence and advanced analytics with the purpose of securing online data, generate reports at the click of a button. The proposal needs to take advantage of the data archiving and processing capabilities already in place to support the transition towards a modernised and technology-enabled future of water quality monitoring. The need for progressive transformation use of technology in monitoring has been noted by the Department of Water and Sanitation through deliberations of the National Water Quality Monitoring Committee in which the Water Research Commission participates.

2. Main Objective

The aim of the call it to explore the feasibility of transforming surface water quality monitoring from traditional monitoring towards digitally-enabled, real time and AI-supported approaches.. The real time data allows the managers to intervene instantly when a polluter pollutes the water resource. Properly validated, such that the data can undoubtedly stand litigation much better than a once-off sample per month which leaves the resource vulnerable between sampling days in a month. However, there are numerous barriers and enablers that must be circumvented to get to the point where managers trust and invest in technologically driven monitoring as opposed to old methods.

3. Specific Objectives

- Conduct a comprehensive situational analysis of water quality monitoring in South Africa and selected transboundary catchments, covering infrastructure, data flows and institutional arrangements. Identify gaps and limitations in conventional monitoring approaches, including spatial coverage, frequency of data collection, cost, and data accessibility.
- Review and evaluate emerging digital monitoring technologies, including remote sensing, in-situ sensors, IoT platforms, drones, eDNA, and AI-based analytics for applicability in South African conditions. Highlight international advances in surface water quality monitoring using digitally=enabled technology, as well as artificial intelligence.
- Use strategic assessment tools such as SWOT (Strengths, Weaknesses, Opportunities, and Threats) and SOAR (Strengths, Opportunities, Aspirations, and Results) analyses to guide implementation
- Investigate and provide evidence based fundamental information (e.g. by using a S.W.O.T or a P.E.S.T.E.L) critical in decision-making by managers for adopting and on investing in technologically driven monitoring (data acquisition, archiving and reporting).
- Review and Recommend priority pilot projects in collaboration with the Department of Water and Sanitation (DWS) Digitalisation Committee and using the DWS developed Digitalisation design and implementation plan to test and demonstrate digital tools in real-world settings, using the outcomes to refine the national implementation plan and support the scaling of solutions across regions.
- Using selected variables, pilot test the practicality of implementing digitally-enabled, real time water quality monitoring in a selected catchment areas through extensive consultation and collaboration with the DWS affected staff and other key stakeholders.
- Evaluate data integration and interoperability with existing national platforms such as the Water Research Observatory.
- Conduct cost benefit analysis critical in transforming monitoring approaches from traditional to technological advancements
- Recommend the skills and capacity (resources and trained staff) that will be required to realize the transformation and adoption of the technologically driven monitoring
- Develop a roadmap and a policy brief on the justification for scaling digital monitoring systems across South Africa and transboundary catchments. Recommend a strategy to align implementation with the National Water resource Strategy 3, legal compliance, and international data protection standards, while also establishing performance monitoring and stakeholder feedback mechanisms.
- Provide guidelines or recommendations for the integration of risk governance and ethical AI by developing a risk governance framework that addresses cybersecurity and AI ethics; introducing an Ethical AI Charter that promotes transparency, accountability, and compliance with POPIA/GDPR; and ensuring human oversight of AI-driven decisions alongside public accountability through transparent reporting.
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4. Scope of work and deliverables

The project shall include, but not be limited to, the following scope and deliverables:

- **Inception and baseline assessment report** – The project shall commence with a review and update of the Digitalisation Situational analysis report developed in the DWS and a comprehensive baseline assessment of existing water quality monitoring systems in South Africa and selected transboundary catchments.
- A review and update of the DWS-developed Data Management Strategy for Water and Sanitation in South Africa to incorporate the integration of 4IR and remote sensing technologies with in situ instrumentation within South Africa's water quality monitoring networks and programmes, across its entire value chain.**Technology scan/review report** - the project shall undertake a detailed review and update of the Digitalisation design and Implementation plans developed in the DWS as well as emerging digital monitoring technologies, with a specific focus on those that have already been developed, tested and demonstrated in the field. This should include remote sensing (e.g., satellite-based monitoring, aerial imagery, drone-based remote sensing, and radar and thermal imaging), in-situ sensors/IoT-based systems, biological and molecular monitoring tools (e.g., environmental DNA, biomonitoring, etc), biotelemetry approaches, digital and smart monitoring systems, data analytics and artificial intelligence, citizen science and participatory monitoring. The suitability of these technologies will be assessed against traditional laboratory and advanced analytical techniques in relation to South African environmental conditions, operational contexts, and institutional capacity.

- **Feasibility assessment report (technical, economic, institutional, and regulatory)** - A feasibility assessment will then be conducted to determine the practicality of adopting viable digital monitoring system(s) in selected catchments, including transboundary systems. This will cover technical feasibility, cost-benefit considerations, infrastructure and data requirements, skills, capacity and resources requirements, as well as regulatory and institutional readiness for implementation.
- **Design of a conceptual digital monitoring framework and implementation of a proof-of-concept report** - Based on the findings from the feasibility assessment, the project will develop a conceptual digital water quality monitoring framework defining water quality monitoring approach(es), water quality monitoring system architecture, data flows, and reporting mechanisms, and will be aligned with existing national systems, including the Water Research Observatory. To validate the proposed approach(es), a pilot demonstration(s) will be implemented at selected representative sites, including transboundary locations where feasible. Selected technologies will be deployed and their performance evaluated in terms of data quality, reliability, and operational efficiency. The outcomes and deliverables of the pilot demonstration will include a business case comprising the following: a national scale-up and roll-out strategy for the pilot project; a lessons learned and improvement plan report; detailed technology development and customization; a cost-benefit analysis report; an AI risk analysis report; and a capacity-building strategy that addresses both DWS operational requirements and academic research needs.**Final report including a roadmap for scaling digital monitoring systems** - a final report, policy brief and a roadmap for implementation will be developed. This will outline a strategy for scaling digital monitoring systems across South Africa, identify potential funding mechanisms, and propose necessary policy and institutional reforms to support long-term adoption.

5. Additional information

- Proposals are invited from universities and research institutions, consulting firms, technology developers and innovation hubs, as well as multidisciplinary consortia.
- Applicants must demonstrate relevant experience in water quality monitoring, expertise in digital technologies, AI, or data systems, experience in large-scale environmental or water-related projects, and capacity to undertake pilot implementation.
- The project team should include expertise in water quality monitoring and hydrology, environmental engineering, remote sensing and GIS, data science and artificial intelligence, environmental monitoring, systems integration and digital platforms, and water policy and regulation.
- Important to note that this investigation entails extensive consultation and negotiations, convincing authorities, hence the importance of case studies and multidisciplinary teams. The citizen scientists form part of the entire consultation process.
- Additional information that can be included as an attachment as part of the BMS submission includes: company/consortium profile, relevant experience and track record, key personnel and expertise, examples of similar work undertaken and indicative partnerships or collaborations.
- Co-funding opportunities - The Water Research Commission encourages applicants to explore opportunities for co-funding or in-kind support that may strengthen project implementation. Such contributions may include data/case study contribution, access to monitoring sites, equipment, digital infrastructure, specialised technical expertise, data systems, or financial support from partner organisations. Applicants should clearly state the nature and indicative value of any proposed co-funding arrangements.

6. Expected Outcomes

The project is expected to:

- Provide evidence on the feasibility of digital monitoring systems
- Cost benefit analysis comparing technological vs traditional monitoring approaches
- Demonstrate the application of selected technologies
- Inform national strategies for modernising water quality monitoring
- Support improved data availability and decision-making
- Business Case
- National Workshop

7. Budget

A total budget of R1 000 000 has been made available for this project with the following yearly allocations:

Year 1: R300 000

Year 2: R400 000

Year 3: R300 000

Duration: 3 years