Synergizing the Nexus: Leveraging Constructed Wetlands for Integrated resource Management in South Africa

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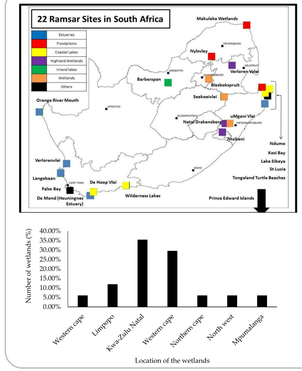
Introduction

The interlinked nexus of water, energy, and food is pivotal for sustainable development, especially in South Africa—a region grappling with resource scarcity and socio-economic inequalities. Constructed wetlands, as a nature-based solution, can play a crucial role in advancing this nexus by providing a multifunctional approach to managing water resources, enhancing biodiversity, and supporting agricultural productivity. In South Africa, governance of these sectors is multifaceted, with significant state and private sector involvement. For constructed wetlands to be successful, it is imperative to navigate these governance structures effectively.

Aim

The project aims to create a unified management framework for South Africa's water, energy, and food sectors by harnessing the multifunctional benefits of constructed wetlands. As wetlands improve water quality, they will simultaneously support agricultural productivity, contributing to food security. A crucial aspect of the project involves comprehensive stakeholder mapping to ensure inclusive engagement across all sectors, paving the way for collaborative governance. Subsequently, the project will leverage digital twins to create virtual models of these wetlands, offering a real-time, interactive visualization of the nexus, allowing for the precise assessment of interventions and facilitating informed decision-making. By integrating nature-based solutions with cutting-edge technology, the project aspires to establish a blueprint for resource management that can respond dynamically to South Africa's environmental and socio-economic challenges.

Overview of Wetlands in South Africa



Constructed wetlands play a minor role in South Africa's water management with no policies and frameworks in place, due to the emphasis on protecting natural wetlands, with few examples existing mostly on inaccessible private lands and no public constructed wetlands. In South Africa, a water-scarce region, approximately 300,000 wetlands, covering 29,000 km² or 2.4% of the land, include 791 types of wetland ecosystems. Of these, 48% are critically endangered, 12% endangered, 5% vulnerable to human activities, and 35% least threatened. These threats are exacerbated by socioeconomic issues like poverty and lack of awareness. Only 11% of these ecosystems are protected, mostly by Ramsar [1].

Methodology

In collaboration with local partners, our team embarked on mapping stakeholders across South Africa's water, energy, and food sectors. Utilizing interviews and questionnaires, we engaged with government bodies, regulatory agencies, and non-governmental organizations to gather comprehensive data. Interviews with key personnel provided deep insights into sector roles and interconnections, while questionnaires helped identify overlapping responsibilities and competing interests among stakeholders. The collected data were analysed to delineate interactions, pinpoint conflicts, and uncover collaboration opportunities (see figures1&2). This analysis was crucial in understanding the complex dynamics within and between the sectors (see table 1). Looking ahead, we plan to employ digital twin technology to develop dynamic models to facilitate scenario development, demonstrating how constructed wetlands can integrate and synergize solutions across sectors. Stakeholders will interact with these digital twins to explore various management strategies and visualize potential outcomes. This project is the second phase of our RAE funded project on Unlocking the Nexus: Digital twins in Sustainable Decision-making for Water-Energy-Food, where we developed a DT model for a constructed wetland in Malaysia.

Results

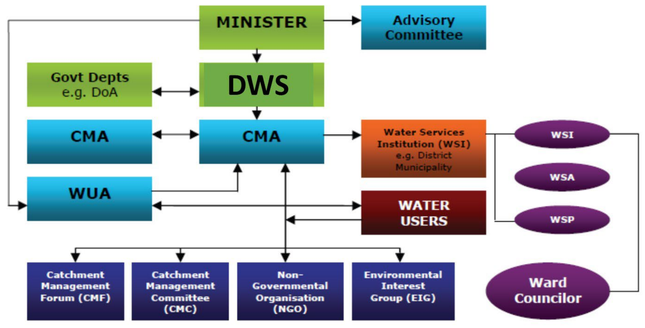
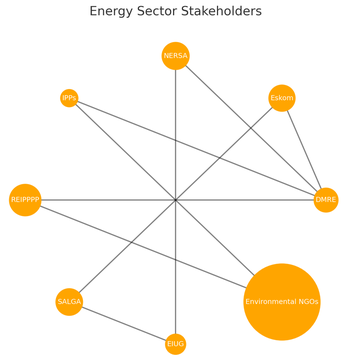
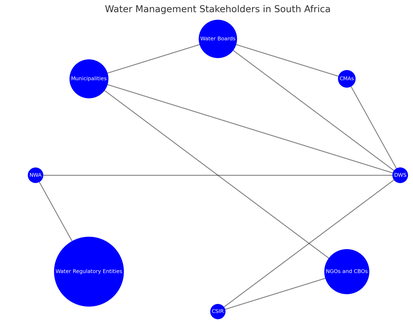


Figure 1: Hierarchy and interrelations amongst the different stakeholders in managing water resources in South Africa

Department of Water and Sanitation (DWS)
Water user associations (WUA)
Water Services Act (WSA)
Water service providers (WSPs)





Intersectoral Coordination Challenges	Stakeholder Engagement and Cooperation	Regulatory and Compliance Issues
The complexity of intersectoral coordination cannot be understated. Each sector—water, energy, and food—operates under its own set of policies, priorities, and regulatory frameworks. The diverse interests and objectives have led to conflicting priorities, especially where resource allocation is involved. For instance, water usage conflicts between agricultural demands and energy production need careful balancing to ensure that the implementation of constructed wetlands does not negatively impact either sector.	Effective stakeholder engagement is critical. Our research highlighted varying degrees of responsiveness and willingness to collaborate among stakeholders. Ensuring active participation from all sectors requires building trust and demonstrating the mutual benefits of constructed wetlands. We believe the development of our Digital Technology model can aid in providing the much-needed transparency and highlight the benefits of the integrated management of these resources.	Constructed wetlands must comply with existing regulations across all three sectors. The National Water Act, energy policies, and agricultural regulations intersect in complex ways that can pose barriers to the rapid deployment of new environmental projects. Navigating this regulatory landscape requires a clear understanding of legal constraints and the ability to negotiate sector-specific compliance challenges.

Table 1: navigating a web of intersectoral challenges

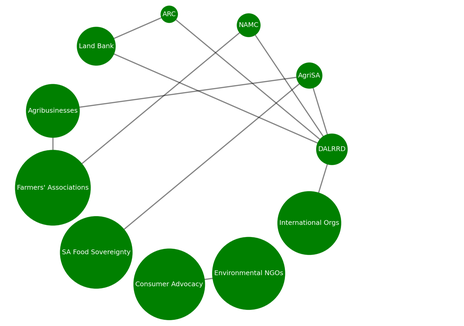
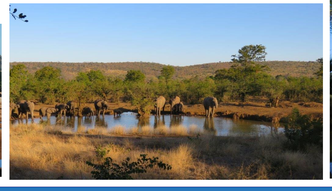


Figure 2: Interactions among WEF stakeholders in each sector, in South Africa, based on literature review and questionnaire



The Makuleke Wetlands is a Ramsar wetland in the northern region of the Kruger National park, South Africa's number one tourist destination [2].

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[1,2] Southern Africa's Ramsar Sites, pictures: Makuleke Wetlands (saramsar.com)
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