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IWR

IWR: ARUA Water
Centre of Excellence Hub

ARUA
African Research
Universities Alliance

ARUA
Water
CoE

Centre for
Environmental
Water Quality

Institute for Water Research

ANNUAL REPORT 2024

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List of Abbreviations

ARGs	Antibiotic Resistance Genes
ARUA	African Universities Research Alliance
AVICC	Aggregate Vulnerability Index for addressing Climate Change
AWaRMN	African Water Resources Mobility Network
BPG	Best Practice Guideline
CEWQ	Centre for Environmental Water Quality
CoE	Centre of Excellence
COP	Community of Practice
CoRE	Cluster of Research Excellence
DPSIR	Drivers, Pressures, State, Impact, Response
DRC	Democratic Republic of Congo
DSS	Decision Support System
DWS	Department of Water and Sanitation
ECR	Early Career Researcher
EDCTP	European and Developing Countries Clinical Trials Partnership
EDCTP2	European and Developing Countries Clinical Trials Partnership
EFTEON	Expanded Freshwater and Terrestrial Environmental Observation Network
EPT	Ecole Polytechnique of Thies
FEAHL	Future Earth Africa Hub Leadership
FEAHLC	Future Earth Africa Hub Leadership Centre
FRIEND	Flow Regimes from International Experimental and Network
GBS	Guillain-Barré Syndrome
GHMs	Global Hydrological Models
GIS	Geographic Information Systems
GRC	Global Research Council
HEI	Higher Education Institution
HKL	Harvest and Kill
IAHR	International Association for Hydro Environment Engineering and Research
ICIREWARD	International Centre for Interdisciplinary Research on Water Systems Dynamics
IHP	Intergovernmental Hydrological Programme
IIASA	International Institute for Applied Systems Analysis
INRAE	Institut National de Recherche Pour L'Agriculture, L'Alimentation et L'Environnement
IWR	Institute of Water Research
JV	Joint Venture
KBV	Koue Bokkeveld
MCDA	Multi-Criteria Decision Analysis
MSU	Michigan State University
NbS	Nature-based Solutions
NbS4AfrRes	Nature-based Solutions for African Resilience
NHLA	National Health Laboratory Services
NICD	National Institute for Communicable Diseases
NMBM	Nelson Mandela Bay Municipality
NRF	National Research Foundation
PPCSPs	Private-Public-Civil Society Partnerships
Pywr-WQ	Python water resources – Water Quality
RESBEN	Resilient Benefits for African Water Resources
RQO	Resource Quality Objectives
RU	Rhodes University
SAHS	South African Hydrological Society
SASBMB	South African Society for Biochemistry and Molecular Biology
SGCI	Science Granting Councils Initiative
SL	Sustainable Livelihoods
SOC	Soil Organic Carbon
SPEI	Standardised Precipitation Evapotranspiration Index
SRI	Sustainability Research and Innovation

TDS	Total Dissolved Solids
UCAD	Université of Cheikh Anta Diop
UCT	University of Cape Town
UKRI	United Kingdom Research and Innovation
UKZN	University of KwaZulu-Natal
UN	United Nations
UNIKIN	University of Kinshasa
UNISA	University of South Africa
WAEMU	West African Economic and Monetary Union
WAR	Water Allocation Reform
WQSED	Water Quality and Sediment Model
WRC	Water Research Commission
WWTW	WasteWater Treatment Works

Staff and members of the Institute

Staff

Professor Nelson Odume, Director
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Dr Morakane Madiba
Dr Phindile Madikizela
Dr Fenji Materechera-Mitochi
Dr Thendo Mutshekwa
Dr Miracle Osoh
Dr Enahoro Owowenu

Associates

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Dr Rebecka Henriksson, Research Associate
Dr Jai Clifford-Holmes, Research Associate
Professor Denis Hughes, Professor Emeritus
Dr Eric Igbinigie, Senior Research Associate
Professor Elizabeth Mack, Visiting Professor
Dr Paul Mensah, Senior Research Associate
Dr Nikite Muller, Senior Research Associate
Professor Tally Palmer, Professor Emeritus
Professor Tony Palmer, Professor Emeritus
Dr Patsy Scherman, Senior Research Associate
Dr Andrew Slaughter, Research Associate
Professor Jill Slinger, Visiting Professor

Registered postgraduate students

Ms Njabulo Dlamini MSc (Hydrology)
Ms Anelile Gibixego MSc (Water Resource Science)
Mr Sakikhaya Mabohlo PhD (Hydrology)
Mr Sivuyisiwe Mapapu PhD (Water Resource Science)
Mr Siyabonga Mazibuko MSc (Water Resource Science)
Mr Voice Mlonzi MSc (Water Resource Science)
Ms Havillah Nnadozie MSc (Water Resource Science)
Mr Simpiwe Ngilana PhD (Water Resource Science)
Ms Harriette Okal PhD (Hydrology)
Ms Mateboho Ralekhetla PhD (Water Resource Science)
Ms Esther Seriki PhD (Water Resource Science)
Mr Sinetemba Xoxo PhD (Hydrology)

2024 graduated students

Ms Mary Chibwe PhD (Water Resource Science)
Ms Regina Dakie MSc (Environmental Science co-supervised by IWR)
Ms Sofia Lazar MSc (Water Resource Science)
Mr Sakikhaya Mabohlo MSc (Hydrology)
Ms Malaika Mahlatsi MSc (Water Resource Science)
Mr Miracle Osoh PhD (Water Resource Science)
Mr Enahoro Owowenu PhD (Water Resource Science)
Ms Pippa Schlegel PhD (Geography, co-supervised by IWR)
Ms Esther Seriki MSc (Water Resource Science)
Mr Edgar Tumwesigye PhD (Water Resource Science)
Mr Peter Wasswa MSc (Hydrology)
Mr Kamva Zenani MSc (Water Resource Science)

Members of the Board

Dr Kwezi Mzilikazi, Deputy Vice-Chancellor: Research, Innovation and Strategic Partnerships, Rhodes University
Professor Joanna Dames, Dean of Science, Rhodes University
Dr Albert Chakona, SAIAB (South African Institute for Aquatic Biodiversity)
Dr Tena Alamirew, Addis Ababa University
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Prof Frances Cleaver, Lancaster University
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Dr Jane Tanner, ARUA Director & Hydrology Head, Institute for Water Research, Rhodes University
Prof Gladman Thondhlana, Environmental Science Department, Rhodes University
Ms Juanita McLean Secretary to the Board; Senior Administrator, Institute for Water Research

Institute for Water Research Director's report

Introduction and Highlights

The year 2024 was significant for the Institute as many milestones were attained and important events took place. Key among these milestones and events were:

- The successful graduation of **13 postgraduate students** (five PhDs and eight Masters students). PhD graduates: Drs Miracle Osoh, Enahoro K. Owowenu, Mary Chibwe, Edgar Tumwesigye, Pippa Schlegel (in Geography); Masters graduates: Mr Peter Waswa, Ms Malaika Mahlatsi, Ms Esther Ahuoiza Seriki, Mr Kamva Zenani, Ms Sofia Lazar, Mr Sakikhaya Mabohlo, Mr Rodney Tholani (in Computer Science), Ms Regina Dakie (in Environmental Science). This is the highest graduation rate in the history of the IWR. I warmly congratulate the graduates and their supervisors.
- The successful presentation of the **professorial inaugural lecture** by Prof. Odume. The inaugural lecture, which was titled "*Water for Ecological and Social Justice*", was well attended by both local and international delegates.
- The official launch of the **Africa-Europe Cluster of Research Excellence (CoRE**) on water resource management for a sustainable and just future. The CoRE was officially launched at Rhodes University from 5 – 8 March 2024.
- The kick-off workshop of the **Water Science Cluster on Africa's water-resilient future**. This science cluster is funded by the National Research Foundation as part of the Future Earth Africa Hub Leadership Centre. The workshop, which also doubled as the closing meeting for the African Water Resources Mobility Network (AWaRMN), took place at Makerere University from 13–16 May 2024.
- The development of a **five-year strategic plan (2025–2029)** for the Institute. The strategic plan has six inter-related strategic goals covering: 1) research, 2) teaching and learning, 3) community engagement and policy influence, 4) funding and partnership, 5) human capability and wellness, 6) visibility, communication and dissemination. This plan will guide how we work in the next five years.
- The official launch of the **Erasmus+ project** on Nature-Based Solutions for African Resilience
- The award of three new Water Research Commission (WRC)-funded projects.
- IWR actively participated in the funding renewal application for the Africa Multiple Cluster of Excellence. The IWR co-lead the work on the Ecologies thematic field.

October 2024 graduation. From left to right Dr Chika Nnadozie, Ms Esther Seriki, Dr Miracle Osoh, Mr Kamva Zenani, Dr Mary Chibwe, Dr Edgar Tumwesigye, and Prof. Nelson Odume.

Prof. Odume delivering his inaugural professorial address.

CoRE launch

A cross-section of IWR staff and students during the strategic planning session.

Funding and Projects

The African Water Resources Mobility Network (AWaRMN) project, funded by the Intra-Africa Academic Mobility Scheme of the European Union, has provided much of the funding for the students within the Institute over the past four years. This project comes to an end in June 2025. As a result, we expect fewer students within the Institute in the next one to two years until we are able to secure replacement anchor funding for our students. The IWR team is working seriously on alternative funding sources for students registered within the Institute.

Other important international projects also came to an end in 2024. These projects include the EDCTP-funded project on Campylobacteriosis, the Swedish Research Council-funded project on Vibriosis, the UKRI-funded project on resilient water benefits (RESBEN), and several WRC-funded projects. The successful completion of these projects reflects the dedication of IWR staff and students to research excellence. By the end of 2024, there was a total of 17 active, externally funded projects (seven international and 10 local projects). The on-going projects cover a range of topics in the field of water quality, human health, hydrology, climate change and nature-based solutions, water and agriculture, water security and governance.

Outputs and impact

The IWR remains a research-intensive environment. In 2024, we initiated a compulsory weekly paper-writing session. Every Tuesday, all academic staff, including post-docs and students, write for four hours in a Pomodoro-like fashion. We will only be able to assess the impact of this initiative in 2025. An important highlight of the year is the successful graduation of 13 students. This is a remarkable achievement, given that there are only two Council-funded academic posts in the IWR. Academic staff members must balance their supervision commitment with those of funders, ensuring that project reports are submitted in time. Once again, I express my deep appreciation to the supervisors, and I also congratulate the graduates and wish them every success going forward.

Publications remain a priority in the IWR. In 2024, a total of 36 papers were published in peer-reviewed journals. International conference attendance and presentations stand at 17. Projects implemented within the IWR have significant policy and practice dimensions, and I invite readers to engage with the various project reports for their impacts.

Community engagement remains a critical pillar within the Institute. As usual, under the leadership of Ms Khaya Mgaba, the IWR continued to engage with high school students in and within Makhanda on the importance of water resources and river health. Key highlights in 2024 include the training of 100 Grade 10 students from Kingswood College on aquatic ecosystem health and water testing, biomonitoring training for 29 second- and third-year students at Stenden University, and awareness raising on the importance of water quality and water preservation for learners from Khutliso Daniels, Graeme College, Ntsika Secondary School, Victoria Girls High School, and Mary Waters High School. I invite readers to refer to the community engagement section of the annual report.

Human capability and wellness

The Institute welcomed two new post-doctoral fellows and three new students in 2024. Drs Phindile Madikizela and Morakane Madiba joined the Institute as post-doctoral fellows. Ms Esther Seriki and Sakikhaya Mabohlo returned as PhD students; Ms Sivuyisiwe Mapapu joined the student as a doctoral student, and Ms Njabulo Dlamini as a Masters student. As I welcome these new students, I encourage them to take advantage of every opportunity the IWR and Rhodes University has to offer.

The research projects of all our registered students are progressing satisfactorily. Our post-docs have contributed immensely to the research enterprise of the IWR. Dr Materechera-Mitochi secured a R3.2 million WRC-funded project, showcasing the value that post-docs brings to the IWR. Dr Djim Diongue play a pivotal role in the Erasmus+ project and the water management plan project for the University.

In 2024, the IWR said goodbye to Drs Rebecca Powell, David Gwapeza and Djim Diongue. Dr Powell was the co-lead of the Erasmus+ project and the Rhodes University water management plan. The IWR continues to maintain an active relationship with these colleagues as we wish them well going forward.

Partnerships

The Institute took part in the following key strategic partnership events in 2024

- A three-month (February – May 2024) visit by Prof. Odume to the Michigan State University (MSU) which deepened the partnership between IWR and MSU as it led to the submission of three joint collaborative research proposals. Discussions are also on-going in areas to further strengthen the relationship between MSU and RU.
- The Sustainability Research and Innovation

Congress (Finland, 10–14 June 2024) and the Africa Satellite Events (Durban, 21–24 May 2024). The SRI Congress brings together leading researchers, policy makers and innovators in the field of sustainability research and innovation. The Future Earth Africa Hub Leadership Centre, which is co-hosted by the IWR, featured prominently at these events.

- The Society for Freshwater (SFS) Africa Chapter training workshops (2024). As the regional secretariate, the IWR led the organisation of a series of training workshops for emerging researchers and students in the field of freshwater science. Through this initiative, the IWR is strengthening its collaborative partnerships with members of SFS globally.
- The first INITIATE Annual Workshop in Morocco, 2024. INITIATE is an international, intercultural, and interdisciplinary network of PhD candidates working on water issues globally. As a founding member of this network, the IWR sent two of its PhD students (Ms Sivu Mapapu and Mr Sakhi Mabohlo) to attend the workshop in Morocco.
- The successful submission of the five-year funding application of the Africa Multiple Cluster of Excellence. The IWR actively contributed to the development of a research proposal for the second phase of the Africa Multiple Cluster of Excellence. We await the funding outcome from the German government.
- The successful participation of the IWR co-led CoRE during the 1st Africa-Europe CoRE Conference in Stellenbosch.
- The IWR participation in the Science Granting Councils Initiative (SGCI) Academic Symposium and Global Research Council (GRC) Africa Regional Meeting held in Gaborone, Botswana (14–15 November 2024).
- The Africa Multiple Cluster of Excellence annual academic coordinators meeting at the Joseph Ki-Zebo University, in Burkina Faso. The Academic Coordinators are responsible for the academic programmes of the entire cluster across all five universities that form part of the ACC.
- The IWR participation in the Modelling for Change, a science and public policy challenge workshop (13–15 November, 2024). The workshop was organised by the UNESCO Centre at the University of Montpellier and the International Centre for Interdisciplinary Research on Water Systems Dynamics

Technical capacity

Progress on the renovation of the stream laboratory has been rather slow. The extent of renovation required would require capital budget as against the maintenance that we had earlier envisaged. We are in communication with the Infrastructure and Operation Division on how best to address the renovation work required. The significance of the stream laboratory cannot be over-emphasised; it is to be re-purposed as the IWR central water quality lab where all water quality analytical work will be done once renovation is complete. Discussions with the Makana Local Municipality are on-going regarding skills development in the field of water quality analysis, and on joint laboratory utilisation.

Ongoing renovation work at the stream lab

Visibility

The IWR seeks to increase its visibility across the University and beyond as an interdisciplinary institute that fosters sustainable impact and innovation locally and globally. We continue our focus on fostering new partnerships, increasing our social media presence via Twitter, and updating and maintaining our website. Thanks to the IWR media team, and in particular Mr David Forsyth and Mrs Margaret Wolff, for keeping our website regularly updated.

We have also focused on increasing our community engagement initiatives. The IWR staff and students attended a number of local and international conferences, including the Society for Freshwater Science conference in Philadelphia (Dr Nnadozie); the SRI congress, and Africa Satellite event (Prof. Odume, Dr Owowenu and Dr Chibwe), the Africa-Europe CoRE conference (Dr Tanner, Dr Gwapedza, Mr Xoxo and Mr Mabohlo); and the University-Industry partnership symposium attended by Prof. Odume, Dr Nnadozie and Dr Materechere-Mitochi.

I extend my gratitude to all staff, post-docs, students and Research Associates of the Institute for their continued support.

Professor ON Odume
Director, IWR

African Research Universities Alliance (ARUA) Centre of Excellence (CoE) report

CoE Hub: IWR, Rhodes University

CoE partners: Makerere University, Université Cheikh Anta Diop, University of Rwanda, Addis Ababa University, University of Lagos, University of Dar es Salaam, University of Cape Town, University of KwaZulu-Natal.

The Water CoE is an international enterprise which operates with a distributed governance system, having two Deputy Directors, one each at Makerere University and the University of KwaZulu-Natal (UKZN). Dr Rebecka Henriksson of UKZN was collectively selected as a new Deputy Director in 2024, representing the ongoing outstanding support she provides the Water CoE. We are the most inclusive ARUA CoE with a hub and eight nodes, and the only one that includes a francophone country. The Water CoE has fully embraced the vision of ARUA to promote excellent African scholarship, and we have attended and contributed actively to all the ARUA meetings, conferences and networking opportunities to date.

This year the UKRI-funded Research Excellence grant (Resilient Benefits for African Water Resources, RESBEN) concluded in March 2024. The project was successfully completed, with 12 students graduated (MSc students from: Rhodes University (2), University of Rwanda (1), Dar es Salaam University (3), Lagos University (1), Makerere University (3), Addis Ababa University (1); and a PhD from Senegal (Université Cheikh Anta Diop), awarded the National Best Doctoral Dissertation in 2023).

These students have already published five papers in international peer-reviewed journals (with two submitted papers under review). The RESBEN developed Adaptive Systemic Approach was published in *Rivers Research and Application* in 2024, authored by all the Water CoE lead researchers, and a Commentary on that paper has recently been published as part of the *South African Journal of Science, Special Issue on Engaged Research*. We continue to work on a Special Issue showcasing the RESBEN project for the pre-eminent transdisciplinary journal *Ecology and Society*. Eight papers are in preparation and will be submitted for review in March 2025. All this has strongly supported ARUA's first Secretary-General, Prof. Ernest Aryeetey's vision of African scholarship.

The ARUA Water CoE submitted a number of proposals in 2023 and 2024 to work towards sustainability for the network. Prof. Sukhmani Mantel, the Academic Manager of the Water CoE, secured an international grant from Erasmus+ Capacity Building for Higher Education, titled 'Nature-Based Solutions for African Resilience'. This project started in 2024 and partners with ARUA Water CoE members Université Cheikh Anta Diop, Senegal, and the University of Cape Town, as well as Ecole Polytechnique of Thies, Senegal, and three partners in the EU: TÜ Delft, Netherlands; AgroParisTech, France, and Institut National de Recherche Pour L'Agriculture, L'Alimentation et L'Environnement, (INRAE), France. The project's overall objective is to enhance the capability of future professionals (current students) and of current environmental specialists and engineers (through professional development courses) for facilitating climate resilience in Africa. The project envisages both North-South and South-South knowledge exchange, and African contextualisation to ensure students and professionals are exposed to courses that incorporate transdisciplinary approaches with high standards of knowledge base, teaching and assessment methods, and quality assurance. This, we believe, is an important strategy not only to combat the impacts of climate change, but also to stem brain drain and migration out of Africa. Further information is detailed under the Project Reports.

Erasmus+ project objectives

Postdoctoral Fellow Dr Djim Diongue joined the IWR from September 2023 to October 2024 as an ARUA Carnegie-funded post-doc. Dr Diongue was involved in the RESBEN project (he achieved the award for the best PhD in Senegal) and spent the year assisting

with preparation of the *Special Issue*, working on the Water Management Plan for Rhodes University, as well as working on the Erasmus+ funded project, Nature-Based Solutions for African Resilience, detailed above. Dr Diongue has completed his fellowship and has begun a lecturing position at Université Cheikh Anta Diop. Gratefully, our collaboration with Dr Diongue continues through the Erasmus+ project.

Dr Djim Diongue with PhD student Phatsimo Ramatsabana carrying out a pump test on a RU borehole for the Water Management Plan

As reported in last year's Annual Report, in 2023 the ARUA partnered with its European counterpart, the Guild network of research-intensive universities, to form Africa-Europe Clusters of Research Excellence. The ARUA Water CoE submitted a proposal and was awarded an **Africa Europe Cluster of Research Excellence (CoRE) in Water Resource Management for a Sustainable and Just Future.** This new partnership is co-led by Rhodes University (representing ARUA) and the University of Ljubljana in Slovenia (representing the Guild). Partners in the CoRE include all ARUA Water CoE partners (listed above) as well as the University of Ibadan, Nigeria. Representing the Guild are the University of Bern, Switzerland; Radboud University, Netherlands; Uppsala University, Sweden, as well as a non-Guild member, the University of Natural Resources and Life Sciences (BOKU), Austria.

CoRE partners from ARUA and the Guild

This year we officially launched the new CoRE in a blended event at Rhodes University from 5–8 March. Representatives from all ARUA partner institutions (nine institutions), including the new partner, the University of Ibadan, joined us in Makhanda for the blended launch. Previous ARUA Secretary-General, Prof. Ernest Aryeetey, also joined in person, together with visiting researcher, Dr Olivier Barreteau (INRAE, France). This was an incredibly exciting event, and included a blended workshop designed to plan the focus areas of the CoRE over the next few years (Days 1 and 2), planning for the Doctoral School proposal (Day 3) and the official CoRE launch (Day 4). We had 42 in-person representatives and 43 individuals joined online.

Representatives from nine ARUA CoRE institutions, together with Rhodes University Vice-Chancellor, Prof. Sizwe Mabizela; DVCs, Prof. Kwezi Mzilikazi and Prof. Mabokang Monnapula-Mapesela; Rhodes University senior management, and previous Secretary-General of ARUA, Prof. Ernest Aryeetey, on the steps of the main admin building.

We were well represented at the recent CoRE conference held in Stellenbosch from 29 September to 2 October. We had an outstanding group of researchers representing six ARUA Universities and one Guild university (see picture and caption below for details). At the conference we met the new Secretary-General of ARUA, Prof. John Owusu Gyapong, and connected with representatives from Uppsala University. Grateful thanks to the Universities who covered their researchers' attendance, and especially to Rhodes University who covered funding gaps where necessary.

Jane Tanner (Rhodes University), Djim Diongue (Université Cheikh Anta Diop), Andreja Zgajnar (Ljubljana University), Rebecka Henriksson (University KwaZulu-Natal), Zerihun Woldu (Addis Ababa University), David Gwapedza (University Namibia), Zoran Bosnic (Ljubljana University), Kirsty Carden (University Cape Town), Sinetemba Xoxo (Rhodes University), Augustina Alexander (University Dar es Salaam), Sakikhaya Mabohlo (Rhodes University), and (missing from the pic) Tadesse Fetahi (Addis Ababa University).

The ARUA Water CoE was successfully awarded a **Doctoral School** for 350 PhD scholarships over 10 years. This programme was championed by previous ARUA Secretary-General, Prof. Ernest Aryeetey, and 16 Doctoral schools were awarded across the continent. The Water CoE proposal included twelve ARUA partners (adding the University of Kinshasa, Democratic Republic of Congo; Cape Coast University, Ghana; and University of Ibadan, Nigeria, to the current eight Water CoE partners) two Guild partners (the University of Ljubljana, Slovenia, and Radboud University, Netherlands), and two non-Guild European Universities (the University of Natural Resources and Life Sciences, Austria, and the University of Montpellier, France). The ARUA secretariat are currently sourcing funding for this opportunity, and the programme is in its planning phase. This represents another success for the partnership.

Continuing our support of ARUA activities outside of the Water CoE, Dr Jane Tanner travelled to Kampala, Uganda to support the ARUA CoE in Notions of Identity, at their annual board meeting. The meeting was chaired by Makerere Vice-Chancellor, Prof. Barnabas Nawangwe, and included three days of fruitful discussions on progress achieved by the CoE, and future plans for sustainability.

Board members at Makerere University, Uganda for the ARUA Centre of Excellence in Notions of Identity board meeting

Finally, I offer thanks again to UKRI for their support over the past few years which has enabled the Water CoE to flourish and grow. Additional thanks to Rhodes University, who have always fully supported the CoE. Special thanks go to previous Director Prof. Tally Palmer who has continued to support the CoE in a multitude of ways. Finally, a big thank you to the researchers and support staff involved in the CoE research and management over 2024.

Dr Jane Tanner
ARUA Water CoE Director

Centre for Environmental Water Quality (CEWQ) report

The Centre for Environmental Water Quality (CEWQ) has made significant progress across its projects in 2024, expanding our understanding of how to manage water resources in Africa sustainably. Highlights include the Grootdraai Dam Catchment, Upper Vaal water quality modelling study, which was presented at the Vaal Management Forum, and the successful completion of the Ecological Water Quality Guidelines project (in collaboration with the University of South Africa, UNISA). These initiatives were supported by the South Africa Water Research Commission (WRC) and highlight CEWQ's influence on water research in South Africa. Likewise, the SASOL-funded Mine Closure project came to an end with important contributions in favour of appropriate mine closure procedures. The European and Developing Countries Clinical Trials Partnership (EDCTP2) project, supported by the European Union and Botnar Foundation, entered its final phase with the submission of final reports in July 2024. The WRC Waterborne Zoonoses Detection and Prevention project and the Vibrancy project, Cyanobacteria-Vibriosis, funded by the Swedish Research Council, are on track with timely deliverables.

The African Water Resources Mobility Network (AWaRMN), funded by the European Union, is nearing the conclusion of its funding cycle. In May 2024, a wrap-up workshop facilitating information sharing and sustainability planning took place in Uganda.

A number of MSc student exchanges occurred, including Marinette Bira and Spirou Genie Lutonadio from UNIKIN, DRC, who finished a six-month exchange at Rhodes University, and Angela Nomatovu and Justine Odu Amulen from Makerere University. Rhodes University students also completed their exchanges: Voice Mlonzi, finished his ten-month exchange at Makerere University in Uganda, while Anelile Gibixego and Siyabonga Mazibuko finished theirs at the Federal University of Technology in Minna, Nigeria.

With the completion of data collecting, the WRC-funded Sundays Great Fish River Catchment project – titled *Governance and Institutional Arrangement for Accelerating Equity in the Water-Land-Agricultural Nexus* – reached a major milestone. The interviews are currently being analysed and transcribed, and a publication is anticipated by January 2025. Regular meetings of the reference group guarantee that the project stays in line with the deliverables. In the meantime, concept notes and drafts of the 2025 WRC proposal are being developed.

The South Africa National Research Foundation (NRF) Community of Practice (COP), which is making good progress, is one of the several projects in which CEWQ staff members are active. The Community of Practice is dedicated to promoting transformative research using creative, African-centred approaches and promoting sustainable development by tackling the particular issues facing the continent in line with the Sustainable Development Goals of the UN, and Agenda 2063 of the African Union.

Professor Oghenekaro Nelson Odume, Dr Chika Nnadozie, and several other African academics authored a special issue published in the *South African Journal of Science* in January 2024. Staff members of CEWQ are also actively involved in the Future Earth Hub Leadership (FEAHL) Centre initiative, which coordinates sustainability initiatives throughout Africa. During the October 2024 induction workshop at Rhodes University, Professors Nelson Odume (Rhodes University), Francis Arimoro (Federal University of Technology, Minna Nigeria), George Nyakairu (Makerere University) Raphael Tshimanga (University of Kinshasa), and Drs CF Nnadozie (Rhodes University), Paul Mensah Mensah (University of Cape Coast, Cape Coast, Ghana) developed the vision, mission, and objectives for the Water Science Cluster.

Looking ahead, CEWQ remains engaged with Eskom for potential project funding and emphasizes collaboration, capacity-building, and impactful research. Dr Chika Nnadozie participated in the 2024 Science Granting Councils Initiative (SGCI) Academic Symposium and Global Research Council (GRC) Africa Regional Meeting held in Gaborone, Botswana (14–15 November 2024) where she presented the CEWQ SDG-pathfinding project, which develops tools to understand and manage SDG interlinkages for sustainable development pathways in Africa. IIASA, INRAE, and GAIA have partnered on this Belmont Forum-funded project.

The CEWQ welcomed Dr Phindile Madikizela as a new

post-doctoral fellow in 2024, further strengthening its team. Congratulations are due to the 2024 graduates: Dr Enahoro Kennedy Owowenu, Dr Miracle Osoh, Dr Mary Chibwe, Dr Edgar Tumwesigye, Ms Malaika Mahlatsi, and Ms Esther Ahuoiza Seriki.

Significant accomplishments for CEWQ in 2024 included the completion of four PhD and two MSc programmes, the publication of at least five peer-reviewed research papers, four under review, and six research project deliveries. We are grateful to our funders for their assistance in making these accomplishments possible. The CEWQ looks forward to completing ongoing projects, growing collaborations, and carrying out its purpose of sustainable water resource management as we reflect on the past year's accomplishment.

Dr CF Nnadozie
Academic Lead CEWQ

Hydrology Research Group report

It has been an active year, tempered by some sad goodbyes. Two post-doctoral fellows who have been key contributors to hydrological development in the IWR, moved on to permanent academic positions at other institutions. Fortunately, their involvement in the IWR remains strong owing to ongoing projects. This year, five students graduated under the supervision of the hydrology group: Peter Wasswa graduated with an MSc in Hydrology in April; in October, four students graduated: Sakikhaya Mabohlo (MSc Hydrology), Kamva Zenani (MSc Water Resource Science), Rodney Tholani (MSc Computer Science), Regina Dakie (MSc Environmental Science) and Pippa Schlegel (PhD Geography). The range of students co-supervised outside the IWR demonstrates the Institute's impact and involvement in the wider Rhodes community. A further PhD student, Sinetemba Xoxo, has submitted his thesis and will graduate with a PhD in Hydrology in April 2025.

PhD graduate Dr Pippa Schlegel, and MSc graduate Mr Kamva Zenani with co-supervisors Dr Jane Tanner and Prof Sukhmani Mantel

MSc Hydrology graduate Mr Sakikhaya Mabohlo with supervisors Dr Jane Tanner and Prof Sukhmani Mantel.

Dr David Gwapedza, who graduated with his PhD at the IWR in 2021 and has been a post-doctoral Fellow since then, has taken up a lecturer position at the University of Namibia. He was a research leader in both sediment modelling, as well as participatory modelling development. Our linkages with him remain strong, through a newly funded Water Research Commission project, and through the Flow Regimes from International Experimental and Network (FRIEND) network where he has a leadership role.

Dr Djim Diongue has worked with the IWR since 2020 on the UKRI-funded ARUA project, Resilient Benefits from African Water Resources (RESBEN), during which time he completed his PhD at the Université of Cheikh Anta Diop (UCAD), and won best PhD thesis in Senegal. He joined the IWR formally in September 2023 and spent a year with us on an ARUA Carnegie Fellowship. Dr Diongue has returned to UCAD to take up a lecturer position. We are grateful to retain strong linkages with Dr Diongue through his involvement in the Erasmus+ Nature-Based Solutions for African Resilience project, as well as the upcoming Mastercard ARUA Doctoral School.

Hydrology team farewell for Dr David Gwapedza. From left PhD student Ms Phatsimo Ramatsabana, PhD student Mr Sakikhaya Mabohlo, Dr Djim Diongue, Dr David Gwapedza, Mr Sinetemba Xoxo, Dr Jane Tanner, MSc student Ms Njabulo Dlamini and Professor Emeritus Denis Hughes

Networking events

The biennial South African Hydrological Society Conference took place from 2–4 October. Dr Tanner represented the IWR, together with Research Associate, Dr Rebecka Henriksson, two post-doctoral Fellows (Dr David Gwapedza, and Dr Djim

Diongue), two students (Sinetemba Xoxo and Sakikhaya Mabohlo) and Dr Augustina Alexander, an ARUA Water CoE partner from the University of Dar es Salaam, Tanzania. Everyone presented at the conference (six papers presented), and ran a workshop on exploring key hydrological contributions to the Mastercard Foundation doctoral school programme, focusing especially on FRIEND-Water hydrological themes.

The team running a workshop at SAHS. From left Mr Sinetemba Xoxo, Dr Augustina Alexander, Dr Jane Tanner, Dr David Gwapedza, Dr Rebecka Henriksson, Mr Sakikhaya Mabohlo and Dr Djim Diongue

SAHS workshop participants

Dr Jane Tanner was invited to give a keynote presentation at the 6th IAHR (International Association for Hydro Environment Engineering and Research) Africa Division Congress in Marrakesh, Morocco from 9–12 December 2024. The conference was themed *African Water Security in the context of Climate Change*. Dr Tanner presented a keynote paper titled: 'The risks of relying on global hydrological model outputs for water resource development in Africa, amidst lagging investment in people'. Dr Tanner also spoke in a high-level panel on governance and cooperation. The conference was held at the Mohammed VI Polytechnic University (UM6P) which is a new ARUA member university. Dr Tanner met with University management around collaboration with the ARUA Water CoE.

International Association for Hydro Environment Engineering and Research (IAHR) on Governance and Cooperation Africa Congress attendees at UM6P

Dr Tanner speaking in the high level panel.

Dr David Gwapedza presented a paper titled 'Enhancing participatory decision making in agricultural water use' at the Ogongo Annual Research Conference from 12–13 November 2024, in Ogongo, Namibia. His co-authors on the paper included Rodney Tholanah, Olivier Barreteau, Bruno Bonte, Sukhmani Mantel, Karen Bradshaw, Bruce Paxton, and Jane Tanner.

Dr Tanner and two PhD students, Saikhaya Mabohlo and Sivu Mapapu attended the INITIATE for PhDs event in Marrakesh, Morocco from 25–29 November 2024. INITIATE for PhDs is a new platform aimed at strengthening the emergence of a robust international, intercultural and interdisciplinary network of PhD candidates working on water-related issues. It gathers PhD candidates and their mentors from 12 universities across the world, among them, three UNESCO International Centres (Delft, Dundee, Montpellier) and aims to provide PhD candidates opportunities to exchange and develop interdisciplinary and transdisciplinary knowledge with PhD candidates from other universities, who are struggling with similar issues.

Dr Olivier Barreteau, Dr Jane Tanner, Mr Sakikhaya Mabohlo and Ms Sivu Mapapu in Marrakesh, Morocco

As part of a series of the working Group on *Co-Creating Water Knowledge, Hydrology Engaging Local People in one Global World*, the scientific decade of the International Association of Hydrological Sciences (IAHS), Dr David Gwapedza presented a webinar on: 'Co-creation in a conflict-ridden space: A reflection' on 23 October 2024.

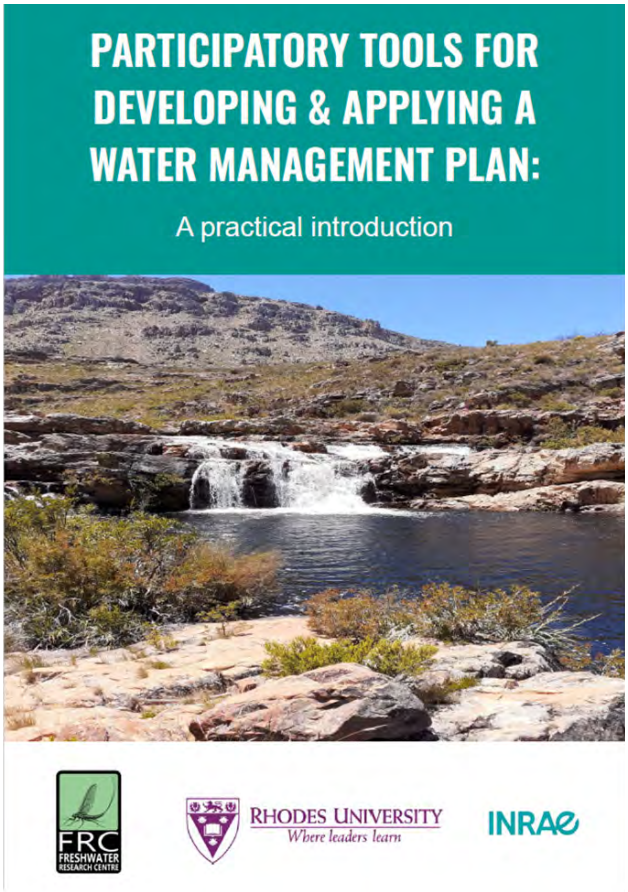
Overview of the research from 2024

The Water Research Commission (WRC)-funded social-hydrology project working with stakeholders in the Western Cape Koue Bokkeveld region concluded in March. However, an additional small grant from ARUA U21 is ongoing. The overall project worked with stakeholders, assisting them to overcome the high levels of conflict around water access and use. The project enabled stakeholders to co- produce a water management plan, using five tools, including two existing hydrological models that informed:

1. the development of an Agent-Based Model in collaboration with Dr Olivier Barreteau (Montpellier, France) and Prof. Karen Bradshaw (Computer Science Department, Rhodes);
2. a decision support tool that enables stakeholders to decide how to share water when there is a deficit, or when the catchment's total allocated amount is unavailable (a novel development, as it incorporates stakeholder impact into the equations); and
3. a modelling tool that helps farmers comply with both their water use allocations, and with the environmental water requirement.

A project impact outcome was the participation of the Department of Agriculture, Western Cape, who collaborated and intend to use model materials with Water User Associations throughout the Western Cape. The ARUA U21 funds have been used to produce a guideline to the tools developed aimed at supporting the Department of Agriculture's efforts to engage Water User Associations. The additional funding is also being used to support PhD student, Sakikhaya Mabohlo, to make further modifications and improvements to the hydrological model used (SWAT+).

Lastly, NRF Protea funding for project team mobility has been extended and will support Dr Tanner's and Dr David Gwapedza's travel to Montpellier in early 2025 to work with project partners, INRAE, on publishing outputs from this groundbreaking work.



Stakeholder report

An ongoing WRC project led by Prof. Sukhmani Mantel examines the water use of cannabis, aimed at supporting small-scale rural farmers in the Eastern Cape. The project team produced a stakeholder engagement report, two deliverables and short videos for smallholder farmers on best practices for growing cannabis. Mr Jamie Botha (PGDip student) used these videos during a stakeholder engagement with Township Cannabis Incubator NPO in the Eastern Cape. The project is progressing towards the final deliverable due in January 2025.

The IWR was requested by Rhodes University to produce a water management plan during 2023. Rebecca Powell and Dr Tanner led the project and submitted the final report in November. The University aims to improve water supply security for campus, and in doing so, move away from reliance on Municipal water supply. The report provides an overview of the potential for water supply supplementation from rainwater harvesting, greywater reuse, and finally, groundwater supplementation. The project aims to provide a guide to investment in water infrastructure development for the University that takes existing water-saving initiatives into account and considers current and future growth parameters to ensure a reliable supply. The project is moving into the engineering phase with the pre-feasibility study underway.

Lastly, an exciting new WRC project focused on improving and mainstreaming IWR developed water quality model WQSAM began in October. This project is a three-year project and is detailed below under new partnerships.

New partnerships

The IWR has a history of involvement in the FRIEND-Water hydrological network through Prof. Denis Hughes. This link has been reestablished through my involvement as the new Regional Coordinator for Eastern and Southern Africa. The Flow Regimes from International Experimental and Network Data (FRIEND-Water) is a UNESCO Flagship Initiative within the Intergovernmental Hydrological Programme (IHP) which seeks to facilitate, promote and foster collaborations across borders between scientists (hydrologists and related disciplines) to conduct studies on shared river basins. FRIEND-Water consists of over 162 participating countries in six regional groups to foster and strengthen international scientific cooperation. Dr Augustina Alexander from the University of Dar es Salaam (an ARUA Water CoE partner) is Deputy Coordinator, and Dr David Gwapedza is thematic lead for socio-hydrology.

At the South African Hydrological Society conference in October 2024, the FRIEND-Water network generously funded a social, which was much appreciated by the SAHS community and conference organisers.

Dr David Gwapedza, Dr Jane Tanner and Dr Augustina Alexander at the South African Hydrological Society FRIEND- Water sponsored Social

A new partnership with the Resource Protection Division of the Department of Water and Sanitation (DWS) has emerged. The DWS has requested training on the IWR-developed water quality model WQSAM; they plan to use the WQSAM model to revise the waste discharge standards nationally. The WQSAM model will assist with calculating the current loads at the Resource Quality Objectives (RQO) sites, determining how much of the load needs to be reduced in order to meet the RQOs. This initiative represents the culmination of 15 years of water quality research in the IWR, and is an example of the real-world impact of IWR's research.

Training at Rhodes University for Department of Water and Sanitation employees part of the Resource Protection Unit

This new partnership is timeous, given the hydrology group was awarded a new WRC grant (A-rated) which started in October titled: 'Enhancing a Platform for Practical Water Quality Management in Support of the Implementation of the Waste Discharge Charge System'. By combining two models developed at the IWR, we are developing a

model better suited for DWS water quality planning needs. The component models are the WQSAM water quality model developed by IWR Research Associate Dr Andrew Slaughter, and a sediment model developed by post-doctoral Fellow Dr David Gwapedza. This project is in collaboration with the Geography Department and uses their data to validate the model. We have agreed to support the DWS Resource Protection Unit to apply the model, while we work on updating it.

Looking forward to 2025

The professional involvement of the hydrology group in advisory committees continues to grow. This includes Dr Tanner's positions as advisory board member of the International Scientific Council of the UNESCO ICIREWARD (International Centre for Interdisciplinary Research on Water Systems Dynamics) based in Montpellier, France; Technical Committee advisory member on Hydrology for the Expanded Freshwater and Terrestrial Environmental Observation Network (EFTEON), and of the ARUA Centre of Excellence in Notions of Identity based at Makerere University. The new Regional Coordinator position of FRIEND-Water will contribute to consolidating many different water initiatives, and will be a specific area of growth in 2025. Prof. Mantel and I serve on the Environmental Committee at Rhodes University. A new post-doctoral Fellow, hosted jointly with the Geography Department, will begin in 2025, and will contribute to the new WRC project focused on water quality modelling.

I am immensely proud of the hydrological team for their commitment and support in 2024, and I look forward to 2025 and more exciting research emerging.

Dr Jane Tanner
Hydrology Group Lead

Community Engagement

May 2024 was a busy month for the IWR Citizen Science team, Khaya Mgaba and Dr Miracle Osoh, who conducted a biomonitoring training session for 29 second- and third-year students of The Disaster Management School of Stenden South Africa Port Alfred.

Stenden college students during Mini SASS field trip with Khaya Mgaba and Dr Miracle Osoh.

In the same month over a three-day period, Khaya and Dr Osoh trained 100 Grade 10 students at Kingswood College in the importance of aquatic ecosystem health and water testing. They were assisted by IWR Masters students, Havilah Nnadozie and Sofia Lazar, and visiting exchange programme students, Angela Namatovu, Justin Amulen and Marinette Bira.

Kingswood college students sampling macroinvertebrates.

In June 2024, Khaya Mgaba and Dr Osoh trained five MBA students as part of an MBA course about the need for water quality preservation, the need for improved wastewater treatment works practices, and the unsustainable degradation of the Bloukrans River in Makhanda.

Postgraduate Diploma - Sustainable Learning students Rhodes University MBA students during Mini SASS field trip)

Training and awareness sessions were held for 50 top science learners from local secondary schools in Makhanda. Participating schools were Khutliso Daniels, Graeme College, Ntsika Secondary School, Victoria Girls' High School and Mary Waters High School. The IWR staff and post-docs assisted Ms Khaya Mgaba: Mrs Margaret Wolff, Dr Djim Diongue, Dr Phindile Madikizela, and post-graduate students, Esther Seriki, Havilah Nnadozie, Njabulo Dlamini worked together to make the training successful.

Makana Top science achievers from Khutliso Daniels, Graeme College, Ntsika secondary school, Victoria Girls' High school and Mary Waters High School.

Kingswood college students with Genie Spirou Kiala and Khaya Mgaba at IWR central lab.

June and September saw ten Environmental Science learners from Kingswood College trained to conduct biomonitoring sampling using Mini-SASS tools and other instruments to analyse water quality and metal loading in freshwater samples.

Project reports

Assessing supplemental water supply for long-term water security at Rhodes University

J Tanner and R Powell

The Institute for Water Research and Drs Jane Tanner and Rebecca Powell were tasked with assessing the potential for supplemental water supply for Rhodes University. The goal is to shift away from reliance on Municipal water, thereby avoiding the ongoing water supply crisis the University has faced for many years, which affects student well-being and enrolment numbers.

Using information collated from a range of sources, we assessed the potential for rainwater harvesting, greywater re-use and groundwater (boreholes) to meet water demand for the University. We also examined the feasibility of each of these options from a cost and infrastructure design, and development perspective.

Our findings thus far indicate that rainwater harvesting and greywater re-use are less efficient in meeting water demand than groundwater, and each of these requires a decentralized (building-specific) system of water harvesting, treatment, storage and redistribution. The groundwater aquifer is relatively resource rich, and the design of a centralized groundwater treatment and distribution system would be the most efficient means of meeting water demand (Plate 1). There is existing groundwater infrastructure that can be utilized if it is upgraded (Figure 1). However, supplementation with rainwater (infiltration galleries that recharge groundwater), and potentially, greywater re-use will be needed to ensure sustainability of groundwater.

Our recommendations to the University have been as follows:
Phase 1: A groundwater treatment and supply system for upper-campus residences, using existing groundwater pipelines and campus boreholes that feed water into a small water treatment plant and reservoir (to be built), before passing safe drinking water to upper campus. Detailed modelling indicates this option to be sustainable.

Phase 2: Expansion of Phase 1 groundwater supply system to supply mid-lower campus. This option is less sustainable on its own, and would require more extensive and complicated infrastructure development. Supplementation with rainwater infiltration galleries and greywater would improve the sustainability of this scenario.

Plate 1: The IWR team, Djim Diongue, Jacobus van Jaarsveld, Phatsimo Ramatsabana and others preparing to conduct borehole pump tests to determine sustainable pumping rates for Rhodes.

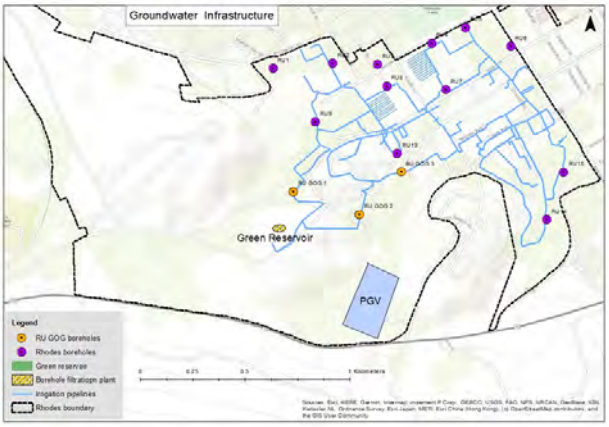


Figure 1: University groundwater infrastructure showing existing boreholes and a groundwater pipeline system that could supply a treatment plant, if these are upgraded.

The realisation of Phase 1 and Phase 2 depends on the outcomes of the application for a Water User Licence for groundwater use, as well as a detailed engineering feasibility study. In addition, the design and development of Phase 1 will be more than ZAR10 million, and so the University is exploring funding through private investment. Our tentative predication is that Phase 1 may only near completion by the end of 2025.

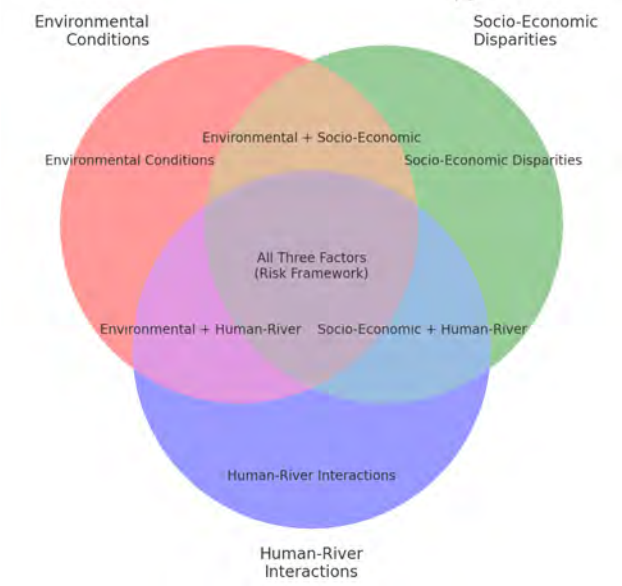
Investigating the multiple risk dimensions associated with Campylobacteriosis - a key poverty-related disease of South African urban-source water environments

CF Nnadozie

July 2021– June 2024

Sponsor: European and Developing Countries Clinical Trials Partnership (EDCTP) supported by the European Union

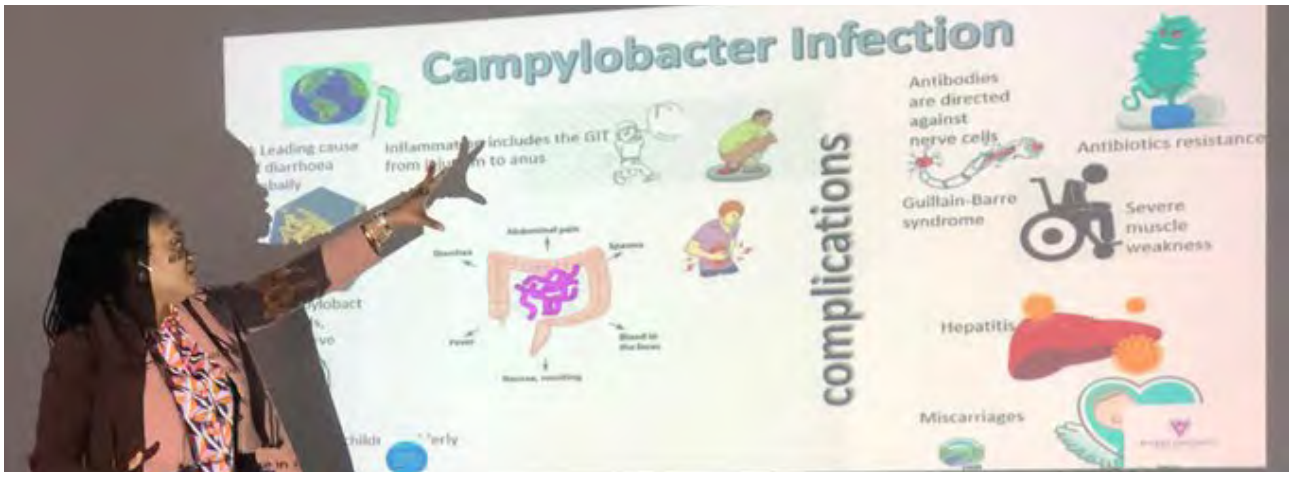
Campylobacteriosis, a disease caused by *Campylobacter* spp., is a leading cause of diarrhoea globally and in South Africa, with complications such as Guillain-Barré Syndrome (GBS). High resistance to first-line antibiotics (fluoroquinolones, macrolides, and tetracycline), driven by gyrA and 23S rRNA mutations and the multi-drug efflux pump *CmeABC*, is prevalent, complicating treatment. Ingestion of faecal-contaminated water is a principal risk factor for Campylobacteriosis.



The multi-dimensional framework for Campylobacteriosis risks shows the overlap between environmental conditions, socio-economic disparities, and human-river interactions, emphasising their interconnectedness and combined impact on exposure risks.

The Swartkops River in the Nelson Mandela Bay Municipality (NMBM) and the Kowie River of Makana Local Municipality, Eastern Cape, South Africa, were investigated in this project. This comprehensive investigation, which has now concluded, reveals the intricate interactions between environmental conditions, socio-economic disparities, and human behaviour that influence exposure risks. The findings highlight the significant public health threats posed by these rivers, particularly in communities with limited access to essential services such as sanitation and clean water. The presence of Campylobacter in these rivers, compounded by the detection of antibiotic resistance genes, underscores the urgency of addressing these environmental health challenges. By integrating Campylobacter occurrence data with the physicochemical properties of river water, socio-economic conditions, and human-river interactions, this study has developed a multidimensional framework for assessing Campylobacteriosis risks. The outcomes of this framework will inform future research, public health interventions, and policy development to mitigate risks and improve community health outcomes.

Workshop on campylobacteriosis in local water sources:



Dr. Chika presents her findings on Campylobacter infection in Swartkops and Bloukrans rivers in South Africa at the B&E Conference Centre, Port Elizabeth.

An integrated approach to timely detection and prevention of waterborne zoonoses outbreak in selected municipalities of the Eastern Cape, South Africa

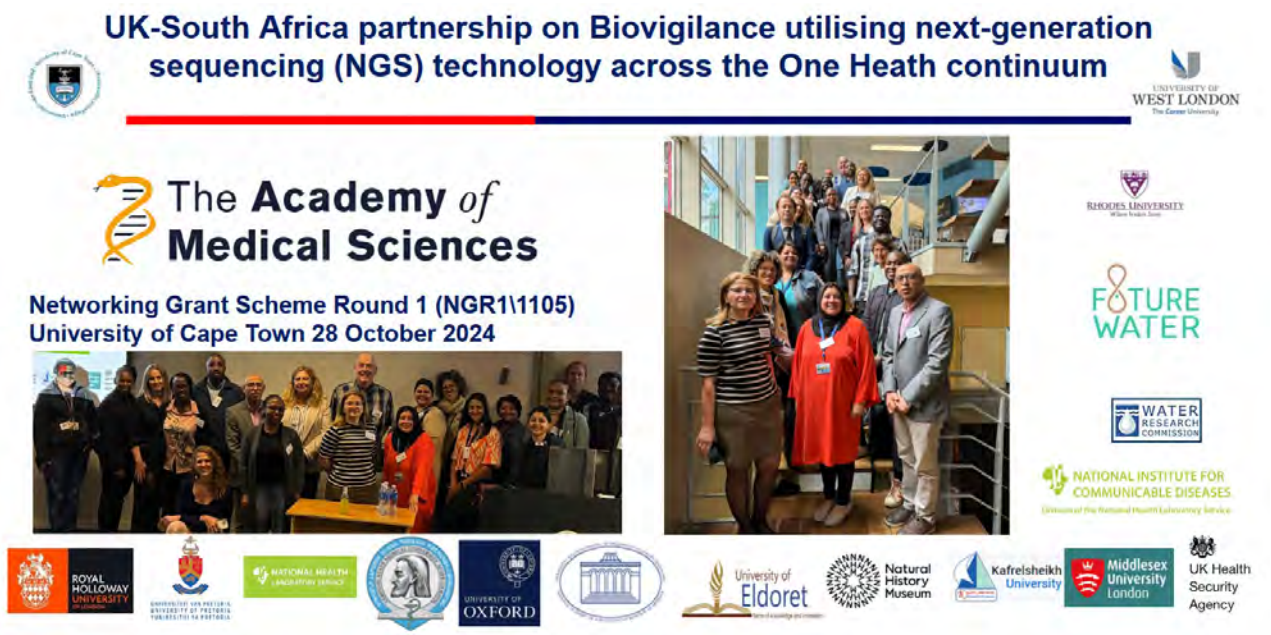
CF Nnadozie, N Odume, F Akamagwuna, SM Mazibuko and N Mgaba
Collaborators: V Msimang (South African National Health Laboratory Services (NHLS) and National Institute For Communicable Diseases (NICD))
April 2023 – March 2026

Sponsor: Water Research Commission

The incidence of waterborne zoonoses outbreaks is expected to rise and worsen due to climate change. Waterborne zoonoses that emerge at the animal-environment-human interface present a health problem. South Africa is a water-scarce country, and people rely on freshwater systems for their recreational, domestic and irrigation activities; furthermore, many communities share these freshwater systems with their livestock.

This study integrates environmental surveillance with community (human) and animal surveillance data to develop an integrated surveillance system to identify emerging infectious disease threats, and the timely detection of environmental, waterborne zoonoses outbreaks. The findings of this study provide critical understanding, such as those zoonoses posing the highest risk, local hotspots for disease transmission, and the animal reservoirs that will potentially and significantly contaminate shared water sources by their presence near water.

Dr Chika Nnadozie: Leading One Health Research to Prevent Waterborne Zoonoses in the Eastern Cape - Presenting at the UCT Workshop on Biovigilance and NGS Technology Across the One Health Continuum.



Participants of the UCT Workshop: Biovigilance Utilising NGS Technology Across the One Health Continuum

Applying an integrated environment, animal and human disease surveillance for early detection and prevention of bacterial zoonoses from a selected source water in Eastern Cape

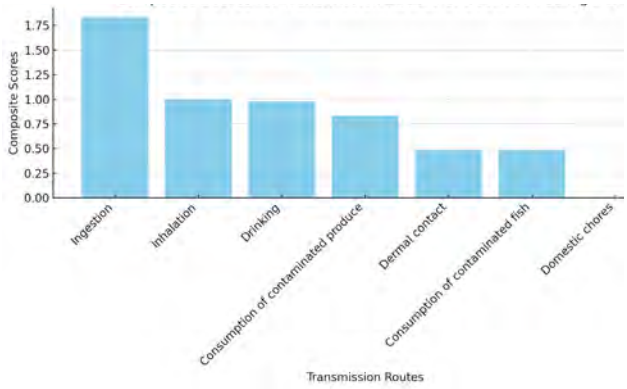
CF Nnadozie

April 2023 – April 2026

Sponsor: South African Medical Research Council

The project aims to identify pathogens that are zoonotic and transmissible through water, based on local human and animal specimen analyses. It also aims to identify the most critical source of the pathogens in the river, and expose the pathways that enable the spread and transport of bacterial disease between humans and animals. The analysis of the composite scores shows that (accidental) ingestion exhibits a more substantial overall contribution to the spread of the selected pathogens in the river ecosystem.

By scrutinising the normalised and summed weights assigned to each transmission pathway, we identify those critical in the spread of the zoonoses. *Campylobacter* spp and *Vibrio* spp are the targeted zoonotic pathogens in this study because their occurrence has been ascertained locally, and they are associated with the critical transmission routes and sources of contamination identified in Aim 1. Their selection was based on a subjective assessment, taking into consideration the available information.



Impact of transmission routes on the spread of zoonotic pathogens: Composite Scores Analysis

Assessing the impact of different pollution sources on the type of microplastics, associated microbial communities, antimicrobial resistance and transport of microplastics in selected urban rivers in South Africa.

ID Amoah, R Indhur, N Malambule, C Nnadozie, S Kumari
Collaborators: Institute for Water and Wastewater Technology, Durban University of Technology, Durban, South Africa
April 2022 – March 2025

Sponsor: Water Research Commission

The Umgeni River in KwaZulu-Natal and the Swartkops River in the Eastern Cape were chosen for this project. The microplastic transport model provides a valuable framework for evaluating the effects of microplastic contamination beyond its source. The problems of microplastic pollution in rivers are thoroughly covered in this study, which offers valuable resources to aid in creating and using pollution-control measures.

The final report, which will summarise the main conclusions and knowledge, is being developed as the project draws to a close. Investigating the microbial interactions of microplastics, this research has greatly improved our understanding of the consequences of microplastics in rivers. A technique for locating the sources and hotspots of microplastic contamination in the watershed is another result of this work that may be applicable in other areas.

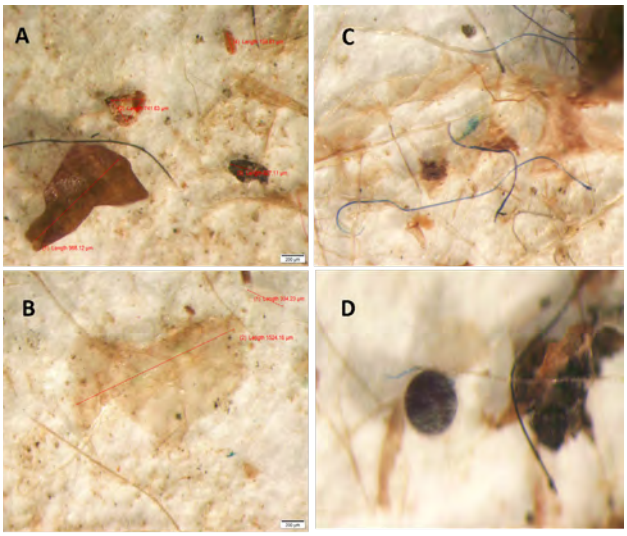


Figure 5. Forms of microplastic found in Swartkops River

Cyanobacteria - the missing link in vibriosis spread

R Amer, G Bwire, R El Shehawy, ON Odume, CF Nnadozie, H Pienaar and E Vellemu
Collaborators: City of Scientific Research and Technological Applications SRTA-City, Makerere University, Stockholm University, Council for Scientific and Industrial Research Natural Resources, Centre for Agricultural Transformation Malawi
January 2022 – December 2024

Sponsor: Swedish Research Council

Climate change has been connected to the spread of vibriosis, a group of illnesses caused by *Vibrio* bacteria. As global temperatures rise, environmental conditions have become more conducive for *Vibrio*, leading to far-reaching effects on ecosystems, humans, and animals. Beyond directly promoting *Vibrio* growth, climate change also affects other ecosystem elements, such as bloom-forming cyanobacteria, which establish habitats and maintain *Vibrio* populations in ecological reservoirs. *Vibrio* infiltration into groundwater is more likely in these systems, and its spread is made worse by

other stressors like plastic pollution. The food web components can be used for SIA and cyanotoxins to establish trophic relations in each system.

The purpose of the research is to investigate the environmental and ecological drivers influencing *Vibrio* populations in natural habitats and to understand how ecological interactions and environmental factors shape *Vibrio* variability. Here, 'ecological interaction' means the transfer of *Cyanobacteria* through food webs, and the role of cyanotoxins in water. The environmental factors include surface- and groundwater quality, biofilm dynamics, and other ecosystem influences. The investigations in this project combine molecular microbiology techniques such as qPCR and advanced statistical modelling (e.g., multivariate regression, permutation tests, Bayesian modelling) to identify and quantify the factors driving *Vibrio* population dynamics in complex ecosystems. This all-encompassing strategy should provide us with mitigation strategies and an improved understanding of *Vibrio's* ecological and environmental dynamics.

Figure 6. Dr Chika Nnadozie (centre) with students Siyabonga Mazibuko (left) and Havilah Nnadozie (right) at a Swartkops site, collecting water and microplastic (for biofilm) samples.

Revision of the 1996 South African water quality guidelines: development of risk-based approach using aquatic ecosystems responses

ON Odume, Neil Griffin, P Mensah, D Forsyth
Collaborators: L Ncube, E van Niekerk
April 2020–January 2024

Sponsor: Water Research Commission

This project revises the 1996 South African water quality guidelines for freshwater ecosystems, with a view to developing risk-based guidelines that are operationalised through a software-based decision support system (DSS). The final system has spatially specific guidelines for a greater number of parameters than the 1996 guidelines. This approach follows the revision of water quality guidelines for other water users in South Africa.

The imperatives for the project arose out of the realisation that 1996 water quality guidelines have limitations in several important areas, including i) non-alignment with approaches to water resource protection; ii) not being sufficiently risk-based; iii) lacking internal coherence between guidelines for different users; iv) not reflecting the full range of critical water quality variables, despite local and international research regarding these variables. The project addressed these short-comings through the development of a multi-tier DSS allowing for risk identification, analysis and management.

Production of risk-based guidelines is data based, and data on responses of taxa to stressors, as well as data on spatially specific water quality have been gathered to support the generation of suitable guidelines. The project has gathered 219,442 toxicological results from international databases, as well as 332,084 water quality records from regularly monitored sampling points around the country.

The software tool for guideline derivation has been developed and is available for download by users.

The guidelines are provided in three Tiers, each with a different purpose. Tier 1 guidelines simply produce ecological category boundary values for 25 inorganic, 45 organic and 26 pharmaceutical compounds using a database of toxicological responses. Tier 2 guidelines produce spatially specific (at ecosystem level 2 scale) risk-based guidelines, using either observed water quality data or macroinvertebrate data to generate an estimate of risk. Tier 3 guidelines are issue-based, and allow users to explore aspects of the risk scores generated by the other tiers. Where insufficient data are available for reliable higher level Tier boundary generation, users should defer to Tier 1 guidelines to provide a risk-based estimation of the impact on freshwater ecosystems of any particular stressor.

This guideline project has been completed, and a process to train users on the application of the guidelines is beginning.

Developing long- and short-term technical solutions, mitigation measures and decision-support strategies that will improve water quality in the Grootdraai Dam Catchment

AR Slaughter, NJ Griffin, S Lazar, ON Odume, F Akamagwunu

March 2022 to March 2024

Sponsor: Water Research Commission

The deteriorating water quality in the Grootdraai Dam catchment on the Vaal River above Standerton has serious economic, social, and ecological implications because of its strategic importance to South Africa's economy. On the economic front, pollution has affected the quality of the raw water, and thus the operation of industries relying on raw water. Some of these industries have had to abstract more water to fulfil their operational needs, but this is not sustainable in the medium- and long-term owing to water scarcity within the catchment. The poor quality of the raw water also implies that it becomes more costly to treat abstracted water to standard fit for industrial use, which then contributes to variable and operational costs of these industries and, in the long term, can lead to job losses and put into jeopardy the viability of the operations of raw-water dependent industries in the catchment.

A water quality modelling approach was adopted to explore future water quality in the catchment and its response to various interventions. The project team engaged stakeholders in the catchment for input as to likely scenarios. The DWS and Rand Water water quality datasets for the catchment have been obtained.

Pywr was used to model yield from the catchment, calibrated against an extant yield model. This approach was taken so as to be able to represent flows at a finer resolution than were contained in the WRMP yield model. For modelling of water quality we had planned on using WQSAM, but there were problems with this approach, and so WQSAM routines were re-coded in Pywr to give Pywr-WQ, which was used for water quality modelling. A water quality model was set up in Pywr-WQ, and calibrated against DWS and Rand Water data to give the baseline condition. Models to medium- and long term timeframes were run in Pywr-WQ where possible, and we used a multiple regression-based model when changes in land use were considered.

Models were based on likely changes in the catchment as suggested by stakeholder in a workshop. Major consideration was given to the effect of climate change, expansion or reduction of coal mining in the catchment, changes in intensive agriculture, and changes in urban areas.

Climate change alone was found to have a limited impact on many water quality parameters, but certain salts and salinity increased relative to the baseline with time. Combining this with a small increase in mining lead to intolerable salinities in the future. Increases in cultivated land led to an increase in nitrogen nutrients, with the associated risk of algal blooms and/or ammonia toxicity. Increasing urban land in the catchment led to increased phosphate levels, which appears to be a function of increased wastewater leakage, a problem reported by stakeholders and the press. Looking at scenarios where a combination of several changes were modelled together did reveal that

management of the catchment can lead to a future where cleaner water can be available, even with an increased demand for water. The modelled impact of mining (as modelled land area under mines) is significant, and uncontrolled increases here are a threat to water in the catchment. However, should coal mining decrease (as is anticipated under the proposed Just Energy Transition process), future salinity threats to the catchment will be reduced.

Vaal Catchment streamflow and water quality modelling in support of the G4 & G5 closure process for Sigma Colliery in Sasolburg

AR Slaughter, NJ Griffin, ON Odume

August 2022 to January 2023, then to July 2024, and possibly ongoing

Sponsor: Sasol Mining via Jones and Wagener

Sigma Colliery is a defunct coal mine that was operated by Sasol Mining (Pty) Ltd. It is situated to the north, west and south of Sasolburg in the Free State. Sasol is taking steps to formally close the mine. As a part of this process, the potential impacts and mine water management considerations for mine closure need attention. The best practice guidelines (BPGs) for this aspect of mine closure are the guidelines of the Department of Water and Sanitation that use source-pathway receptor and risk-based approaches to mine water management. The BPG G4 impact prediction and BPG G5 water management aspects for mine closure outline requirements with which Sasol will have to comply.

Closure of the Sigma Colliery requires that water quality impacts on the Vaal River water are curtailed. Although the Leeuspruit carries water with salinity (mostly as sulphates) and nutrients (most notably as phosphate) to the Vaal, previous surveys have found no impact on Vaal River water quality where the Leeuspruit joins the Vaal River. However, downstream assessments of Vaal River water quality (highway bridge over Vaal River) show decreased quality and there is concern that decant from the Sigma Colliery may be responsible for this.

As part of a larger specialist team, we modelled surface water quality in the Leeuspruit, the Rietspruit (south bank), two unnamed south bank tributaries, and the Vaal River to simulate water quality in the region. This required modelling water quality in the Rietspruit (north bank) as this affects the Vaal River water quality in the Leeuspruit locality. The developed water quality model was then used to assess the mitigation of impacts through scenario analysis.

The Sigma Colliery Defunct Mine area contributed to a small fraction of total flow in the Vaal River, ranging between 0.38% to 0.63% among the different scenarios. Water quality loads from the Sigma Colliery Defunct Mine area were substantially less than the cumulative loads from upstream catchments. Depending on the scenarios assessed, the salinity and sulphate loads from the Sigma Colliery Defunct Mine area ranged from a high of 3.6% of TDS and 4.5% of sulphate at the Vaal Barrage to less than historic loads under other scenarios. While there were some differences in water quality concentrations from the Sigma Colliery Defunct Mine among the different scenarios, the loads from the mine were significantly less than those coming from upstream and from the Rietspruit North. As a result, salinity changes at the Barrage between scenarios were small. In summary, depending on management strategy chosen, Vaal River salinity might be only slightly worse or even slightly better after mine closure.

Governance and institutional arrangements for accelerating equity in the water-land-agricultural nexus: A case study of resource-poor farmers in smallholder irrigation schemes in the Lower Sundays River and Great Fish River catchments.

ON Odume, F Materechera-Mitochi, S Ngilana, M Weaver, E Mack, S Mapapu
April 2023–November 2025

Numerous government policies and interventions have targeted support towards emerging farmers to increase their capacity to contribute positively to the agricultural economy against the backdrop of historical inequities created by the apartheid system. An overarching goal of many policies is the realisation of equity (RSA, 1998). Many government departments, including the Department of Water and Sanitation; the Department of Agriculture, Forestry and Fisheries; and the Department of Rural Development and Land Affairs have designed a variety of policies to ameliorate historical disparities between commercial and emerging farmers. These include the development of small-scale irrigation schemes to support emerging/resource-poor farmers (Ncube, 2017).

The project focuses specifically on a type of agricultural partnership, namely joint ventures (JVs), as an example of a support mechanism adopted by government to facilitate water allocation reform (WAR) at the farm scale. In this project, JVs are understood as a strategic partnership in which the government facilitates the pairing of emerging farmers with established commercial farmers for capital and economic purposes. This was conceived as a mechanism for accelerating equity imperatives within the broader WAR of the Department of Water and Sanitation. The current evidence about the impact of JVs suggests they have not yet been successful in achieving their overarching equity imperative.

This research aims to investigate governance and institutional measures necessary to support emerging/resource-poor farmers at the farm scale. The project makes use of the Lower Sundays River and Great Fish River catchments as case studies to co-explore social, institutional and governance innovations to accelerate equity goals at the farm scale alongside farmers' perceptions of WAR, JVs, and the institutional and governance challenges that may impede success. The objectives of the project are:

1. To examine the disparity between relevant policy intents and implementation on equity goals via joint ventures within the context of water allocation reforms (WAR) in the Lower Sundays River and Great Fish River Catchments.
2. To analyse the enablers and/or barriers to the benefits intended for emerging farmers via joint ventures. Such benefits may include social, economic, livelihoods and technical know-how.
3. To analyse the governance dimensions, and the suitability of joint ventures for realizing equity, efficiency, and sustainability imperatives in the context of water allocation reforms within the Lower Sundays River and Great Fish River Catchments.
4. To explore governance and institutional measures/arrangements/systems, including polycentricity, necessary to support emerging/resource-poor farmers at the farm scale to achieve the imperative of equity.

Project team member and PhD candidate Mr Simphiwe Ngilana during field work on an emerging-farmer farm in the former Thyefu Irrigation Scheme

The project commenced in April 2023 and is currently in its second year. In the past year, data collection, which involved in-depth interviews with farmers in JVs and a selection of key informants, was concluded in the first quarter of the year. This was followed by analysis. Two deliverables have been submitted to the WRC and one progress reference group meeting was held in July. The project team welcomed three additional members: Prof. Elizabeth Mack from Michigan State University, USA, Dr Matthew Weaver from the IWR, and Ms Sivuyisiwe Mapapu from the IWR.

Field photo of a commercial citrus farm belonging to a joint venture partnership in the Lower Sundays River Valley

Deliverable 3 (Report on an analysis of intents of selected policy and implementation outcomes of JVs and WAR)

This deliverable addresses objective 3 of the project: *"To analyse the governance dimensions, and the suitability of joint ventures for realizing equity, efficiency, and sustainability imperatives in the context of water allocation reforms within the Lower Sundays River and Great Fish River Catchments".*

We approached this by focusing on an analysis of South African policies across the sectors of land, water and agricultures to explore the nature equity. The results of the analysis were documented in a deliverable report. The project team is developing this work into a paper that unpacks equity as more than just 'fair shares'; we explore equity's different dimensions, including distributive (fair allocation of resources, benefits and costs), procedural (fairness in decision-making processes), recognitional (acknowledgement of diverse identities and histories) and contextual equity (consideration of specific circumstances and needs), and how these shape justice today. Our analysis shows how post-1994 policies have prioritised redress in the water-land-agricultural nexus through initiatives like the Land Redistribution for Agricultural Development Programme. However, uneven implementation and policy blind spots often perpetuate inequalities and leave communities waiting for meaningful change. Our paper helps to connect the dots between land, water, and agriculture, arguing that policies in one area affect the others.

Our findings show a lopsided focus on distributive equity, shallow evidence of contextual equity and less evidence of procedural and contextual equity across the policies analysed. Without intentional and explicit linkages between policies, integrative efforts required for reform that considers these different equity dimensions will remain a challenge. Our paper serves as both a progress report and a map for future action, asking policy makers to aim for deeper, interconnected policies that put fairness front and centre. We aim to submit the paper to the journal, *Development Southern Africa,* in 2025.

Deliverable 4 (Analytical report on social, economic and livelihood benefits derived from derived water allocation reform)

This deliverable is meant to respond to the fourth project objective: "To analyse the enablers and / or barriers to the benefits intended for emerging farmers via joint ventures. Such benefits may include social, economic, livelihoods and technical know-how". The deliverable is thus an analytical report on social, economic and livelihood benefits derived from water allocation reform. We use a sustainable livelihoods (SL) framework as a lens to analyse the socio-economic and livelihood benefits accrued by emerging farmers in JVs, based on field interview responses. We position this analysis within the broader context of the distributive equity dimension and attempt to evaluate the equity goals and targets of water allocation reforms in South Africa as expressed from different viewpoints (key informants, commercial farmers in JVs, emerging farmers not in JVs). The project team intends to develop this report into a research article for publication in 2025.

Reference group meeting

The progress reference group meeting for the project was held on 17 July and was attended by a variety of stakeholders across the sectors of water, land

and agriculture. A key takeaway from the meeting was the importance of including regulations and municipal policies in policy analyses as these pre-set the operational aspects of policy. The project team was also advised to consider the significance of the recently approved revision of the Pricing Strategy for Raw Water Use Charges that will come into effect from 2026/27 onwards. Section 3.1.1 of the strategy may be of interest specifically as it refers to the application of the charges to resource-poor farmers.

Capacity building

The project supports one PhD student, Mr Simphiwe Ngilana, whose PhD research project takes a deeper analytical look at the role of the regulatory environment in the implementation process of joint ventures in South Africa. Mr Ngilana is supervised by Prof. Odume and Dr Materechera-Mitochi; a student report by Mr Ngilana is included in this annual report.

Improving process representation in a hydrological model for enhancing water users' benefits in the Koue Bokkeveld farming region, South Africa.

D Gwapedza, S Mabohlo
Collaborators: SS Dash (University College, Dublin. Ireland)
November 2023 – May 2025

Funder: ARUA/U21

Background

In November 2023, we secured the ARUA_U21 funding, marking the commencement of our endeavours. The initial phase focused on identifying specific hydrologic processes crucial for representation. Our broad aims were to:

- Improve and expand the hydrologic process representation for the SWAT+ model application in the Koue Bokkeveld (KBV) catchment, South Africa.
- Develop an effective irrigation framework that captures the complex irrigation sequences prevailing in the study area.

To ensure the relevance and effectiveness of our project, we leveraged a hydrology feedback session during a stakeholder engagement workshop in November 2023 in the KBV. During this session, we shared the outcomes derived from the existing model and actively sought feedback from water users. This engagement proved invaluable in pinpointing areas for improvement that formed the basis of this project.

Collaboration workshop report

The workshop for improving the representation of irrigated catchments in the SWAT+ model was conducted at the Rhodes University Library from the 11–14 June 2024. This workshop aimed to improve the SWAT+ model structure by incorporating the complex dynamics of the intensively irrigated Twee and Leeu River Catchments. These dynamics include groundwater abstraction, springs/ponds, and irrigation scheduling that could not be adequately represented using the regular version of the model.

Model set-up review

In the first day of the workshop, the initial SWAT+ model set-up for the Twee and Leeu catchments (Western Cape, South Africa) were reviewed and interrogated. The team agreed to make changes in irrigation scheduling to improve the set-up for the modelled catchments. The calibration and validation approach were also discussed; the discussion resulted in consideration of multiple component calibration and validation approaches which will include verification of simulated crop ET against ET computed with the crop-coefficients method.

Irrigation conceptualisation

After reviewing the original model set-up in which irrigation was implemented based on a plant water stress auto-irrigation function, participants made changes and scheduled irrigation in the model based on soil water deficit. Switching to a soil water deficit irrigation schedule was decided after realising that few irrigation events were triggered by the previous irrigation approach. To better represent irrigation conditions in the semi-arid Twee and Leeu Catchments, we opted to implement a soil water

deficit threshold of 50% below field capacity. Dams were used as the primary source of irrigation with aquifers set as back-up source for irrigation. When the dam is 95% empty, water withdrawal for irrigation switches to an aquifer source. Unlike in the original model, Harvest and Kill (HKL) was incorporated in the irrigation schedule to suspend irrigation after a growing season.

Outcome and results

The model suspended irrigation after harvesting when the Harvest and Kill (HKL) option was added in the management schedule of cash crops (Figure 1).

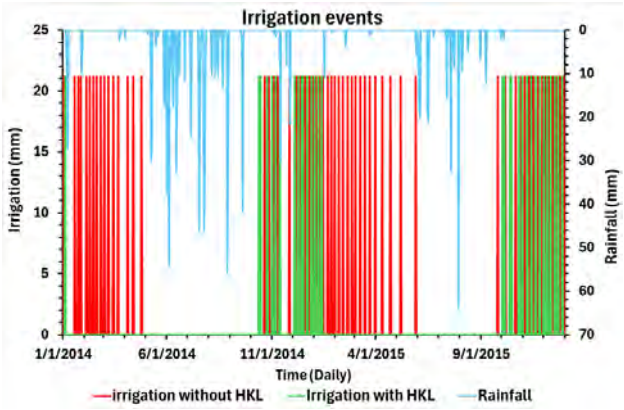


Figure 1: Irrigation frequency when Harvest and Kill (HKL) is included in the management schedule vs when Harvest and Kill (HKL) is not included.

Unlike the previous version, the model now performs irrigation from a pond. The farm dams, including those that are off channel (ponds) in the study catchments, can now be explicitly represented and effectively used for irrigation in the model set-up. Additionally, the model now realistically removes water from the groundwater storage when aquifers are used for irrigation.

Conclusion

The workshop enabled us to make significant improvements to the model which have ultimately made the model more accurate and useful because of its applicability in the study area. Water users can now make more robust decisions regarding climatic and seasonal impacts on hydrology and intersections with irrigation requirements.

Figure 2: Project team during the collaboration working session at Rhodes University. Left: Dr Sonam Sandeep Dash; Middle: Dr David Gwapedza; Right: Mr Sakhi Mabohlo

Nature-based solutions for African resilience

SK Mantel, R Powell, M Weaver, M Wolff, S Xoxo
Collaborators: K Carden (University of Cape Town), S Faye (Université of Cheikh Anta Diop), A Fall (Ecole Polytechnique of Thies), O Barreteau (Institut National de Recherche Pour L'Agricuture, L'alimentation et L'Environnement, France), F Cernesson (AgroParisTech, France), J Slinger (Delft University of Technology)
February 2024 – January 2027

Sponsor: Erasmus+ Capacity Building for Higher Education

Nature-based solutions (NbS) are actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature. NbS go beyond, and complement, land restoration for stemming the loss of biodiversity and ecosystem services, through the incorporation of nature-conscious design principles. These solutions enhance the availability of water, improve water quality and reduce risks of water-related disasters linked to climate change (*United Nations World Water Development Report 2018: Nature-Based Solutions for Water*; https://www.unwater.org/publications/world-water-development-report-2018).

The NbS for Africa Resilience (NbS4AfrRes) project's overall objective is to enhance the capability of future professionals (current students) and of current environmental specialists and engineers (through professional development courses) for facilitating climate resilience in Africa. As a first step, the project focuses on promoting NbS in Higher Education Institution (HEI) curricula, which aligns with the focus of the Rhodes University Institutional Development Plan focus on diversifying and growing research and post-graduate students. NbS is also high on the agenda of the EU (Green Deal), Africa (Agenda 2063 for Africa's Development: *The Africa We Want*) and national (climate) policy documents in Senegal and South Africa. Considering the need to build capacity for these solutions in Africa, the project goes beyond university curricula in HEIs and responds to the need to build the capacity of professionals who are an intricate part of the design, development and implementation of resilient infrastructure. We are working with civil engineers (the designers) and environmental scientists (the gatekeepers) of infrastructure development.

The project was launched with team members in Cape Town in March 2024 (Figure 1) and internationally on Earth Day, 22 April 2024, as a blended event with contributions from partner university leaders. The consortium consists of two universities in South Africa (Rhodes University and the University of Cape Town [UCT]), two universities in Senegal (Ecole Polytechnique of Thies [EPT] and Université Cheikh Anta Diop [UCAD]), and three partners in the EU: TÜ Delft (Netherlands), AgroParisTech (France) and Institut National de Recherche Pour L'Agricuture, L'alimentation et L'Environnement (INRAE, France). The project also builds upon the African Research University Alliance (ARUA) Water Centre of Excellence (CoE) and African Water Resource Mobility Network (AWaRMN) for sharing knowledge and training future professionals. The project envisages both North-South and South-South knowledge exchange and African contextualisation to ensure students and professionals are exposed to courses that incorporate inter- and transdisciplinary approaches with high standards of knowledge base, teaching and assessment methods, and quality assurance. This, we believe, is an important strategy not only to combat the impacts of climate change, but also to stem brain-drain and migration out of Africa.

Figure 1: The NbS4AfrRes Project Team at the launch meeting in Cape Town

Designing and implementing inclusive NbS requires specific knowledge and new approaches with close involvement of all stakeholders. This means that we need to train engineering students in new ways and equip professionals with new insights and skills. To this end the project consists of seven Work Packages (Figure 2), all contributing to the following expected results:

- Revised curricula in the field of environmental sciences and civil engineering. This revision means inclusion of: state-of-the-art knowledge about NbS and related climate resilience, interdisciplinary / transdisciplinary skills / co-creation, ethical considerations, and real-life assignments for students with local stakeholders.
- A network of expertise and joint activities across the curriculum partners.
- Teaching staff equipped with the latest insight in NbS through Training-of-Educator activities.
- Ongoing training programmes (and related continued partnerships) for professionals / alumni in NbS.

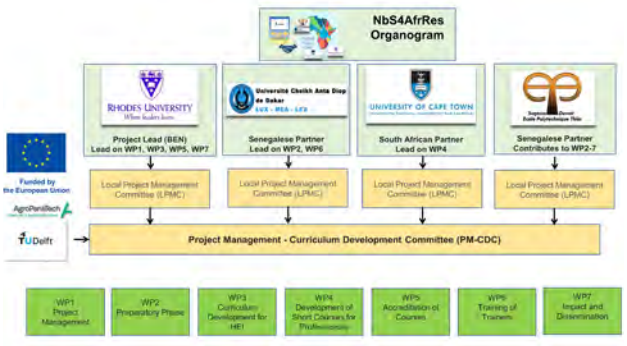


Figure 2: Organogram of the NbS4AfrRes consortium team and the Work Packages under the project

To ensure that the project is cognisant and inclusive of the needs of the local beneficiaries and stakeholders, these stakeholders have been involved from the start in co-designing the educational programme. The HEI stakeholders (students, alumni, University administrators, government department

representatives responsible for higher education) were surveyed under Work Package 2 (Figure 2: WP2, led by UCAD). The needs analysis revealed significant gaps and challenges in integrating NbS into education and professional training, including:

- Insufficient NbS integration in curricula: limited presence of NbS concepts in existing educational programmes, especially in foundational courses.
- Lack of multi-disciplinary skills: a gap in combining technical, ecological, and social aspects, hindering a holistic approach to NbS.
- Practical application challenges: inadequate opportunities for hands-on training, resulting in limited real-world experience with NbS projects.
- Insufficient tools and resources: limited access to data analysis tools and methodologies, affecting the ability to evaluate NbS effectively.
- Weak stakeholder engagement: challenges in involving communities, policymakers, and professionals in participatory NbS planning and implementation.

Many of the above identified skills and knowledge gaps will be addressed under Work Packages 3 and 4 (Figure 2), via a diverse set of HEI and Professional courses. Under Work Package 3 (Curriculum Development for HEI), the project is working on contextualising and updating six courses originating from European partners, noted below:

- Building with Nature (TU Delft)
- Beyond Engineering: Building with Nature (TU Delft)
- Responsible Innovation: Ethics, Safety and Technology (TU Delft)
- Joint Water Management and Planning in Social-Ecological Systems (AgroParisTech/INRAE)
- Multi-disciplinary Research Methods for Engineers (TU Delft)
- Co-Creating Sustainable Cities (TU Delft)

Four of the six courses will be included in existing or new degrees at the four African HEI partners.

At the same time, under Work Package 4 (Development of Short Courses for Professionals), we are pulling out a key set of skills from the HEI courses to develop six courses for professionals, that align with training needs identified under the needs analysis (WP2). These courses and the HEI curricula will be piloted in each HEI in 2026.

Outputs and Impact

Survey and interviews with South African and Senegalese stakeholders (over 250) under Work Package 2; Presentation at RU120 Sustainability Colloquium; Launch videos (4 and 10 mins) by project team; an article in *The Conversation* (in prep).

Determining water use of the cannabis tree in the Eastern Cape and KwaZulu-Natal provinces

SK Mantel
Collaborators: AR Palmer (IWR), S Gokool (University of KwaZulu-Natal), A Clulow (University of KwaZulu-Natal), K Chetty (University of KwaZulu-Natal), S Tesfay (University of KwaZulu-Natal), T Mabhaudhi (University of KwaZulu-Natal), R Kunz (University of KwaZulu-Natal)
April 2021 – March 2025

Sponsor: Water Research Commission

Interest in *Cannabis sativa* as a feasible, high-value crop for emerging small-scale farmers is increasng. *Cannabis sativa* is a multi-purpose crop that can be grown for fibre, seed, oil and medicinal properties, as well as having bioenergy potential, and numerous other environmental benefits, such as phytoremediation. Despite being one of the oldest cultivated crops, little is known about the water use of the crop except for the consensus that it is a water-thirsty crop.

The proposed project aims to produce new knowledge and information to guide a growing interest in *C. sativa* in response to the changing legal and regulatory requirements, as well as an increasing drive to follow environmentally sustainable development pathways (e.g., bioenergy). Water use estimates will be determined through field-based trials, and pot experiments. The field-based trials and pot experiment data will be used to parameterise the AQUACROP model, and

national scale-model runs will be undertaken to provide simulations of crop yield, water use and water productivity. These will be combined with bioclimatic suitability mapping using the MAXENT model, with the resultant product mapping areas of high to low *C. sativa* production potential.

Distribution maps of the current areas of *C. sativa* will be produced using high-resolution hyperspectral imagery. Additionally, complementary maps of potential target areas for *C. sativa*, where dual environmental and economic benefits may be recognised, will be produced. These aspects will be included in a preliminary framing document to guide stakeholders at all levels and decision makers across the agricultural, water and development sectors. This project will provide the necessary understanding of the production potential of *C. sativa* and, more importantly, the potential knock-on impacts on the water resources and downstream water availability. Without this knowledge, adequate water provision for citizens and sustainable development could be compromised if continued expansion of *C. sativa* cultivation occurred.

The aims of the WRC project are:

- To conduct a scoping review of available literature on the water use, distribution and agronomic management and value chain of *C. sativa* crops for both fibre and oil production.
- To map the extent and distribution of *C. sativa* stands as well as identify suitable growth areas.
- Determine the water use and yield of *C. sativa* for either fibre or oil production using field-based measurements.
- Undertake multi-scale modelling of the water use, yield and potential hydrological impacts of *C. sativa*.
- Undertake a preliminary socio-economic feasibility assessment based on value chain principles including suitable areas for growth and best management practices.

The project commenced in April 2021. Since the last report, two deliverables were submitted and accepted by the WRC. The team is now writing up the final deliverable due on 15 January 2025.

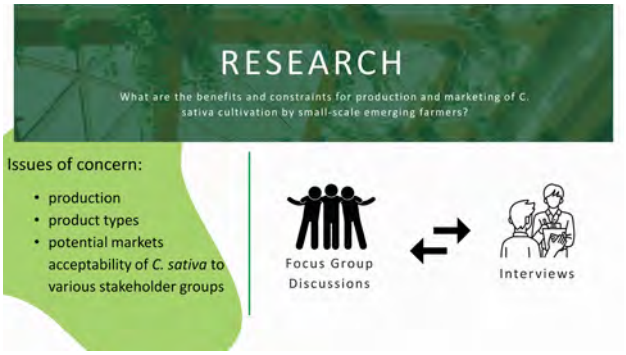
Deliverable 6 (*Cannabis sativa* Water Use Estimates based on Pot and Field-based trials)

The report presented the methods and results for two MSc students from UKZN: Mr Gary Denton (MSc candidate, University of KwaZulu-Natal, Chapter 2) and Ms Sindiswa Mbelu (MSc candidate, University of KwaZulu-Natal, Chapter 3) that address Project Aim 3. Two chapters of the report were dedicated to the background of the crop modelling activities using AquaCrop. The results of the modelling will be included in the final report and this report was targeted to gather feedback from the Reference Group members on the planned way forward for the modelling. These chapters provided an updated methodology for the national-scale modelling of yield and water use of *Cannabis sativa* and address Aim 4 of the project.

Cannabis pot experiments conducted by Ms Mbelu at University of KwaZulu-Natal

Deliverable 7 (Stakeholder engagement workshop report)

This report partially addressed Project Aim 5. The report built on the previous six deliverables, with the aim of providing a preliminary framing of the value chain aspects for *C. sativa*. The report included the background and literature review, with focus on two recent South African theses that researched the smallholder, traditional / legacy farmers in Mpondoland. The recent stakeholder engagement is being designed and conducted by Mr Jamie Botha, and includes a meeting with Dr Ncebakazi Galada, CEO of the Township Cannabis Incubator NPO. We discussed the complexities of the cannabis permit process and the specific documentation required, and the involvement of indigenous farmers in their research study and the challenges posed by poor soil quality. This meeting was followed by a stakeholder workshop the results of which will be presented in the final report.



Stakeholder engagement research planned by Mr Botha

Outputs and Impact

A stakeholder engagement report, two deliverable reports to the funder (Deliverables 6 and 7) and production of short videos for smallholder farmers on best practices by the project team.

The African Water Resource Mobility Network (AWaRMN)

Collaborators: Rhodes University, South Africa; University of Kinshasa, Democratic Republic of Congo; Federal University of Technology, Nigeria; Makerere University, Uganda; National School of Hydraulics, Algeria; TU Delft, The Netherlands (technical partner).
January 2024–November 2024

Sponsor: The Intra-Africa Academic Mobility Scheme of the European Union

The African Water Resources Mobility Network (AWaRMN) is a multi-partner project of the European Union (EU)-funded Intra-Africa Academic Mobility Scheme which aims to foster collaboration and cooperation between higher education institutions in Africa in the water research sector through mobility in Africa. The overall objective of the project is to enhance human capital development in Africa, while strengthening intra-African cooperation in higher education as called for by Agenda 2063. The project, initiated in 2019, is a collaboration between five partner institutions on the continent: Rhodes University in South Africa, the University of Kinshasa in the Democratic Republic of Congo, the Federal University of Technology in Nigeria, Makerere University in Uganda, the National School of Hydraulics in Algeria, and TU Delft in the Netherlands. The Institute for Water Research is the project lead. To date, the project has successfully supported 32 MSc students, 12 PhD students and 12 academic and administrative staff on exchange programmes.

2024 Overview

The year 2024 marks the final full year of the project's operations, which has prompted the project management team to direct its efforts towards transitioning the project into a collaborative platform aimed at sustaining research capabilities across stakeholders in the field of water resources in Africa through various avenues beyond the project's end. In response to this goal of successful transition, an impact and sustainability committee was formed to steer the plan for ensuring the sustainability of the network. The project team applied for a six-month extension of the project into 2025 to accommodate uncontrolled delays incurred through visa applications, et cetera. The extension application was successful, and the European Union extended the project completion date to June 2025. The extension will ensure that all staff and students with outstanding mobilities will be able to complete their mobility within the project duration.

Mobility

There was ongoing mobility for staff and students this year. Table 1 provides a summary of mobility as of November 2024 and indicates that all partners participated in mobility of either staff or students.

Table 1: Summary of mobility in 2024 and expected in 2025 by partner institution.

University	Staff mobility		Student mobility	
	2024	2025	MSc	PhD
Rhode University	1	1	6	4
FUT, MINNA	1	0	4	2
Makerere	1	0	5	2
UNIKIN	0	0	4	2
ESNSH	0	1	3	1
TOTAL	3	2	16	11

Strategic vision for sustainability

One of the main activities related to this transition was the workshop on strategic vision for impact and sustainability that was held in Kampala, Uganda, from 11–16 May 2024. Representatives from the five institutional partners, and potential future external partners from other institutions within and outside Africa gathered to deliberate on the sustainability strategy of the AWaRMN project and develop an action plan for how to operationalise the transition into a collaborative network.

Figure 1: AWarMN institutional partners and external partners at strategic vision and sustainability workshop in Kampala, Uganda.

The workshop was a hybrid event and included representatives from Makerere University, Uganda; Karatina University, Kenya; the University of Cape Coast, Ghana; ICATALIST, Spain; the World Bank; Michigan State University, USA; Future Earth Africa Hub Leadership Centre, and the Dundalk Institute of Technology, Ireland. Key outcomes of the workshop include:

The formation of the Water Science Cluster affiliated to the Future Earth Africa Hub Leadership Centre (FEAHLC)

The concept of Sustainability Science Clusters was conceptualised by the FEAHLC. Science clusters are meant to be semi-autonomous and adopt a decentralised leadership approach comprised of co-leads from different African countries. Science clusters are to be strictly African led, though international partners can be invited to be part of a cluster. Science clusters are aimed at driving disciplinary excellence and addressing problems that arise in the science-policy-practice domain. The existing AWaRMN network, in conjunction with the external partners that were invited to the workshop, are ideally positioned to form a Science Cluster, and this is the premise on which the Water Science Cluster has been established.

Figure 2: Workshop participats at strategic vision and sustainability workshop in Kampala, Uganda]

Action plan for the formation of a new collaborative platform (AWaRMN)

Based on engagement at the workshop and the inputs from an interactive visioning exercise, the action plan for the formation of the new network was agreed on and responsibilities delegated. All core institutional partners are members of the new platform: African Water Resources Network (AWaRN) and several new partners have joined. There have been numerous, ongoing activities surrounding the organization of AWaRN, such as establishing the platform's vision, mission and research agenda, work on a foundational review paper on Africa's pressing water challenges, and setting an agenda for Africa water research, establishing the governance structure, capacity development approach and visibility and marketing strategy for the platform.

Achievements

The year was marked by several of the students on the project completing and graduating. A total of eight PhD students completed their projects within AWaRMN. Of the eight, four students are due to graduate in 2025 and four graduated in 2024. Within the IWR, these graduates are Dr Edgar Tumwesigye from Uganda, Dr Enahoro Owowenu from Nigeria, Dr Mary Chibwe from Zambia. The project also had five MSc degree-seeking mobility students graduate from across the network. Within the IWR these included Ms Sofia Lazar from Algeria, and Ms Esther Seriki from Nigeria. The IWR graduates were honoured in a graduation celebration at the Institute and graduated on 11 October 2024.

Makerere University, the project's institutional partner in Uganda, was selected for a site visit by an evaluation team from the African Union (AU) on 12 March 2024. The AWaRMN project was nominated by Makerere University leadership as an example of a highly successful, ongoing international project to serve as a point of benchmarking performance excellence. This was a great achievement for the AWaRMN project and a commendable acknowledgement for the Makerere University team.

Figure 6: AWaRMN colleagues and mobility students at Makerere University with representatives from the African Union on site visit in March]

AWarMN MSc student on mobility at IWR from the Federal University of Technology in Nigeria was a finalist in the FameLab Science Communication competition and made it to the national finals held at the National Research Foundation Auditorium in Pretoria, South Africa, on 19 September 2024.

Equity dimensions of the Nelson Mandela Bay water crisis and the implementing context as enabler or barrier for uptake of translatable lessons from the Cape Town water crisis

ON Odume, C Murata, J Alexander, K Mgaba, V Mlonzi, C Matomane, T Masilela
Collaborators: O Barreteau (Montpellier University), E Mack (Michigan State University)
April 2023–March 2025

Sponsor: Water Research Commission (WRC)

Water security is a major challenge in South Africa, with the Nelson Mandela Bay Metro (NMBM) experiencing one of the country's most severe water crises. This project, commissioned by the Water Research Commission (WRC), investigates the equity dimensions of the water crisis and assesses the implementation context for translatable lessons from Cape Town. Through a participatory research approach involving the Gqeberha Living Lab (NMBLL), this project seeks to explore the distributive, procedural, and contextual equity dimensions of water security, governance challenges, and community-driven solutions.

Over the past year, significant progress has been made in qualitative and quantitative data collection that incorporated interviews, surveys, fieldwork, stakeholder engagement, participatory mapping, and focus group discussions. The findings illustrate how vulnerabilities, inequalities, and governance structures impact access to water security and how communities have responded to the crisis. They also revealed how and where water security has been affected at the grassroots level. The insights generated are critical for informing policy and practice aimed at improving water resilience and equitable access in urban South Africa.

Stakeholder engagement through the Gqeberha Living Lab

The Gqeberha Living Lab has been a central mechanism for engaging communities and stakeholders in this research. The Living Lab serves as a collaborative social innovation platform where diverse actors, including researchers, community members, NGOs, industry representatives, and government officials convene to discuss and co-develop solutions to water security challenges. Last year participants helped to develop a Water Choices serious game that explored the different mechanisms and power relations involved in water security. This year's main workshop session, held on 5 June 2024, focused on participatory mapping and focus group discussions.

Participants co-explored:

- How communities perceive water security and the key challenges they face.
- How communities adapted to the drought and ongoing water scarcity.
- Community perspectives on the municipal response.
- Ranking water-related concerns
- Possible solutions to improve water resilience and equity.

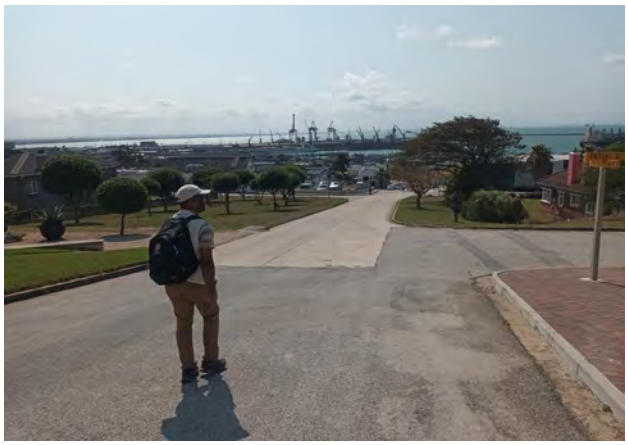
Dealing with a sewage leak in Nelson Mandela Bay metro

The engagement highlighted deep-rooted concerns regarding inequitable access to water, ineffective emergency response strategies, the rising problem with sewage leaks (several members could not attend as they were dealing with a debilitating leak that directly impacted their community), and limited communication from the municipality.

Quantitative and qualitative data collection

A water access survey was piloted and then administered across a range of different areas in the metro, with nine sites covering low-, medium-

and high-income residents living closer to or further from water supply areas. Household and key informant interviews gave in-depth information that was used to design and test the survey, which was administered using Kobocollect. Members of the Living Lab were incorporated and trained in data collection. Survey results and research updates were shared with the Living Lab participants, allowing for iterative participatory research.



Hitting the streets to collect data for the water access surveys

Understanding water security from a community perspective

Research highlighted the need for key dimensions of water security:

- **Availability:** Sufficient water for drinking, sanitation, and household needs.
- **Quality:** Clean and safe water for consumption and daily use.
- **Access:** Free or affordable water services, particularly for lower-income households.
- **Reliability:** Consistent supply and timely notifications about water disruptions.

Local perspectives align with global definitions of water security but emphasize the need for reliability and affordability, factors often under-represented in policy discussions.

Community adaptation to drought and water scarcity

Households and communities have developed various coping mechanisms to deal with water shortages:

- **Household water conservation:** Reduced water use, greywater recycling, and water-efficient appliances.
- **Alternative water sources:** Rainwater harvesting, bottled water purchases, and reliance on boreholes where accessible.
- **Dependence on external water donors:** NGOs and private entities providing water supplies.
- **Municipal assistance:** Water tanker services and emergency supply points, though these were inconsistently delivered.

Lower-income households face significant challenges in securing alternative water sources owing to financial constraints, reinforcing the need for more equitable emergency planning and response mechanisms.

Participants unpacking some of the complexities of water security

Perceptions of the municipal response

Community feedback regarding municipal responses to the water crisis was largely critical. The following themes emerged:

- **Poor preparedness and management:** Lack of long-term planning and proactive interventions.
- **Ineffective communication:** Inconsistent information about water cuts and supply schedules.
- **Slow response to water infrastructure failures:** Delays in fixing leaks and burst pipes, exacerbating water loss.
- **Unfair billing and affordability concerns:** High water bills for pensioners and low-income households with minimal usage.

Residents living in high-density, low-income areas expressed frustration over the municipality's reactive approach and called for improved transparency, accountability, and efficiency in managing water resources. Low-income residents on the fringes of the metro were particularly affected.

Towards collective solutions

The NMBLL sessions facilitated a co-creation process where participants identified short-, medium-, and long-term solutions for improving water security in NMBM.

Short-term:
- Faster response to leaks and pipe repairs.
- More accessible emergency water supply points.
- Improved communication strategies, including community meetings and traditional media outreach.

Medium-term:
- Infrastructure upgrades and expanded water distribution networks.
- Increased borehole installations and alternative water-sourcing projects.
- Strengthening education and awareness programmes on water conservation.

Long-term:
- Comprehensive municipal water resilience planning.
- Integration of desalination projects.
- Upgrading and expanding sewage and stormwater management systems.

These proposed interventions underscore the importance of a multi-pronged strategy that combines infrastructure investment, policy reform, and community engagement. Across the board there was a call to deal with water leaks that result directly from theft and vandalism – particularly theft of copper-related infrastructure. Copper theft is intricately linked to criminal activities, and the cost to residents and the metro to replace stolen infrastructure is crippling.

Lessons from Cape Town's water crisis

Drawing from the lessons of Cape Town's "Day Zero" water crisis, several key insights emerged:

- **Proactive planning and demand management** can significantly reduce the severity of water shortages.
- **Public engagement and behavioural change campaigns** are essential for fostering water conservation.
- **Diversified water sources**, including desalination, groundwater use, and wastewater recycling enhance resilience.
- **Strong governance and inter-departmental collaboration** improve crisis response effectiveness.

The findings from this year's research reinforce the urgent need for equity-sensitive water governance in Nelson Mandela Bay. Addressing the crisis requires a combination of infrastructure investment, policy changes, and inclusive decision-making processes. Key recommendations include:

- **Enhancing water infrastructure maintenance and planning** to minimise wastage and improve supply consistency.
- **Strengthening community engagement** to ensure transparency, accountability, and participatory decision-making.
- **Implementing equitable water pricing and affordability measures** to protect vulnerable households.
- **Exploring alternative water sources** to reduce dependency on conventional supplies.
- **Developing a comprehensive municipal water resilience strategy**, informed by local and global best practices.
- **Exploring ways to deal with water leaks due to theft and vandalism.**

A stakeholder-driven process to develop a more equitable and sustainable water resource management plan.

D Gwapedza, JL Tanner and SK Mantel
Collaborators: B Paxton (Freshwater Research Centre, South Africa), O Barreteau (Institut National de Recherche Pour L'Agricuture, L'alimentation et L'Environnement, France), B Bonte (Institut National de Recherche Pour L'Agricuture, L'alimentation et L'Environnement, France), K Bradshaw (Rhodes University Computer Science Department).
April 2021 – March 2024

Sponsor: Water Research Commission

This project adhered to a successful management model in the IWR where a postdoctoral Fellow leads the project. Gratefully the Water Research Commission supports this leadership model through their focus on capacity building of Early Career Researchers. Dr David Gwapedza led the project team in an outstanding way with the support and supervision of Dr Jane Tanner and Prof Sukhmani

Mantel. The project successfully concluded this year with the Department of Agriculture, Western Cape interested in applying the approach with other Water User Associations in the Western Cape. In response the team developed a stakeholder report which explains the five tools used or developed in the project in simple terms for non-scientists (Figure 1).

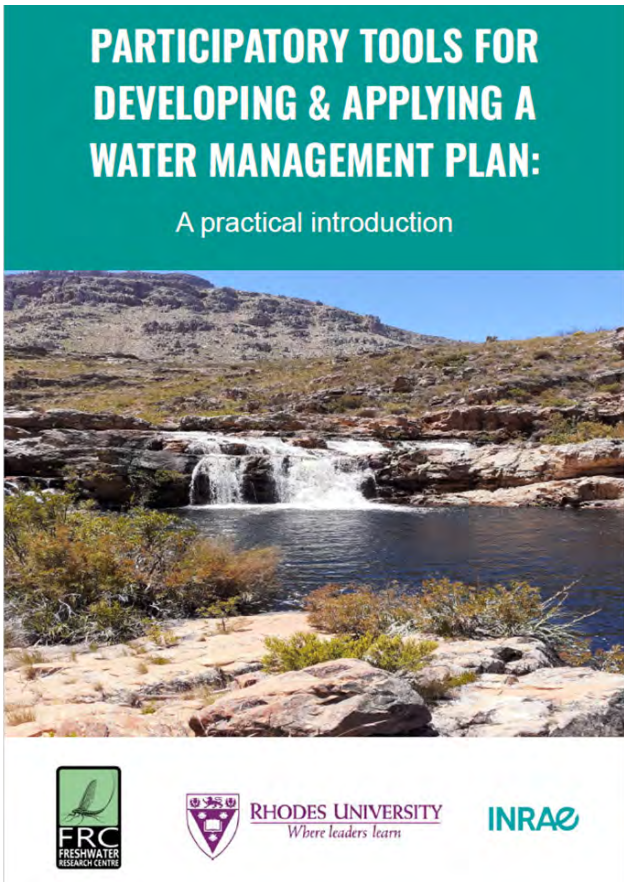


Figure 1: ***Cover page of stakeholder report developed to explain the tools used and developed simply.***

The project engaged a group of stakeholders (primarily farmers) in the Koue Bokkeveld (KBV) to co-develop a shared water management plan that results from a shared understanding of the water challenges in the catchment. The project was framed recognising the catchment challenges, including dry season water conflicts that sometimes spill into the courts. Unfortunately, when water users' have conflict over access to the resource, environmental water requirements are rarely considered. If left unmanaged, a potential loss in agricultural productivity could occur, affecting food security and the livelihood of the thousands of farmworkers who work in the area. Therefore, effective water management is vital to ensure equity in water access to foster shared growth, reduce water conflicts, promote ecosystem health, and prevent biodiversity loss. This project's specific aims were:

- Work with/build relationships between stakeholders while expanding their understanding of the bigger picture of water resource use and management in their catchment.
- To negotiate a sustainable and equitable water management plan that observes environmental water requirements and protects riverine biodiversity.
- To explore scenarios of future water demand under growing agricultural development and water availability under climate change to adapt the water management plan to a set of anticipated scenarios to ensure sustainability under change.

A mixed-methods approach was adopted in this research following multiple disciplines. Hydrological, ecological, social, and computer sciences converged to fulfil the project aims. The project focused on four main areas to fulfil the objectives. Firstly, (1) Understanding water distribution, flow, and use. This was focused on hydrological model setups (IWR's Pitman Model and the international model SWAT+). These models produced the foundational data for the remaining three tools developed. The focus of the hydrological modelling included determining how much water there is, how and when it moves through the landscape, how people are currently using it, and how secure or uncertain the conclusions are. The hydrological modelling is detailed in MSc student Mr Sakikhaya Mabohlo's student report. Then (2) The development of tools to produce and apply a water management plan. Two tools were developed that enabled stakeholders to negotiate a shared plan for how water will be used and managed. The tools enabled users to think about how to prioritise different water users' needs, especially during dry periods, as well as imagine different possible future situations and how they would deal with them. These tools include an Agent Based Model (developed with Prof Karen Bradshaw and MSc student Mr Rodney Tholanah of the Computer Science Department). The second tool is a Water Sharing Tool (detailed in PhD student Dr Sinetemba Xoxo's student report). Thirdly, (3) Once we have a water management plan, we need to be able to monitor what is happening in the catchment, and how the plan is being followed. The third tool is designed for this and is called the Water Balance Tool. Lastly (4) the project continuously engaged stakeholders, both in the field and via four workshops (Figures 2, 3 and 4). The stakeholder engagement focused on bringing different water users together to be actively involved in the process of developing a fair and sustainable water management plan. For all five tools used or developed, we took a participatory modelling approach, meaning the stakeholders were actively engaged in all of the tool development.

Figures 2 and 3. Two of the workshops held during the project in the KBV.

Figure 4. Dr Sinetemba Xoxo leading a role playing game with the stakeholders, that he developed to better explain the outputs from his Water Sharing Tool.

Three institutions collaborated on the project: Rhodes University's Institute for Water Research- (IWR-RU) and computer Science Department. The IWR specialises in hydrology and water governance and lead the project. The RU Computer Science Department developed the Agent Based (ABM) Model together with INRAE, France (see below). The Freshwater Research Centre (FRC) in South Africa specialises in ecology, conservation, and stakeholder engagement within the KBV. The National Research Institute for Agriculture, Food and the Environment (INRAE), France specialises in developing ABM models and agricultural sciences. Four postgraduate students have graduated through the project: Mr Sinetemba Xoxo (PhD), Mr Sakikhaya Mabohlo (MSc), Mr Rodney Tholanah (MSc) and Ms Njabulo Dlamini (BSc Hons).

We disseminated the project work extensively in South Africa and across the globe. Project team members from the various collaborating institutions have shared the work at various conferences and symposia. For example, this year, the project work was shared at three conferences held in South Africa, France, and Senegal. We have produced several research reports for the WRC, NRF and other funding organisations, including the Oppenheimer Memorial Trust and Rhodes Research Office. One publication has been published so far, and we have another under review. We plan to publish many other papers from this work.nInterest in the project has been widespread with some notable support and interest in the project from the Western Cape Department of Agriculture, from the World Wildlife Fund - Africa, and farmers from other regions.

Figure 5. Team photo after the last stakeholder workshop was held. Missing team members include Prof Sukhmani Mantel, Dr Olivier Barreteau and Dr Bruno Bonte.

Enhancing a platform for practical water management and implementation of the waste discharge charge system in South Africa.

JL Tanner (IWR), D Gwapedza (University of Namibia)
Collaborators: L Bannatyne (Rhodes University Geography Dept), A Slaughter (IWR), N Dlamini (IWR), J Rasifudi (Department of Water and Sanitation) and M Ngwenya (Rhodes University Geography Department)
October 2024 – March 2027

Sponsor: Water Research Commission

In recent years, South African municipalities have increasingly struggled to meet water quality standards for both drinking water and wastewater discharge. Climate change is a key factor, disrupting catchment hydrology and sedimentation, which impacts water quality. Other contributing factors include population growth, urbanisation, rising demands for food and energy, and poor management of solid and liquid waste from households, industry, and mining. Although river water quality monitoring has improved in the South African context, significant challenges still remain. The Department of Water and Sanitation (DWS, 2023) has emphasized the urgent need for innovative technologies and collaborative approaches involving the private sector, civil society, and researchers to improve water management.

This project aims to advance knowledge to support the implementation of a waste discharge charge system in South Africa. While the Water Quality System Assessment Model (WQSAM) developed at the IWR shows promise, it currently lacks a sediment module to simulate nutrient and metal dynamics. The proposed integration of two models developed at the IWR - the Water Quality and Sediment model (WQSED) and WQSAM—both part of the SPATSIM framework—will address this gap. Although WQSED has been tested in Southern Africa and the USA, it remains largely untested in South Africa due to limited sediment data. Broadly, this project responds to the DWS Integrated water quality management policy by aiming to update and improve WQSAM by incorporating sediment and metal simulation, during which model validation will be achieved using the long-term sediment observation dataset.

The project has three specific and interlinked broad objectives:

- To establish a South African water quality modelling platform by coupling the WQSED model to the WQSAM model and avail it for water quality assessments.
- To robustly test and validate the modelling platform under varying land use and/or climatic conditions, then re-factor the model to improve functionality and ease of use.
- To run training workshops on applying the modelling platform, then establish a community of practice for its application and development to ensure sustainability

The project commenced in October 2024. Short summaries of two recent deliverables submitted to the WRC are listed below:

Deliverable 1 (Capacity building)

This deliverable is linked to Aim 3 and included addressing the critical deficit in water quality modelling expertise within South Africa. To bridge this gap, a comprehensive training workshop tailored for governmental agencies and students was conducted. This workshop served as a pivotal platform for imparting knowledge and proficiency in utilising WQSAM. The strategic focus of WQSAM training was to ensure that participants understood this advanced tool for water quality assessment and management.

Figure 1: Training on model WQSAM in November 2024 at Rhodes University for Department of Water and Sanitation, and RU students.

Deliverable 2 (Literature review and description of the study area):
This deliverable is linked to Aim 1 and included a review of literature of existing water quality management strategies and water quality modelling in South Africa as well as the case study descriptions. In order to model and predict the WQSAM data inputs, gaps (sediment transport, metal simulation) and the WQSED model were explained. Overall, the Vaal River Catchment and the GrootDraai Dam Catchment were selected as the case study sites.

The project includes one MSc student Ms Njabulo Dlamini who is working on the validation of the sediment model, and one Post-Doctoral Fellow Dr Mthulisi Ngwenya who is based in the Geography Department. This project represents a concrete collaboration between the IWR and the Geography Department through Dr Ngwenya's involvement, and through the involvement of Geography PhD student Ms Laura Bannatyne who has produced a comprehensive sediment dataset for the project to use in validating the sediment model. The project also involves Dr Joshua Rasifudi from the Department of Water and Sanitation (DWS), which will ensure that the products developed remain practical and usable for DWS. Finally, the WQSAM model has recently been selected by the Resource Protection Unit of DWS to revise the national waste water discharge standards (set in the 1980s) to bring them in line with the more recently determined Resource Quality Objectives. The project is therefore timeous and we have committed to working closely with the Resource Protection Unit to support them wherever we can in the application of the model. The project promises to be exciting, multi-disciplinary and highly applied, and will make a significant contributions to water resource protection in South Africa.

Unlocking Resilient Benefits from African Water Resources (RESBEN)

Dr JL Tanner and f Tally Palmer
Collaborators: Z Woldu (Addis Ababa University, Ethiopia), N Banadda / I Kabenge (Makerere University, Uganda), S Faye (Cheikh Anta Diop University, Senegal), E Longe (University of Lagos, Nigeria), J Nobert (University of Dar es Salaam, Tanzania), N Venuste (University of Rwanda), K Winter (University of Cape Town, South Africa), S Gurmessa (University of KwaZulu-Natal, South Africa). Two UK collaborators on the RESBEN project are: F Cleaver (Lancaster University, UK) and V Speight (Sheffield University, UK).
Project dates: April 2020 – March 2024

Sponsor: United Kingdom Research and Innovation (UKRI)- Global Challenges Research Fund (GCRF)

Project website: https://www.ru.ac.za/iwr/aruacoe/

This project concluded after four years working across Africa with ten partner institutions. The project was funded by UKRI through the ARUA network and was a competitively awarded grant (four grants were awarded to Centres of Excellence that produced a top-rated proposal). Notable achievements include the collective (African) development of a guided approach to transdisciplinary research which focuses on catchments as Complex Social Ecological Systems (CSES). This approach has been published with authorship across the network.

Other notable achievements include 12 students graduated (MSc students from: Rhodes University (2), University of Rwanda (1), Dar es Salaam University (3), Lagos University (1), Makerere University (3), Addis Ababa University (1); and a PhD from Senegal (University Cheikh Anta Diop), awarded the National Best Doctoral Dissertation in 2023). These students have already published five papers in international peer reviewed journals (with two submitted papers under review). These publications are from students in Tanzania (2), Rwanda (1), Uganda (1) and Ethiopia (1). Researchers from the various case studies have also published including South Africa (3), Rwanda (2), and Uganda (1). We continue to work on a Special Issue showcasing the RESBEN project for the pre-eminent transdisciplinary journal Ecology and Society. Eight papers are in preparation and will be submitted for review in May 2025. All this has strongly supported ARUA's first Secretary General, Prof Ernest Aryeetey's vision of African scholarship.

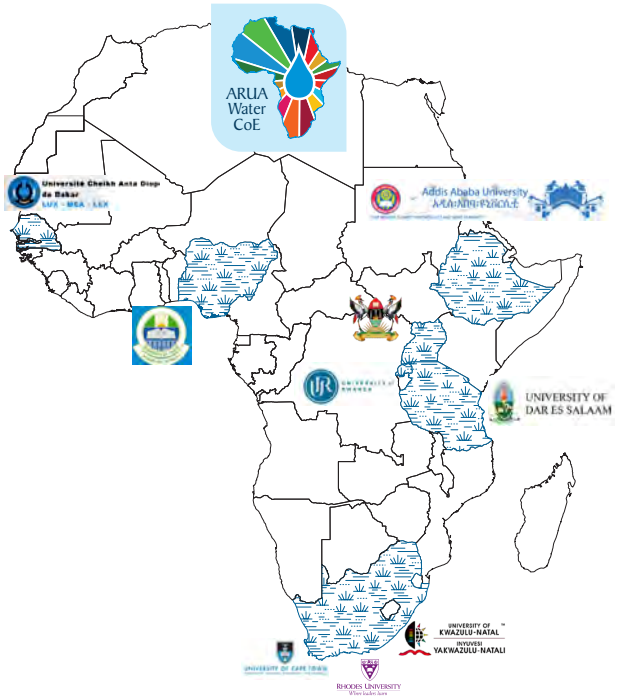


Figure 1: Collaborating universities of the ARUA Water CoE in Africa and their strengths

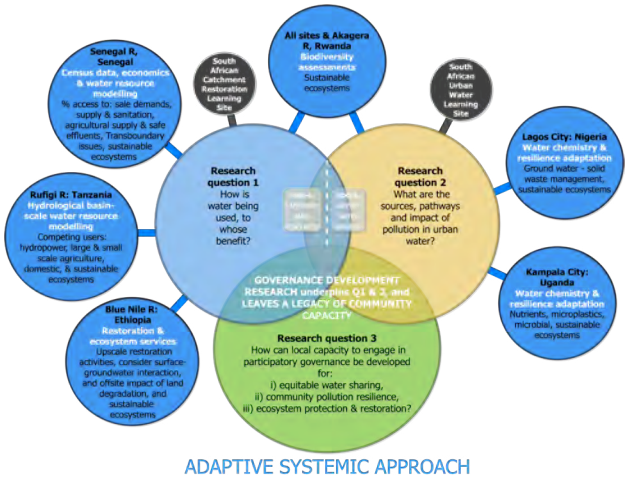


Figure 3: Research questions and case study overview in the RESBEN project.

The project consisted of six project case studies that exemplify water-related challenges across Africa, and support progress towards SDG 6, the core water-related goal. In addition to the six Case Studies, there were three South African learning sites (ongoing study sites run by University of KwaZulu-Natal, University of Cape Town and Rhodes University) that have provided insights and learning opportunities related to Case Studies. The African Node research projects have contributed to addressing SDG 6: water supply and sanitation, and therefore contributing to African SDGs related to water. The research projects have worked on critical questions around improved water quality in African cities and improvement in management of water resources use and development across several large river catchments in Africa. Two of the six case studies were centred on urban water pollution, two on water supply and contestation issues, and two on biodiversity restoration. All were underpinned by a strong focus on water governance. Social scientists and natural scientists worked together to start shifting the different water issues from the bottom up through participatory governance development, and by opening communication channels between those experiencing the water problems and those managing the water problems.

The co-Investigators on the team, have reported certain key findings resulting from the work, some of which are reported below (paraphrased from their inputs): a) Stakeholders appreciated how different the ASA process was from other research they have been involved. They liked the elements of co-creating the vision and the platform to interact with different levels of stakeholders. Stakeholders at the different levels are very willing to be part of the solution; each stakeholder has a critical role to play. Bringing stakeholders earlier on in the project shapes the solution to one that can easily be socially accepted, and thus be easily adopted. b) The RESBEN project has enabled the Cape Town Living Lab to frame and apply a sustainability transition involving the co-evolution of change in a catchment where bottom up (local community interests) and top down (local authority) inertia is being facilitated by leadership, management and demonstrations at the Water Hub and outside the boundaries of the site. We are learning that transitions take time, require researchers and research to demonstrate the potential to change, and are necessary to disrupt the status quo. We are learning to work with risk and uncertainty. c) Good Governance is key for sustainable water resources management. Stakeholders have a better understanding of their problem and therefore a big contribution in finding solution that works for them. Therefore, continued engagement with stakeholders can bring about sustainable management of water resources d) Integration is strategic and requires thinking big. The Strategic Adaptive Management was the first workshop to bring together stakeholders in water resources management from different Governmental and Non-governmental institutions and representatives of local communities as well. Widening the network of stakeholders and interest groups and being open / invitation has generated new interest, creativity and ideas to expand on existing solutions in the co-evolving project.

Overarching findings: (1) Links between communities and government are essential, we established participatory governance pathways to effective

intervention. Examples: Kampala, Uganda - We connected government officials with the Ggaba Landing residents. We identified: i) barriers to community and government participation, ii) barriers to pollution management; iii) actions needed to progress. Lagos, Nigeria - unusual impact was active involvement of a school on a waste dump. RESBEN participation resulted in government pledging funds to the school. (2) Clean water comes from purification and safe piped water. But in Africa many people get water straight from the environment. Therefore, pollution and waste management are critical. Examples: Senegal - Lake Guiers supplies Dakar with water and, supports large- and small-scale agriculture, livestock breeding, and fishing. Extraction and pollution threaten environmental health and livelihoods. RESBEN: established a Lake stakeholder Whatsapp group connecting stakeholders to each other and an accessible data-base; and built a systemic model that identifies what is working, and what needs to be established and maintained - and how. Lagos, Nigeria: - A city built on polluted groundwater. RESBEN assessed water quality; a) in groundwater at two dump sites not fit for drinking which pose a serious threat to human health and the environment; and b) surface water at Unilag Lagoon Front and Somolu Drainage Canal, and recorded: indiscriminate waste disposal, open defecation, high E. coli, high nitrates and heavy metals (iron, cadmium, lead), and malaria carrying mosquito larvae. The Adaptive planning Process workshop brought this reality to community residents, and government officials – with exposed school children presenting. Our project was ambitious - but we adapted and completed with all partners on board and outcomes in each country.

The research was showcased in a 'RESBEN Research Webinar', on 28 February 2023 with the purpose of sharing key findings of engaged water-related research that has taken place across seven African case studies countries over the last two years, under the RESBEN project.

The grant has created a critical mass of researchers who can contribute to addressing economic and societal challenges related to water quality and supply and sustainable water resources management in the African countries. There has been capacity building of research teams in water management issues and links to social science. This capacity and awareness have been extended to local communities and water resources management agencies. We have demonstrated at scale the need for research continuity to achieve realised impact. We have laid solid foundations for real change in managing pollution and water resources for human and environmental health in 6 African contexts. Finally, we have increased engaged, systemic, transdisciplinary research capacity and capability in Africa. We have demonstrated African scholarship in sustainability science (which will be show-cased in an Ecology and Society Journal Special feature). Finally, we have submitted a number of proposals (including to UKRI where the proposal was rated 9/10 but not funded) to take the work in the case studies forward, and further deepen the Adaptive Systemic Approach, and build the ARUA Water CoE.

Figure 2: The RESBEN team at a 'integration' workshop in Kampala, Uganda in June 2023.

Figure 4: The key water-related problems that have been researched and 'shifted' for each of the RESBEN African Nodes

Postdoctoral project reports

Miracle O Osoh

Host supervisor: N Rivers-Moore

The increasing human population, coupled with the need for increased agricultural yields is driving the proliferation of active pharmaceutical ingredients in the world. Based on their therapeutic use, pharmaceuticals can be classified into a wide variety of groups that include antibiotics, non-steroidal anti-inflammatory drug (NSAIDs), β-blockers, angiotensin receptor blockers, antiepileptics, antihistamines, blood-lipid regulators, serotonin re-uptake inhibitors, anti-ulcer drugs and steroid hormones (Sun et al., 2015). Although pharmaceuticals have advanced measurable success in human and animal health care (National Academy of Sciences, 1999), some of these pharmaceuticals and their metabolites are posing potential risks to aquatic organisms.

Pharmaceutical pollution is a growing and significant threat to the health of freshwater systems in the world (Wang et al., 2015; Azanu et al., 2021; Kamika et al., 2021). Pharmaceuticals reach freshwater systems through direct sources, such as wastewater treatment works (Wang et al., 2015), and indirect sources, such as storm water run-off (Munzhelele et al., 2024).

In South Africa, there is no existing programme for the routine monitoring of pharmaceuticals in freshwater, nor are the impacts of pharmaceuticals on aquatic biota systematically documented. Thus, there is need for extensive research to improve pharmaceutical waste management (Ngqwala & Muchesa, 2020). Considering the budgetary constraints of implementing a nationwide monitoring programme, the development and application of tools that would aid in identifying priority river reaches at risk of high concentrations of pharmaceuticals is of utmost importance. Providing guidance on sites for a targeted river monitoring programme is crucial to mitigate the impact of pharmaceutical pollution on aquatic biota in South Africa. As such, the objectives of this project are to i) gain an improved understanding of the potential range of selected APIs and their associated eco-toxicological impacts to aquatic ecosystems in South Africa, ii) develop a basin-scale spatial product showing high concentration risk zones for selected emerging domestic chemical pollutants, and iii) assess changes in risk under average and low flow dilution scenarios.

Fenji Materechera-Mitochi

Host supervisor: ON Odume

Being a part of the IWR team offers a unique and rewarding experience marked by a fast-paced and dynamic work environment that requires adaptability. I have learnt over the past year that being a post-doc at the IWR requires one to juggle multiple tasks. Success in this role does not rely solely on intellectual rigour, but is also hinged on a strong skill set that includes efficient administration, effective multi-tasking, and critical thinking to solve problems and make informed decisions. The IWR offers a wealth of opportunities for career growth for early career researchers. I can attest to this by reflecting on the exciting year that I have had; 2024 has been my second year as a post-doc at the IWR and this is my year in review.

Fenji at Makerere University beside Prof. G Nyakiru, AWarMN project coordinator in Uganda.

Three-month academic staff mobility at Makerere University, Uganda

I applied for academic staff mobility under the African Water Resources Mobility Network (AWaRMN) project funded by the Intra-Africa Academic Mobility Scheme of the European Union in 2023 and was awarded funding to go on mobility this year. I spent three months as a visiting scholar hosted at the School of

Agricultural Sciences and the College of Agricultural and Environmental Sciences at Makerere University in Uganda. During my time there I collaborated on a review article with a team of experts in different aspects of farming systems research; contributed to supervision and mentorship of multiple doctoral and MSc candidates; and contributed to teaching during a field trip for final-year undergraduate students in Fort Portal, Western Uganda, where different farming systems in Uganda were explored.

Arrival and welcome in Uganda by members of AWaRMN project team and AWaRMN students.

Grant proposal writing

I submitted a proposal as lead proposer to the WRC in January and was pleased to have been awarded funding for a four-year project under the title: *"Assessing the commercialization potential of the former Transkei's land and water resources through an integrated water-land-agricultural nexus in the Eastern Cape Province of South Africa."* The project begins in December 2024 and is my first funded research project for which I will be the project lead after my PhD.

Publication writing

I have authored one journal article this year as co-author and have several publications in production: two have been submitted and are under review; I am the main author for one and co-author for the other. I have two journal articles due for submission in the first quarter of 2025, one as first author and the other as co-author. The papers focus on a range of issues within the water-land-food-agriculture nexus.

Project administration and management

I have continued my work in assisting with the administration for the African Water Resource Mobility Network (AWaRMN) project as a part-time administrator and an active member of the project management team. I also continue to take the lead in the project team for a WRC-funded project titled: *"Governance and institutional arrangements for accelerating equity in the water-land-agricultural nexus: A case study of resource-poor farmers in smallholder irrigation schemes in the Lower Sundays River and Great Fish River catchments."* The project is in its second year and has focused mostly on analysis of primary data. I participated in conducting in-depth interviews in the first quarter of the year as part of outstanding data collection, presented findings at the progress reference group meeting, and have significantly contributed to project deliverables that have been submitted during the year.

Sustainability Research and Innovation (SRI) Africa Satellite event

I attended the annual SRI Africa Satellite Event which was hosted in Durban from 21–24 May 2024 where I contributed as a speaker in one of the early-career focused sessions entitled: *"How African ECRs can shape African Sustainability Science Innovation"* alongside a panel of fellow early-career researchers from across the continent.

Fenji presenting as speaker at SRI Africa Satellite Event in Durban, South Africa.

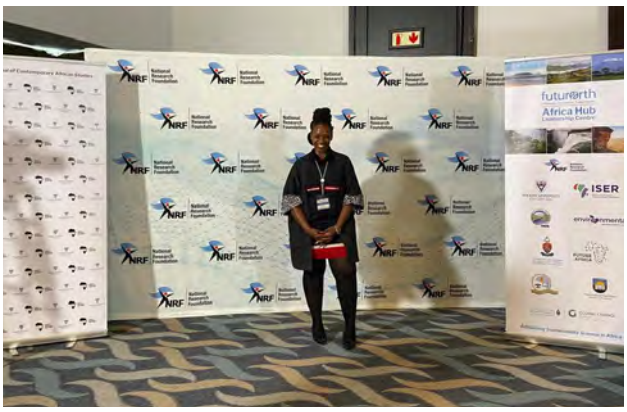
AWaRMN strategic vision for impact and sustainability workshop in Kampala, Uganda.

The five-year African Water Resource Mobility Network (AWaRMN) project is coming to an end in 2025, and the project team is actively working on transitioning the project into a collaborative platform. I joined the AWaRMN sustainability and impact committee this year and attended a workshop in Uganda from 13–16 May 2024 as part of the team. As part of the workshop activities, I facilitated an interactive visioning exercise aimed at informing the action plan for the way forward. One of the outcomes of the workshop was the formation of the Water Science Cluster, a programme of the Future Earth Africa Hub Leadership Centre of which I am a member and have been involved in the activities around its formation.

Fenji presenting at AWaRMN strategic vision for impact and sustainability workshop in Kamapla, Uganda]

Future Earth Africa Hub Leadership Centre activities

I am a member of the Future Earth network, and this year presented numerous opportunities to become more involved in the activities of the network at a more local level through involvement with the Future Earth Africa Hub Leadership Centre (FEAHLC). I attended the FEAHLC consultative meeting held in Durban on 20 May 2024 where I was part of the conversations around ideas for the centres' initiatives. I also attended the FEAHLC induction workshop held in Makhanda from 1-3 October 2024 where the newly launched regional nodes for Future Earth Africa Hub were being inducted. This workshop was an opportunity to showcase the work of the Science Clusters which are an initiative of the Hub and operate as the scholarly engine of the regional nodes. In this workshop, I participated as a member of our science cluster and networked with colleagues from the different regional nodes to explore possible collaboration opportunities.



Fenji at the Future Earth Africa Hub Leadership Centre consultative meeting in Durba, South Africa.

Seminars and webinars

I presented the work we have done in the WRC-funded project on governance and institutional arrangements for accelerating equity in the water-land-agricultural nexus to the community of the Rhodes University African Studies Centre with which I am affiliated on 4 June 2024. The seminar was a hybrid event titled: *"Is it fair? Demystifying the goal of equity in the land-water-agriculture nexus in South Africa"* and resulted in robust discussions with academics from different disciplinary backgrounds within and outside the Rhodes University community. I was invited to present a webinar as part of the *Engaged Scholarship for Sustainable Learning Environments* webinar series hosted by the University of West Indies, University of Venda and University of Pretoria. My webinar was titled: *"Navigating science communication as an early career researcher: Reflections from an African sustainability science researcher"* on 12 June 2024.

Fenji Seminar Flyer.

Dr Fenji-Materechera-Mitochi is a postdoc fellow at the Institute for Water Research, Rhodes University, South Africa. Her primary research training is in human geography and environmental sciences with broader research interests around sustainability science, agricultural farming systems, food systems, governance in agricultural systems and the application of systems analysis as a tool to solve complex problems. Her current research work is focused on the land-water and agricultural nexus in South Africa and is positioned at the farm scale. She has strengths in applied qualitative research methods and community engagement.

Register in the link below:
https://zoom.us/meeting/register/tJYrdu6opzkvEtdXzJ8R3AAk_3OartxxPjtE
After registering, you will receive a confirmation email containing information about joining the meeting.

Moderator	TIME	ITEM	FACILITATOR
Prof Dr Vhonani Netshandama, University of Venda	16h00 - 16h05	Introduction and welcome	Prof Dr Vhonani Netshandama, University of Venda
	16h05 -16h55	"Navigating science communication as an early career researcher: Reflections from an African sustainability science researcher".	Dr Fenji-Materechera-Mitochi, Institute for Water Research, Rhodes University
	16h55 -17h30	Questions and Answer	Prof Dr Molebatsi Milton Nkoane, Central University of Technology Dr Laurette Bristol, University of West Indies

Fenji Webinar Flyer.

Supervision

I continue to supervise a PhD candidate who is a part of the WRC project on governance and institutional arrangements for accelerating equity in the water-land-agricultural nexus as a co-supervisor. I attended the *Strengthening Postgraduate Supervision* course hosted by the Centre for Post-graduate Studies between October and November to help sharpen my abilities in postgraduate supervision, which is a new area to me. The course provided a depth of new insights and has inspired me to explore my identity as a supervisor. I was appointed as a co-supervisor for another PhD student who joined the IWR this year.

Phindile Madikizela

Host supervisors: CF Nnadozie and ON Odume

I joined the Institute for Water Research (IWR) as a post-doc on 1 June 2024 as part of a research team working on a project titled, 'Equity dimensions of the Nelson Mandela Bay water crisis and the implementing context as enabler or barrier for uptake of translatable lessons from the Cape Town Water crisis'. The project seeks to understand the extent to which the municipal measures taken in response to the drought reflect sensitivity to equity, especially the three dimensions of distributive, procedural and contextual equity. The project also aims to ascertain whether the governance system at the Nelson Mandela Bay Metropolitan Municipality is an enabler or barrier to efforts to implement translatable lessons learned from the 2017 Cape Town drought.

As part of the project, the IWR research team facilitated a living labs workshop in June with various stakeholders in Gqeberha, to understand some of the water-related challenges within the Metro.

Group discussions during the workshop shed light on the difficulties that the various stakeholders were facing in relation to water.

As part of further data collection, the IWR research team returned to Gqeberha, to provide training to field workers on how to use a software package for survey data collection, which was followed by a successful trial run in the field. The field workers were then allowed to commence with data collection around the Metro and were later joined by the IWR research team. The survey was conducted for a week, with the aim of learning more about water-related issues that the various socio-economic groups in the Metro area experience. Stakeholders in the Nelson Mandela Bay Metropolitan Municipality were given feedback on the preliminary findings from the survey data that was collected. The Metro stakeholders were asked for more information/data to corroborate the findings of the survey data, which they consented to supply.

Djim Mouhamadou Lamine Diongue

Host supervisor: JL Tanner

I joined the Institute for Water Research as a postdoctoral fellow through the ARUA-Carnegie Early Career Research Fellowship programme from October 2023 to 2024. During this time, I have focused on several key research initiatives, including the RESBEN (Unlocking Resilient Benefits from African Water Resources) project, the Erasmus+ NbS4AfrRes (Nature-based Solutions for African Resilience) project, and hydrogeological investigations in Makhanda.

Research focus and publications

My research has centred on water governance and hydrogeological investigations across different scales. A key output has been preparing a manuscript for a special issue in *Ecology & Society* examining participatory water governance in Senegal's Guiers Lake Basin, drawing on the RESBEN project findings. This work received recognition from the Global Water Partnership's IWRM implementation initiative for the West African Economic and Monetary Union (WAEMU) region. I am currently developing two other publications spanning the Fairview Spring system's hydrogeology functioning, and Lake Guiers' water mineralization dynamics, collaborating with colleagues from both South African and Senegalese institutions.

Field investigations

Working closely with Dr Jane Tanner, I undertook comprehensive monitoring of the Fairview Spring in Makhanda to understand its hydrogeological functioning. This research involved systematic collection of spring, rainfall, and groundwater samples for stable isotope analysis to determine groundwater residence times, flow paths, and recharge mechanisms. We implemented continuous monitoring systems for discharge measurements and installed a borehole transducer to track groundwater level variations. I also contributed to Rhodes University's Water Management Plan by conducting pumping tests to determine aquifer properties, providing crucial data for numerical model calibration.

Project engagement

In the Erasmus+ Nature-based Solutions project, I played an active role in curriculum design, collaborating between African and European higher education institutions. This capacity-building

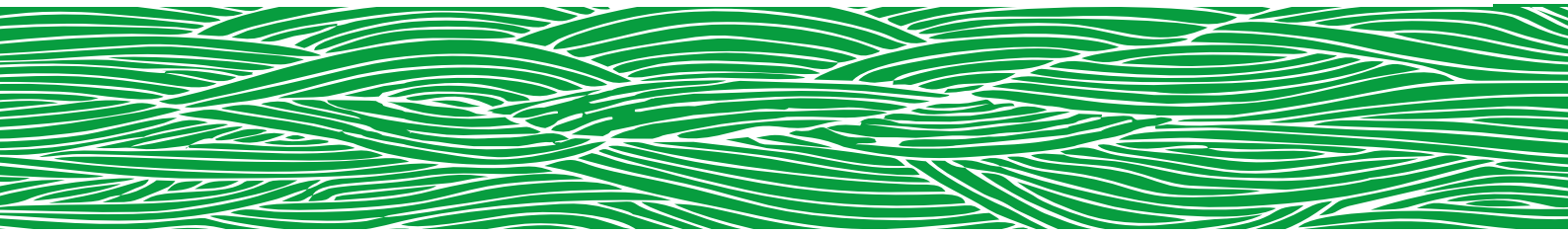
initiative aims to integrate Nature-based solution approaches into Environmental Sciences and Engineering curricula. Working across four African institutions (Rhodes University, University of Cape Town, Ecole Polytechnique of Thies, and Université Cheikh Anta Diop) and three European partners (TU Delft, AgroParisTech, and INRAE), I helped develop and implement stakeholder surveys that identified gaps in NbS education and opportunities for curriculum enhancement.

Recognition and knowledge dissemination

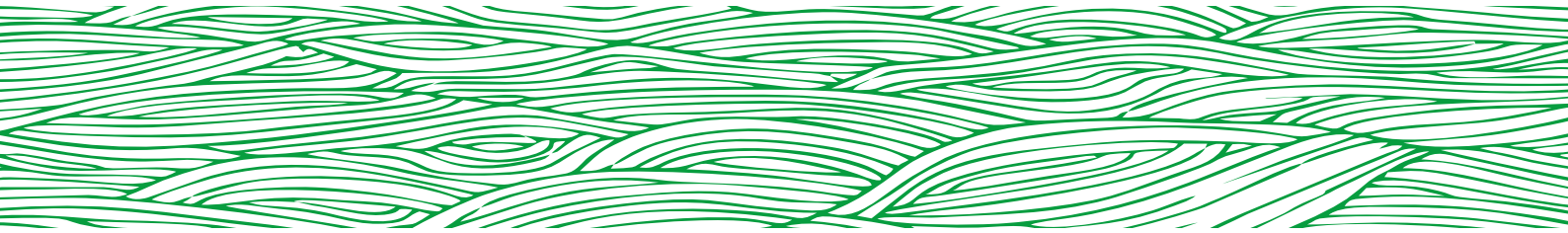
I attended two significant conferences in South Africa: the Africa-Europe Clusters of Research Excellence Conference at Stellenbosch University, and the South African Hydrological Society conference in Cape Town. A particular highlight was receiving the 2024 Falkenmark Award from the International Association of Hydrological Sciences (IAHS) for my thesis work (https://iahs.info/About-IAHS/Awards/Falkenmark-Award/falkenmark-award-winners/d-diongue/).

Future directions

Building on these experiences, I will continue advancing water resource management research in my new role as a permanent lecturer at Cheikh Anta Diop University's School of Geology and Mining. This position offers opportunities to strengthen the collaborative networks established during my fellowship and to contribute to both academic and practical aspects of water management in Africa.



Student project reports



Assessing soil erosion rates along contrasting land uses and soil types in the Rwenzori Highlands of Uganda.

Student: A Namatovu
Supervisors: TAA Basamba and E Opolot
Degree: MSc (Soil Science) Credit Seeking Mobility

About 98% of biomass is produced from the soil; however, soil resources face a number of challenges, erosion being one of the greatest threats. Soil erosion contributes to environmental degradation, resulting in loss of soil fertility, reduced crop production, food insecurity, ecosystem deterioration, sedimentation and eutrophication. This major environmental threat requires evaluation, and soil erosion assessment contributes to creating sustainable and resilient pathways for soil conservation.

Several factors influence rates of soil erosion experienced, with land use and soil type being stressed as having a great influence on erosion rates. This study was carried out in the Rwenzori highlands of western Uganda in Kasese and Kabarole districts. The dominant soil types and land uses in the area were selected for the study. The objectives of this study were to: i) determine soil erosion rates in different soil types; ii) determine soil erosion rates in different land uses; iii) determine soil erosion rates of different soil types under different agricultural land uses.

A split-plot at the same slope was designed with two factors: soil types (Ferralsols and Andosols) and land uses (annual, perennial, woodland and grasslands). Runoff plots were used for data collection, and runoff samples were collected after every rainfall event for 12 months. Measurements of runoff volume, sediment concentration and mass of dry soil were made. Two-way analysis of variance was used to compare variances across means of the soil types and land uses. Tukey's HSD test was used to identify pairs of group means that were significantly different from each other.

Soil type and land use had a significant effect ($p<0.01$) on soil erosion rates: Andosols had a mean erosion rate of (9.81 ± 3.69) t/ha/yr higher than that of Ferralsols (5.92 ± 2.27) t/ha/yr. Andosols experience high erosion rates because of their loose structure, low bulk density, high water infiltration rate and high water retention capacity. These characteristics cause reduced structural stability and increased erosion. Annual land use had the highest mean soil erosion rate, and Tukey's HSD test revealed that it differed significantly from grassland, woodland and perennial land uses. High soil erosion rates were attributed to the frequent tillage practices, land clearing after harvest and towards the sowing season, which coincide with heavy rainfall events that increase erosion.

Annual land use under the Andosols was significantly different from the rest of the soil type: land-use combinations showed the highest mean soil loss rate of 14.21 ± 2.15 t/ha/yr, whereas the lowest mean soil erosion rate was observed in perennial land use under Ferralsols (4.49 ± 2.05) t/ha/yr. Exposing Andosols to annual land use increases the susceptibility of Andosols to erosion.

Macroplastics accumulation, characterisation and macroinvertebrate colonisation in the Chanchanga River, Minna, Niger State

Student: MA Gibixego
Supervisors: ON Odume, F Arimoro and F Akamagwuna
Degree: MSc (Water Resource Science)

Background

Plastics in rivers are an environmental concern globally and require urgent intervention for their management. Plastic production has increased exponentially over the past 30 years due to its applications in leading global industries (medical, construction and food industries). As the population grows and industrialisation surges, plastic material production has also shown marked increases in Africa, leading to the proliferation of plastic materials in rivers, streams, and other freshwater systems. The presence of macroplastics is a major ecological concern, but not much research has been done to better understand the pattern of plastic accumulation and biotic colonisation down the length of a river.

Research aim and objectives

The overall aim of the study was to characterise and investigate macroplastic accumulation and macroinvertebrate colonisation down the length of the River Chanchanga, and the associated riparian areas.

Research objectives

1. To characterise and quantify macroplastic accumulation down the length of the River Chanchanga and associated riparian areas.
2. To examine macroinvertebrate colonisation and assemblage structure on accumulated macroplastics in the River Chanchanga.
3. To analyse and characterise macroinvertebrates in relation to the colonisation of the accumulated macroplastics in the River Chanchanga.

Progress to date

The field work was undertaken in the River Chanchanga in Minna, Niger State, Nigeria from February to May 2024. The macroplastic material has been analysed and characterised. The research report is in progress.

Presentations

I presented at the Freshwater Biodiversity Association of Nigeria (FBAN)'s Annual conference held in Benson Idahosa University in July 2024. My presentation was titled: 'The macroplastic retention in aquatic ecosystems in relation to sediment accumulation and macroinvertebrate colonisation across a land-use gradient in the Chanchanga River, Minna, Niger State'.

Drought ecology and water quality

Student: EA Seriki
Supervisor: ON Odume
Degree: PhD (Water Resource Science)

Introduction

In South Africa, the impacts of drought on the health of freshwater environments, ecological changes, and water quality in drought-prone areas are underexplored. Owing to climate change, droughts in this region are becoming more frequent and prolonged, leading to reduced water availability. These prolonged periods of low rainfall and water scarcity strain freshwater resources and impact the quality of water in rivers, dams, and estuaries. Water quality degradation during droughts can lead to increased pollutant concentrations, higher levels of microbial contamination, and disruptions to aquatic ecosystems. This poses significant challenges for water management systems and threatens public health, agricultural productivity, and ecosystem services. Understanding how drought-induced ecological changes impact water quality is critical for developing sustainable water resource management strategies. This research focuses on the critical issue of how drought conditions affect water quality in drought-prone areas in South Africa and seeks to: (i) identify past and recent drought-prone periods; (ii) monitor and assess the ecological changes and overall health of the aquatic environments; (iii) assess the social-ecological interaction.

Aim and objectives

This research aims to investigate the ecological impacts of drought on water quality in the Eastern Cape Province, South Africa, and to develop strategies for sustainable water resource management. The objectives are: (i) to monitor and analyse changes in water quality during different stages of drought; (ii) to map and identify pollution sources exacerbated by drought; (iii) to assess the ecological health of the aquatic systems of the area; (iv) to provide data-driven recommendations for mitigating the impact of drought on water quality and improving water management strategies in drought-prone areas.

Methodology

Using the DPSIR Framework (Drivers, Pressures, State, Impact, Response), this study will focus on understanding the complex interactions between climate change, drought, hydrological processes, and anthropogenic activities that influence water quality and aquatic ecosystems. This research will adopt a mixed-method approach, combining qualitative and quantitative techniques. Field surveys will be conducted to observe and document the actual conditions on the ground, while modelling techniques will be used to predict future scenarios and assess the potential impacts on water resources. Through a multi-faceted approach, the research aspires to uncover critical insights into the vulnerability of water resources in the region.

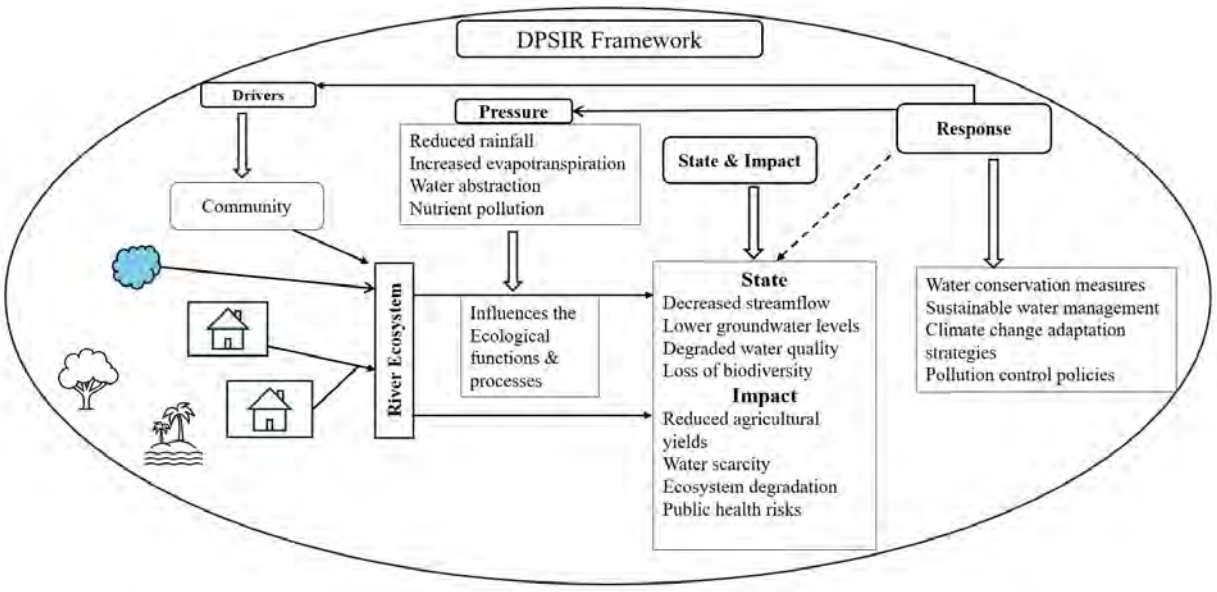


Figure 1: The adopted Drivers, Pressure, State, Impact, and Response (DPSIR) framework, which is used to demonstrate the complex relationships between drought-induced socio-ecological issues. developed by the Organisation for Economic Co-operation and Development (OECD), (1994) and refined by the European Commission (EC), (1999).

Study Progress and Significance

While previous studies have primarily focused on the physical and chemical aspects of water quality, there is a substantial lack of research concerning ecological consequences, such as changes in biodiversity and ecosystem function. This research will enhance the current understanding of ecological assessments during drought by conducting detailed surveys to evaluate the impact of drought on vital aquatic biodiversity, including algae, fish, and macroinvertebrates. Community engagement is essential in this study. Local community members will be involved in data collection and awareness campaigns to foster a sense of ownership and to promote sustainable water management practices. Finally, data-driven, actionable recommendations will be provided to inform water resource management decisions and climate change adaptation strategies in the region.

An Aggregate Vulnerability Index for addressing climate change in the Congo Basin: methodology and application

Student: GSK Lutonadio
Supervisors: RM Tshimanga and ON Odume
Degree: MSc (Water Resource Science)

Context and justification

Climate models are unanimous in warning of the immediate and complex impacts of climate change on communities, particularly in Africa. Countries such as the Democratic Republic of Congo (DRC) and others in the Congo Basin, previously considered relatively immune, now face significant climate-related uncertainties, including erratic rainfall, prolonged dry seasons and extreme weather events. These disruptions increase the vulnerability of the region's 120 million people.

Addressing these challenges requires a holistic assessment of vulnerability, taking into account the dynamic linkages between environmental, socio-economic and institutional dimensions. Traditional approaches often fall short by failing to fully capture these complex interactions. This research proposes the development of an Aggregate Vulnerability Index for addressing Climate Change (AVICC), tailored to the Congo Basin, to assist policy makers in designing targeted adaptation strategies. Specifically, the study examines the climate, water, migration, and conflict nexus (Figure 1) in the north-eastern Congo Basin (Figure 2), providing a detailed vulnerability assessment to inform efforts to enhance resilience within these interdependent systems.

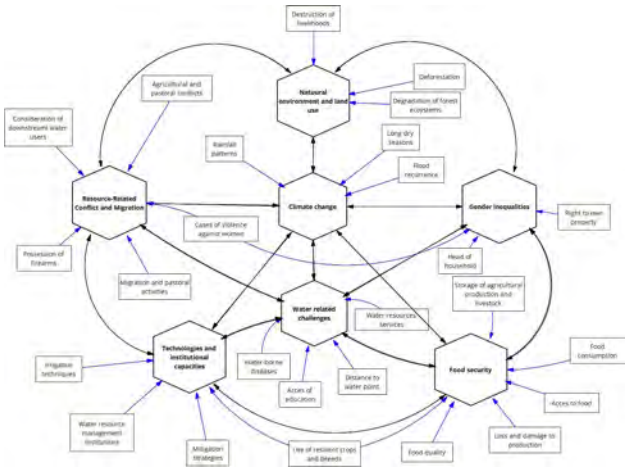


Figure 1

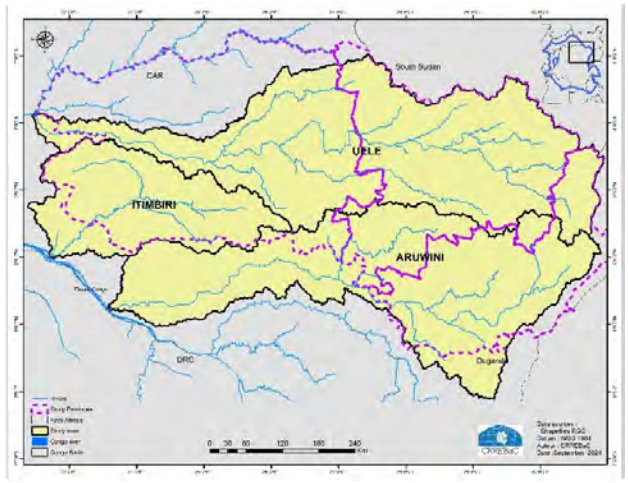


Figure 2

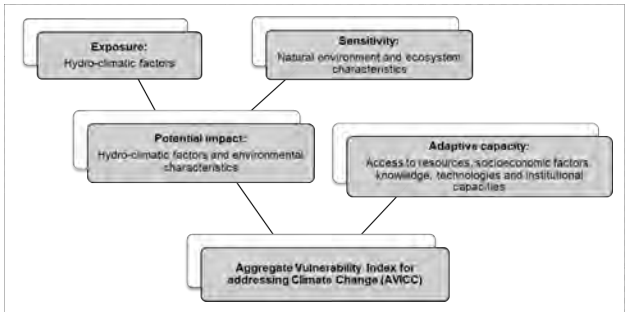


Figure 3

Conceptual framework and methodological approach

The vulnerability of a system to climate change is determined by three key factors: exposure, sensitivity, and adaptive capacity, along with the related concept of potential impact. To develop an AVICC in the Congo Basin, this research adopts a holistic methodology combining quantitative and qualitative approaches. The quantitative approach involves the analysis of data such as land cover maps and hydro-climatic time series derived from climate models. The qualitative approach focuses on socio-economic survey data to capture human dimensions of vulnerability. The methodology includes the analysis, standardisation, and aggregation of vulnerability indices to produce an integrated framework that reflects the multidisciplinary nature of climate change impacts (Figure 3).

Results

Figure 4 shows the vulnerability results for three catchments studied of the north-eastern part of the Congo Basin namely Uele, Aruwimi and Itimbiri catchments, using the AVICC, on a scale of 0 to 1, where '0' is defined as 'optimal situation, no improvement is required' and '1' as 'critical situation, the system no longer functions'.

- Exposure: Moderate drought conditions were observed, with an average Standardised Precipitation Evapotranspiration Index (SPEI) of 0.51 across the three catchments.
- Sensitivity: Forest cover sensitivity, based on Normalised Difference Vegetation Index values, ranged from 0.36 (Itimbiri) to 0.37 (Uele and Aruwimi), indicating sparse to moderately dense vegetation.
- Potential impact: A composite potential impact index of 0.54 on average, with little variation, reflecting a moderately critical vulnerability.
- Adaptive capacity: Low adaptive capacity was recorded for Uele (0.80), Aruwimi (0.72) and Itimbiri (0.76).

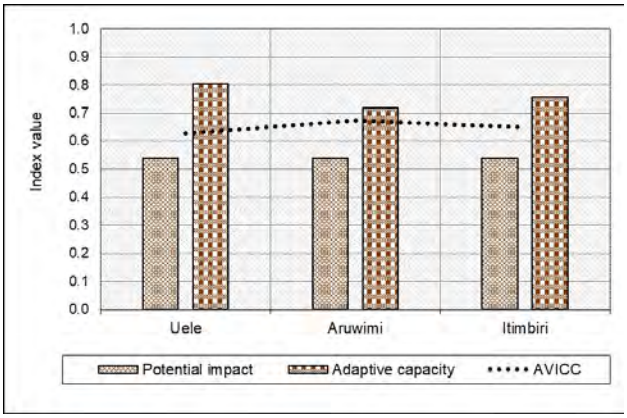


Figure 4

The AVICC results confirm significant vulnerability in all catchments, exceeding 50% of the moderate threshold. The Aruwimi catchment was the most vulnerable (AVICC = 0.67), followed by Itimbiri (0.65) and Uele (0.63). These findings indicate the importance of integrating socio-economic and institutional factors into adaptation strategies, including food security, water challenges, conflict and migration dynamics, gender inequality, and technology access, alongside addressing climate variability. Such comprehensive measures are crucial to enhancing the resilience of communities in these catchments.

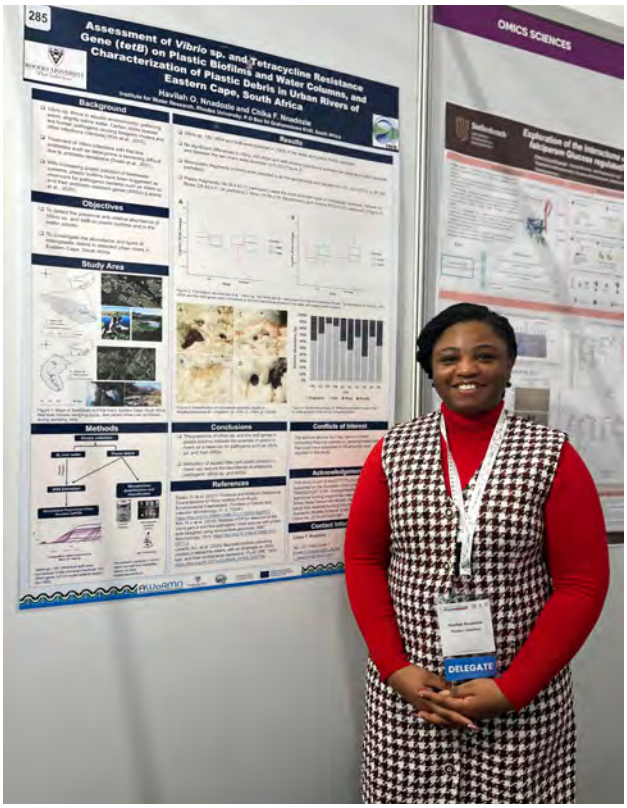
Detection and quantification of *Vibrio* and *Campylobacter* spp. and their antibiotic resistance genes in water and plastic biofilms in selected urban rivers in the Eastern Cape, South Africa: Environmental and public health implications

Student: HO Nnadozie
Supervisors: CF Nnadozie and ON Odume
Degree: MSc (Water Resource Science)

Vibrio and *Campylobacter* spp. are a group of bacteria that thrive in aquatic environments. Some species cause infections in animals, making them important pathogens in the aquaculture and food industry. Some species are human pathogens, causing zoonotic diarrheal diseases such as cholera, Vibriosis and Campylobacteriosis. In humans, infections occur through contaminated drinking water or food, or contact with contaminated water through open wounds. Deteriorating water quality caused by the discharge of waste from urban and informal settlements, industries and wastewater treatment works (WWTWs), as well as increasing surface water temperatures due to climate change favour the abundance of these bacteria in surface waters. Additionally, antimicrobial resistance to antibiotics such as tetracyclines used in treating *Vibrio* and *Campylobacter* infections is increasing. One reason is the rapid dissemination of antibiotic resistance genes (ARGs) among bacteria in the environment. These antibiotic-resistant bacteria may then infiltrate communities, causing infections that are hard to treat. Plastics in aquatic environments may serve as a concentration point or reservoir for these bacteria to such an extent that larger concentrations of these bacteria are found on plastics than in the surrounding water. Several studies have found that plastics enrich ARGs and serve as a central point for their dissemination in the environment.

This study investigated the relative contributions of plastic biofilms and environmental conditions to the abundance of *Vibrio* and *Campylobacter*, and their ARGs in the Kat and Swartkops rivers in Eastern Cape, South Africa. The findings from this study suggest that plastic biofilms and water in the Swartkops and Kat Rivers are reservoirs of ARGs and *Vibrio* spp. and that environmental variables influence the abundances of *Vibrio 16S rRNA and tetB* genes.

The research outputs for this project include two manuscripts, one of which has been submitted for journal review, and the other is currently under development. Results on the quantification of *Vibrio* spp. and *tetB* in water and plastic biofilms from the Kat and Swartkops Rivers were presented at the South African Society for Biochemistry and Molecular Biology (SASBMB) 2024 Congress. The presentation received an award for the best poster presentation in the Omics session at the SASBMB 2024 Congress.



Havilah Nnadozie next to her poster during a poster presentation session at the SASBMB 2024 congress.

Another key achievement during the year was qualifying as a finalist and representing Rhodes University at the national final of the FameLab South Africa Science Communication competition held in the NRF Auditorium in Pretoria on 19 September 2024.

Havilah presenting a three-minute pitch of her research during the National Finals of the FameLab South Africa South Africa Science Communication conference.

During the year, I also served as a volunteer peer mentor in the Rhodes University Ncedana Peer Mentorship programme. The programme provided an opportunity to reflect on my personal journey and professional growth and to share these experiences and the lessons learned with undergraduate students from various scientific disciplines.

Havilah Nnadozie qualified as a finalist in the FameLab South Africa Science Communication competition.

Application of Python water resources – Water Quality (Pywr-WQ) model: A case study in the Grootdraai Dam Catchment, Upper Vaal, South Africa.

Student: S Lazar
Supervisors: NJ Griffin, AR Slaughter and F Akamagwuna
Degree: MSc (Water Resources Science)

The Grootdraai Dam catchment is important for South Africa's economic growth, as it supports diverse industries. However, changes in land use and climate will affect water quality, impacting ecological health and potential for sustainable use. This research focuses on developing tools for water quality management in the Grootdraai Dam catchment. It employs the Python water resources – Water Quality (Pywr-WQ) model that closely mirrors the water system topology and is dynamically linked to a Python water resources (Pywr) model illustrated in Fig.1 (Tomlinson et al., 2020). This study simulated variations in water quality, considering evolving climate conditions and changes in predicted land use within the study area. Additionally, predictive land-cover models were developed to estimate non-point nutrient and salt inputs into the Grootdraai Dam catchment.

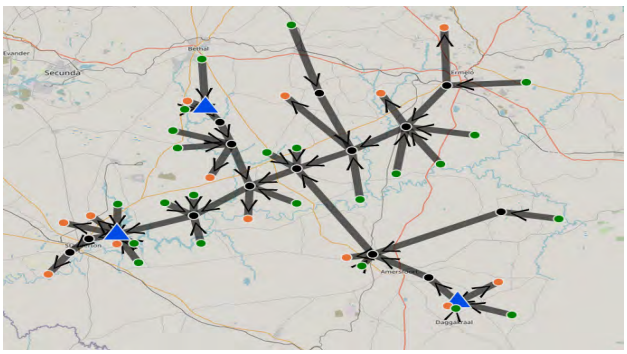


Figure 1: Pywr model for the Grootdraai Catchment implemented in the online version of Pywr (www.waterstrategy.org)

Land-use change models used a multiple regression method and were validated against calibrated Pywr-WQ model. The nodes within the Pywr topology depicted in Figure 1 are distributed throughout the

river system of the Grootdraai Dam Catchment, as illustrated in Figure 2. Each node is situated within either the same or different land-use classes, as detailed in Figure 3.

Figure 2: Grootdraai Dam Catchment river system map.

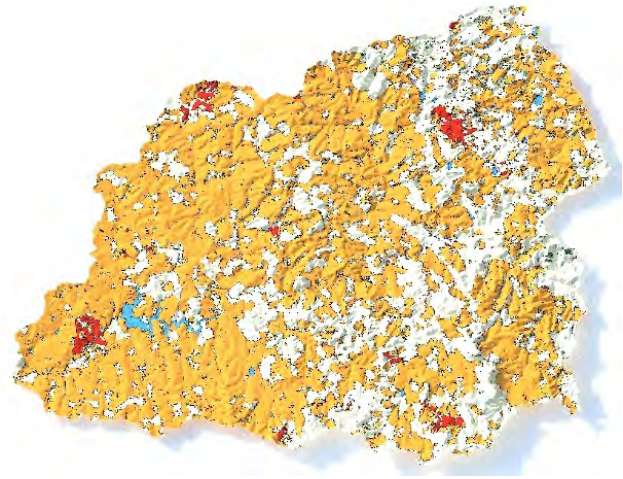


Figure 3: Land-use and land-cover map illustrating the dominant land-use classes within the Grootdraai Dam Catchment. The classification includes cropland (orange), forests/trees (green), urban areas (red), and rangeland (white). Data derived from Esri Sentinel-2 imagery (2020).

A climate map was used to give an additional layer of insight about historical climate variability in the study area. Central regions are moderate, reflecting intermediate precipitation and temperature. Downstream areas are warmer and drier, showing lower precipitation and higher temperatures.

Although the climate change datasets utilised in this study were derived from previous research (Aurecon, 2020), we maintained consistency by utilising the same temperature datasets as a baseline scenario.

The research demonstrated a clear link between increased urbanisation and elevated levels of nitrate plus nitrite and ammonium in the Grootdraai Dam. Furthermore, the expansion of cultivated land was correlated with higher phosphate concentrations. Mining activities were found to be major contributors to increased levels of salinity and sulphate. Analysis of the combined effects of climate change and water abstraction, revealed that increased abstraction, even under changing climate conditions, worsened water quality, particularly in terms of salinity and sulphate. A key finding was the potential for mine closures to improve water quality, primarily through reduced salt loading from groundwater. However, the model's assumption of immediate improvement after mine closure is unrealistic and requires further research.

The Pywr-WQ model proved to be a valuable tool for simulating water quantity-quality changes under various scenarios, including land-use changes, climate change, mine closures, and increased abstraction. It also enabled effective assessment of water quality risks and informed the development of abstraction management strategies that prioritize water quality over quantity.

Assessing per- and polyfluoroalkyl substances (PFASs) in wastewater from treatment plants in Uganda.

Student: M Ashirafu
Supervisors: ON Odume, CF Nnadozie, and GW Nyakairu
Degree: MSc (Water Resource Science)

Over the past year, as a visiting research student at the Institute of Water Research (IWR), Rhodes University, through the African Water Resources Mobility Network (AWaRMN) fellowship, I have had a transformative experience that has profoundly shaped my academic and professional trajectory.

In November 2023, I embarked on research focused on assessing per- and polyfluoroalkyl substances (PFASs) in wastewater from treatment plants in Kampala and Jinja, Uganda. This research addresses critical environmental challenges and contributes to understanding emerging contaminants in African water systems. A key highlight was presenting my

initial findings during a seminar chaired by Prof. Nelson O. Odume, which provided valuable feedback for refining my work.

A pivotal moment was participating in a fully sponsored writing retreat at Assegai, where I developed two review papers under the guidance of esteemed mentors. The first paper, 'Per- and Polyfluoroalkyl Substances in Aquatic Ecosystems and Wastewater Treatment Plants in Africa: Occurrence, Ecological Implications, Management Challenges & Future Perspectives,' has since been published (Miiro et al., 2024). This publication represents a significant milestone in my academic journey, addressing the presence and ecological impacts of PFASs in African contexts. Additionally, the retreat facilitated collaboration on a second paper focusing on ultrashort- and short-chain PFASs, examining analytical methods, toxicity, and remediation technologies, which is currently under review. I also contributed an article to *The Conversation*, aimed at disseminating insights from my research to a broader audience.

During this time, I advanced my thesis dissertation, supported by analytical tools such as LC-MS/MS and the expertise of mentors like Dr. Theo and the late Prof. Liu Krause**.** These collaborations enriched my understanding of PFAS detection techniques and their applications in environmental research. This work forms the basis of my ongoing exploration of wastewater contaminants and their implications for water quality.

Beyond academics, I actively participated in community outreach initiatives that emphasized water security and environmental conservation. Regular Saturday River Rescue activities, conducted in collaboration with local schools and community members, provided hands-on experience in improving water quality and raising awareness about sustainable practices. Additionally, I provided tutorials to undergraduate students on water quality monitoring and environmental management, further fostering community engagement and knowledge sharing.

Attending workshops and conferences throughout my mobility enhanced my professional and academic skillset. A departmental workshop on ICT and professional management honed my research workflows, while interdisciplinary discussions expanded my perspective on water resource challenges. The acceptance of my abstract for an oral presentation at the Philadelphia Conference, scheduled for June 2024, highlights the global significance of my research on PFASs and its potential contributions to environmental management.

Engaging with peers and mentors at Rhodes University fostered a strong sense of community and collaboration. I am particularly grateful for the camaraderie of fellow students, including Dr Edgar Tumwesige, Ms Angella Namatovu, and Ms Esther Sereki, whose support and insights greatly enriched my experience. Regular participation in park runs and fitness activities also provided a refreshing balance to my academic pursuits.

Like any ambitious endeavour, my mobility faced challenges, such as delays in using essential LC-MS/MS equipment. To address this, I proactively explored alternative laboratory options while maintaining steady progress on other aspects of my research. These experiences taught me resilience, resourcefulness, and the value of adaptability – skills crucial for any researcher.

My one-year tenure at Rhodes University has been a period of immense growth and learning. The publication of my research on PFASs and the dissemination of its insights through *The Conversation* underscore the relevance and impact of this work. As I prepare to present at the Philadelphia Conference and finalize my dissertation, I am confident that this experience has equipped me with the tools to address water quality challenges and advance sustainable resource management in Africa.

In closing, I extend my deepest gratitude to the AWaRMN programme, my supervisors, and the IWR community for their unwavering support throughout this journey. This transformative experience has profoundly shaped my academic aspirations and personal development, and I am eager to apply the knowledge gained to contribute meaningfully to environmental research and management.

Using a rare long-term sediment observation dataset to validate and further develop the Water Quality and Sediment Model (WQSED).

Student: NL Dlamini
Supervisors: JL Tanner, D Gwapedza, and LJ Bannatyne
Degree: MSc (Hydrology)

Accelerated soil erosion, transport and sedimentation result in extensive ecological and socioeconomic issues. These issues non-exhaustively include the low abundance of macroinvertebrates, which indicates poor water quality due to sediment stress disturbing aquatic ecosystems. The transport of soil organic carbon (SOC) through landscapes leads to its decomposition and the resultant emission of greenhouse gases into the atmosphere. Lastly, stripping topsoil nutrients through erosion poses a significant food security risk and endangers rural livelihoods.

Sediment erosion and transport models provide sediment yield information to inform catchment management. However, there is a challenge in calibrating and verifying the performance of sediment transport models in sub-Saharan Africa because of the scarcity of regional sediment data, which limits model applicability. The Water Quality and Sediment (WQSED) Erosion and transport model was developed for primary application in South Africa and represents the physical processes in erosive and semi-arid catchments. Recently, a robust sub-daily timestep of observed sediment data from a citizen-technician sampling programme measured suspended sediment from December 2015 to June 2019. This data has undergone laboratory analysis by geomorphology experts and has been made available for my study. This rare data was collected from four sub-catchments within the highly eroded and data-poor Tsitsa River catchment in the Eastern Cape, South Africa (Figure 1). The data thus provides an opportunity for this study to calibrate, validate and further develop WQSED with longer-term observed data than its previous applications in South Africa.

This study is a sub-component of a Water Research Commission (WRC) project (C2024/2025-01598) that aims to integrate WQSED as a sediment component to the Water Quality System Assessment Model (WQSAM). The Department of Water and Sanitation (DWS) employs WQSAM for water quality assessments; however, WQSAM has limited functionality and requires further development because it does not include a sediment component, a crucial gap for water quality assessments and modelling. This MSc research, in addition to the WRC project, aims to address this gap.

The DWS has also approached the Institute for Water Research (IWR) requesting assistance in employing WQSAM to establish and implement a waste discharge system for South Africa. It is, therefore, critical to further develop WQSED for integration into WQSAM as a sediment component for water quality assessment at a national scale. As part of capacity development in improving water quality modelling expertise in the knowledge and proficiency of employing WQSAM, the project held a strategic workshop for WQSAM training for a DWS team and me (Figure 2).

Figure 1: Study area.

Figure 2: WQSAM trainingat Rhodes University

The WQSED model development through this study contributes to erosion and transport modelling advancement in southern Africa by calibrating and validating model performance with a long-term contemporary observed sediment dataset and is a preliminary step to national water quality modelling endeavours in South Africa.

Integration of remotely sensed data in reducing hydrological modelling uncertainty for sustainable water resources management in Africa

Student: HA Okal
Supervisors: JL Tanner and SK Mantel
Degree: PhD (Hydrology)

Introduction

Africa's water resources are vital to its socio-economic development, yet hydrological modelling in the continent faces significant challenges. Variability in climatic and hydrological conditions, coupled with sparse hydro-meteorological networks, hampers effective water management. Remote sensing technologies, such as the ERA5-Land dataset and global hydrological models (GHMs), have emerged as critical tools for addressing data gaps. However, the applicability of these tools in capturing localized hydrological processes remains uncertain, raising questions about their reliability for sustainable water resource management. This study explores the utility of remotely sensed data, focusing on the ERA5-Land dataset, in reducing hydrological modelling uncertainties across African river basins, particularly in the Congo, Zambezi, and Eswatini.

Objectives

1. To identify regions in Africa with reliable hydrological information and assess local capacity in modelling processes.
2. To validate the performance of GHMs using outputs from local modelling studies.
3. To assess the reliability of the ERA5-Land dataset in generating regional hydrological constraints.

Findings

Objective (i): The study revealed significant spatial variability in Africa's water resources, with regions like the Sahel and Central Africa facing severe data scarcity. Local capacity was shown to play a critical role in hydrological modelling success, as demonstrated in basins like the Okavango and Rufiji. Conversely, limited expertise in regions like the Horn of Africa exacerbates challenges in sustainable water management.

Objective (ii): GHMs provided basin-scale insights but often failed to capture localized hydrological processes, leading to substantial biases. For instance, in the Niger Basin, integrating local datasets into GHM calibration improved model accuracy. However, in regions with limited observed data, the reliance on GHMs introduced significant uncertainties in hydrological predictions.

Objective (iii): ERA5-Land demonstrated moderate reliability in regions with stable flow conditions, such as the Zambezi Basin and Eswatini's Flat Highveld. However, it underperformed in capturing extreme events, such as high-flow conditions in the Congo Basin and low flows in Eswatini's Lowveld. Its coarse resolution often failed to represent localized processes shaped by topography, soil variability, and aridity.

Conclusions

The ERA5-Land dataset serves as a valuable baseline for hydrological modelling in data-scarce regions, offering broad spatial and temporal coverage. However, its limitations in accurately simulating extreme hydrological events and localized processes restrict its applicability in

complex terrains and arid regions. While GHMs provide critical insights at a macro scale, their utility is constrained by the lack of validation against local datasets. The study underscores the need for integrating remotely sensed data with ground-based observations and region-specific calibration to enhance hydrological modelling accuracy in Africa.

Recommendations

Governments should invest in hydrological infrastructure and promote public-private partnerships to improve resource availability and data-sharing. Modernising monitoring networks with remote sensing and machine learning is crucial for real-time analysis. Developing region-specific calibration frameworks and using ensemble modelling will enhance reliability. Strengthening local expertise and fostering cross-basin collaboration is also vital for tackling water scarcity and climate change.

Conferences

1. United Nations/Costa Rica/PSIPW – 6th Conference on the Use of Space Technology for Water Management, 2024. *Assessing ERA5-Land Performance for Hydrological Modelling in Data-Scarce Sub-Saharan Africa regions.* Harriette Adhiambo Okal, Jane Tanner, Sukhmani Mantel, Dennis Hughes. 7–10 May 2024, San Josè, Costa Rica.
2. 7th Cairo Water Week, 9th Africa Water Week and the Inaugural Africa Hydrological Conference, 2024, Cairo, Egypt. panellist and speaker:
   - Policy and Technical Solutions for Water Data Diplomacy and Exchange Session: Integrating Data into Diplomacy and Diplomacy into Data (panellist) (above right)
   - Plenary Session: Actions for Water and Climate Adaptation and Resilience. Role of the Youth in Enhancing Hydrological Services Delivery
   - Leveraging Hydrological Data for Integrated Water-Energy-Food Nexus Solutions: Socioeconomic and Resilience Benefits Across Africa (Moderator and Speaker)
3. Drought Resilience + 10 Conference – High-Level Meeting on National Drought Policy, 2024, World Meteorological Organization, Geneva, Switzerland. Session on Private-Public-Civil Society Partnerships (PPCSPs), (panelist)

Harriette Okal at the inaugural function of the Africa Hydrological Conference during the 7th Cairo Water Week and the 9th Africa Water Week in Cario, Egypt

Assessing the occurrence and abundance of microplastics in the longitudinal zones of river systems in protected areas within the Eastern Cape and Western Cape of South Africa

Student: S Mapapu
Supervisors: ON Odume and E Mack
Degree: PhD (Water Resource Science)

Microplastic pollution in river systems is an emerging global concern. In South Africa, rivers within protected areas in the Western and Eastern Cape play vital roles in biodiversity conservation and ecosystem services. These rivers are increasingly threatened by microplastics originating from tourism activities, upstream sources, and inadequate waste management.

Research on microplastics in these regions, especially focusing on freshwater systems, remains limited, particularly concerning their

occurrence, distribution, and relationship with river geomorphology. Furthermore, the impact of tourism on microplastic pollution within these protected ecosystems has not been adequately addressed. The study aims to bridge these gaps by investigating the sources, abundance, and dynamics of microplastics across longitudinal zones of river systems, while also examining social dimensions related to tourism and plastic usage. The study hypothesis that longitudinal river zones are reliable predictors of microplastic concentration and size owing to their distinct hydrodynamic characteristics, and tourism is a significant contributor to microplastic pollution during peak seasons in protected areas. The following objectives have been developed:

- Identify how hydrodynamic factors (e.g. flow velocity) of a river system influence microplastic distribution and occurrence.
- Establish whether a functional relationship between microplastic size and abundance, and river longitudinal zonation occurs.
- Assess plastic usage patterns and waste management during peak tourism seasons and whether these contribute to microplastic occurrence in river systems within protected areas.
- Evaluate the effectiveness of existing tourism-related initiatives addressing plastic pollution and microplastic contamination in these rivers.

Application of SWAT+ model to assess the hydrology of irrigated agricultural catchments in Western Cape, South Africa

Student: S Mabohlo
Supervisors: JL Tanner and D Gwapedza
Degree: MSc (Hydrology)

I spent almost half of 2024 wrapping up my MSc research project which formed part of a broader WRC project (No. C2020/2021-00607) focused on assisting farmers in the Koue Bokkeveld region develop a sustainable water management plan. An in-depth investigation of the impact of agriculture on hydrology is fundamental to developing an effective water management plan, and so, my MSc research applied the SWAT+ model to represent irrigated agriculture in a detailed manner to produce reliable hydrological information in support of the development of water management plan.

Since SWAT+ is a newly introduced semi-distributed model that can accurately represent dams and irrigation from multiple sources, this research explored the capability and limits of applicability of this model in representing catchments with numerous dams used conjunctively with groundwater for irrigation. The SWAT+ hydrological model for this study was configured to explicitly represent as many dams as possible and simulate the hydrological impacts of dam networks and water dynamics in each dam in relation to abstraction.

The model was run for three different scenarios. The first scenario was considered natural, where crops, reservoirs and irrigation were not represented in the model setups. The various aspects of anthropogenic change were gradually incorporated into the model to evaluate the comparative magnitude of the effects of anthropogenic interventions. In the second scenario, cultivated crops and the reservoirs were included in the model setups. Crop irrigation from reservoirs, river channels and aquifers were then represented in the third scenario.

SWAT+ explicitly represented a significant number of dams, although, in some cases, the smallest dams had to be grouped owing to the model's structural inadequacy. Streamflow was simulated satisfactorily with an NSE value above 0.65 after calibration (Figure 1). Model outputs showed that dams and irrigation resulted in an annual average

streamflow reduction of 74% (Figure 2). Moreover, irrigation led to zero spillage in dams 80% to 100% of the time, with this variation dependent on the dam's size, location, and the size of the irrigated area.

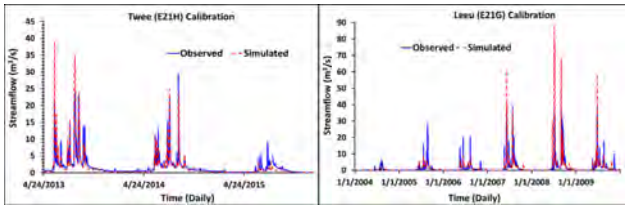


Figure 1: Hydrography of model calibration for Twee and Leeu Catchments.

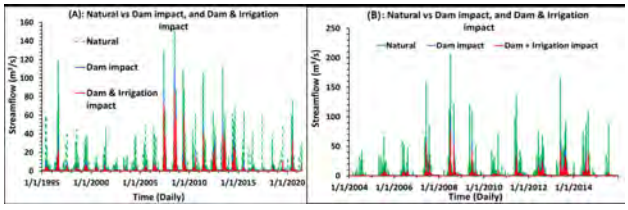


Figure 2: Comparison of Hydrographs of a naturalised scenario, dam impact scenario, and dam and irrigation impact scenario for the (A): Twee Catchment and (B): Leeu Catchment.

These model predictions highlight that dams and irrigation cause discontinuity of flow-path, leading to early and extended hydrological drought downstream. The SWAT+ model demonstrated the capability to represent a dense network of dams and irrigation in detail and provided valuable insights into the hydrological dynamics of an intensively irrigated agricultural catchment.

In the second half 2024, I presented the performance and results of SWAT+ in modelling complex irrigated agricultural catchments at the 2024 South African Hydrological Society Conference (SAHS). This presentation built on my previous talk at the AIHS and SAHS 2022, where I discussed the challenges and complexities involved in configuring SWAT+ to accurately represent irrigated catchments. I presented my research ideas at the INITIATE 1st Annual Meeting, which took place from 25 to 29 November 2024, in Ben Guerir, Morocco, in support of my PhD, which I registered for in July 2024.

Mapping areas of high risk for waterborne zoonoses in the Eastern Cape: Integrating multi-criteria decision analysis with GIS to identify critical rivers

Student: SM Mazibuko
Supervisors: CF Nnadozie
Degree: MSc (Water Resources Science)

Zoonotic diseases are infections transmitted from animals to humans or *vice versa* and are the major causes of health problems around the globe. According to one estimate, they cause about 2.5 billion infections and 2.7 million human deaths annually. Waterborne zoonotic diseases, such as cryptosporidiosis, campylobacteriosis, and schistosomiasis, are of major concern. In the Eastern Cape of South Africa, many rural communities depend on rivers and streams for their drinking water, making these diseases a public health concern. Unsafe drinking water, poor sanitation facilities, and large-scale livestock farming greatly increase the risk of contamination by germs that can be passed from animals to humans in the water. Because detailed river mapping in the Eastern Cape does not exist, it is very difficult to identify which of the rivers in this area are most likely to suffer contamination by waterborne zoonotic diseases. Identifying key factors contributing to zoonotic contamination and developing spatial models to map high-risk rivers by integrating Multi-Criteria Decision Analysis (MCDA) and Geographic Information Systems (GIS) is essential.

This study will use MCDA and GIS methods to identify important rivers contributing to the occurrence of waterborne diseases. The combined approach will help develop maps of high-risk areas so that specific interventions to reduce the risks of diseases can be carried out effectively. This research aims to achieve three main goals: the first is to identify and assess major environmental factors contributing to the spread of waterborne diseases from animals to humans, such as land-use changes, including cutting down forests and breaking up habitats, farming practices, raising livestock, and climate change. This will GIS and MCDA to generate maps showing areas at high risk for spreading these diseases in the Eastern Cape. These models will be verified by conducting fieldwork at the site on local environmental conditions to ascertain that the models are accurate and reliable.

Study progress

Thus far, the ecological drivers of waterborne zoonotic contamination in rivers, which include agricultural runoff, land-use change, livestock, and climate change impacts, have been identified and processed. However, this project is in its initial stages, and therefore many more drivers will be collated when considering the Eastern Cape context. Using AHP in the MCDA framework, an initial risk map was created by fusing various data layers, such as land-use change, proximity to settlements, and hydrological patterns.

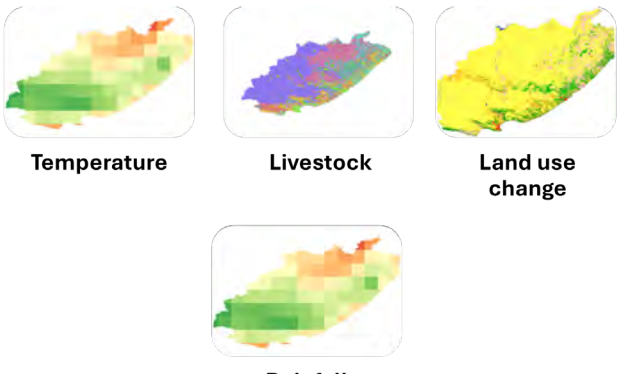


Figure 1: Spatial layers representing some of the drivers of waterborne zoonotic disease transmission used to generate a risk map to identify areas at high risk in the Eastern Cape catchments.

Analysing the distributive, procedural, and contextual equity dimensions of water security challenges in Nelson Mandela Bay Metropolitan Municipality.

Student: V Mlonzi
Supervisors: ON Odume and C Murata

Background

The water needs of a growing population have led to conflicts over water resources in semi-arid regions of the world. The increase in water scarcity seriously impacts environmental justice and equal opportunity. Gqeberha, previously known as Port Elizabeth, of the Eastern Cape Province in South Africa, is one of the regions affected by both water scarcity and pervasive inequality. The Nelson Mandela Bay Metropolitan Municipality (NMBMM) includes peri-urban towns, high-density settlements, wealthier suburban areas, commercial centres, industrial zones, the Ngqura (Coega) Development Zone adjacent to Ngqura harbour, and the surrounding agricultural lands. This study aims to investigate water security challenges in the NMBMM and the implications across the various levels of society.

Research objectives

1. To examine the water security challenges in the Nelson Mandela Bay Metro.
2. To examine the municipal responses to the water security challenges.
3. To analyse the equity dimensions of the water security challenges in the Nelson Mandela Bay Metro.

Progress of study

The research has made notable advancements this year, spanning academic writing, professional development, data collection, and the initiation of data analysis.

I spent ten months at Makerere University under the Department of Environmental Management as part of an exchange programme (Figure 1). I completed several modules and courses, enhancing my understanding of water governance frameworks and adaptation strategies. This experience provided a comparative perspective, enriching the theoretical foundation of my research and offering new approaches to equity-focused analyses.

Academic writing milestones

1. I finalised and submitted two foundational chapters of my dissertation:
   - The *General Introduction* outlines the research problem, objectives, and significance, situating the study within the broader discourse on water security and equity.
   - The *Literature Review* provides a detailed synthesis of existing research, highlighting critical gaps and framing the study's contributions.

Figure 1: Engaging in academic development at Makerere University, Uganda, under the Environmental Management Department

2. Data collection progress
   - Following the successful recruitment of research assistants, data collection activities resumed. Household interviews and surveys were conducted across focus areas: informal settlements, middle-income neighbourhoods, and affluent areas (Figures 2 and 3).
   - Document analysis provided critical insights into municipal drought responses and the implications for equity.
3. Initiation of data analysis
   - Currently, I am analysing the data collected from interviews, surveys, and municipal documents, identifying critical themes related to water security challenges and assessing the equity dimensions of municipal responses.
4. Challenges encountered
   - Logistical difficulties coordinating fieldwork across diverse areas required adaptive strategies to ensure smooth data collection.
   - Analysing data from multiple sources presents complexities but offers the opportunity for a comprehensive understanding of the issues.

Figure 2: On-site data collection in the field, gathering critical information on water scarcity impacts across informal settlements, middle-income neighborhoods, and affluent areas of the Nelson Mandela Bay Metropolitan Municipality

Figure 3: Collaborating with research assistants during fieldwork in Nelson Mandela Bay Metropolitan Municipality. Their support was invaluable in conducting household interviews and surveys across diverse socio-economic areas

In summary, 2024 has been a year of significant progress, marked by academic growth, productive fieldwork, and the transition into the critical data analysis phase. I remain committed to producing actionable insights that address water security challenges and promote equity in Nelson Mandela Bay Metropolitan Municipality.

Mainstreaming equitable decision-making under uncertainty at the water user association level using a reallocation model in the Western Cape, South Africa

Student: BS Xoxo
Supervisors: JL Tanner and SK Mantel
Degree: PhD (Hydrology)
Collaborators: O Barreteau (Institut National de Recherche Pour L'Agricuture, L'alimentation et L'Environnement, France), B Paxton (Freshwater Research Center, South Africa), S Theron (Citrusdal Water User Associaiton, South Africa)

One hundred and forty-six drought events were recorded globally between 2000 and 2020, affecting over 274 million people in Africa and 1.1 billion people in Asia. This recurring water-related disaster is associated with over US$6.8 billion in economic losses (which is an underestimate), over 20 000 fatalities, and puts 80% of jobs at risk. As highlighted by the 2024 United Nations World Water Development Report, this phenomenon can bring our societies into systematic crisis if unmitigated. The uncertainty surrounding the mathematical outcomes used to support water management decisions further complicates the issue.

Scientists worldwide have resolved scientific uncertainty and appreciate its existence, but expressing it effectively for decision making remains a challenge. In water allocation, community objectives and vulnerability to water scarcity are crucial for fairness, increasing uncertainty but also fostering cooperation.

My PhD thesis aims to address water insecurity in South Africa by incorporating uncertainty into equitable decision-making. It involves developing a methodological framework, a serious game, and a Water-Sharing Tool to support fair water reallocation strategies and reduce vulnerability to local water shortages. The model was initially developed within Rhodes University in 2017 but has not been used in a real water allocation planning case study.

The Water Sharing Tool is a water allocation model designed to help decision makers manage supply, demand, and priorities. It calculates environmental impact and offers four strategies for unmet socio-economic demand, aiding in risk-informed decisions for Water Users Associations and Catchment Management Agencies.

The game board, made up of tiles representing units of land that can be cultivated and river bank in the particular catchment. This is done in visual way that mimics the shape of the catchment and is recognisable to local stakeholders.

Post-game debriefing session in Kunje Guest Farm in November 2022.

Quotes from stakeholders in the Koue Bokkeveld reflect their experiences.

"*The game makes one see the impact on other users. For example, losing a portion of water means a lot more loss for smaller farmers.*"

"*The game is ideal for perspective; it helps understand the entire catchment.*"

"*The game is powerful in showing the role of a manager and a co-developed water management plan as a 'referee'.*"

"*We don't need any water-sharing strategies because farmers all work together and can easily request water from our upstream neighbours.*"

"*Ja, there has to be some form of variation in how water restrictions are applied.*"

Some simulation outcomes from the Water-Sharing Tool

Based on a simulation of 27 years, and using the 'Split-the-Bill, or proportional allocation' water sharing scenario (Table 1), results suggested that the most vulnerable user group in the catchment would experience between 11 and 18 months of catastrophic impact, as well as between one and three months of high impact during this period.

Table 1: Summary of several metrics quantifying the supply deficit impacts for irrigation abstractions from Twee River over 324 months

Metric	Range of values over 90% of the ensembles
	User 2 – Suurvlei up
No. months in impact groups 1 to 5	305 to 307
No. months in impact groups 6 to 9	17 to 19
No. months in impact group 10	11 to 18
No. of years with high impacts in Jan.	3.6 to 3.7
Possible impacts in Feb.	3.9 to 6.3
Possible impacts in Mar.	51.2 to 62.6
Max. consecutive months with impacts >50%	3
Max. consecutive months with impacts >90%	3
Max. consecutive years with impacts in Feb and March both >50%	5
Max. consecutive years with impacts in Feb and March	2 to 5

Finally, I offer a number of recommendations including, but not limited to:

- The enduring need to mainstream fair procedures and involve all relevant stakeholders in water management decision-making processes.
- Increase understanding and appreciation of uncertainty and equitable decisions through improved communication.
- Consider holistic implications to assess the fairness of results based on underlying vulnerabilities.

Research outputs

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