

Setting up an Operational Water Resources Accounting System for South Africa: Project Overview

National Natural Capital Accounting Forum

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Background

- WRC funded project No. C2025/2026-01768
- Project Duration: Sep 2025 to Sep 2030 (5 years)
- Project Lead Organisation: Centre for Water Resources Research (CWRR) at UKZN in PMB
- CWRR was formed in 2012, and is active in research, teaching and capacity building related to hydrology and water resources research. Academics were involved in this field since 1984. Director: Prof David Lokhat.
- Expertise in Hydrological Modelling and Water Resources Accounting

CWRR OVERVIEW

CWRR: Advancing Interdisciplinary Science for Water and Climate Sustainability

Interdisciplinary research for water, climate, and environmental sustainability

Institutional Identity & Recognition



A Legacy of Excellence since 1984:

Core team a pillar of South African hydrological research and teaching.



Interdisciplinary Research Leader:

Global linkages, focusing on hydrological and climate systems.



2023 NSTF-WRC South Africa Award Winner:

For cutting edge applied research and postgraduate training

Core Research Mandate



Hydrology & Water Resources Science:

Solving the water balance equation across spatial scales.



Climate Variability & Change:

Assessing impacts of shifts on water availability and extreme events.



The Water-Energy-Food Nexus:

Integrated research for agricultural efficiency and food security.



Ecohydrological Processes:

Studying interactions between water systems, catchments, and wetland health.

Research Themes & Methods



Hydrological & Climate Modelling:
Mimicking real-world scenarios for evidence-based predictions.



Data Science & Machine Learning:

Predicting streamflow, big data analytics via Water Research Observatory (WRO).

Remote Sensing & Earth Observation:
Utilizing satellite data, GIS for large-scale monitoring



Integrated Assessment:

Evaluations across scales, from local catchments to transboundary systems.

Research Applications & Impact



Water Resource Management:

Scientific basis for streamflow reduction and water allocation.



Decision-Support Tools:

Developing repository platforms (WRO) for data and models.



Policy-Relevant Outputs:

Directly informing national water legislation and IWRM implementation.



Climate Risk Reduction:

Analyzing extremes to help communities adapt to flood risks and water scarcity.

Training & Capacity Development



Proven Graduate Success:
63 Honours, 59 Master's, 33 PhD students in hydrology since 2012.



Mentorship & Progression:

Linking Honours students into broader research teams for academic growth.



Specialized Skill Building:

Targeted development for tomorrow's Water Resource Champions.

Partnerships & Collaboration



Multidisciplinary Teams:
Partnering across UKZN Schools and international universities.



Government & Authority Liaison:
Working with DWS and water authorities to translate research into practices.

Institutional Linkages:
Deep collaboration with WRC, Umgeni Water, international networks.

Call to Action



Partner on Research:
Join CWRR in funded initiatives for complex water challenges.



Join the Academic Ranks:
Apply for MSc and PhD programme mentored by leading experts.



Collaborative Supervision:
Opportunities for experts to co-supervise postgraduate students.

Project Partners

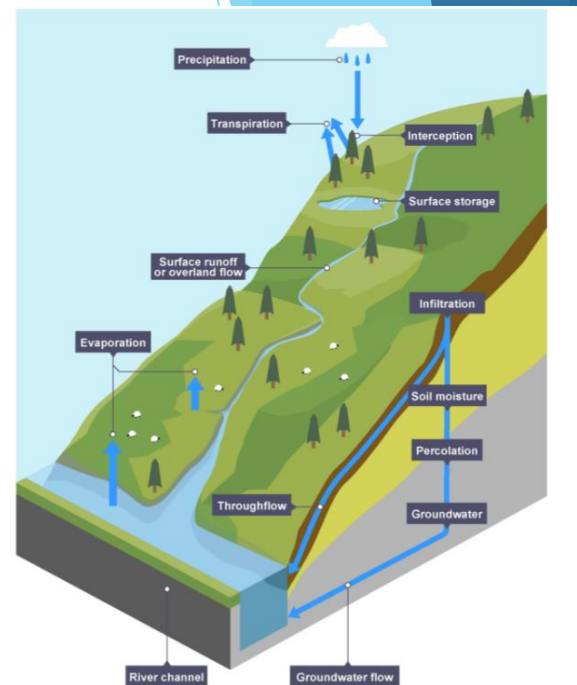
- **SAWS:** Statistical analysis of observed climate data; Contributing to bias-correction of remotely sensed climate datasets using around 250 climate stations.
- **SAEON:** Expertise in data management and visualisation of WRAs through online user interfaces.
- **ARC:** Explore synergies with the WRC's Water Research Observatory Data Portal & provide expertise with regards to data provision.
- **DWS:** Provision of data & guidance regarding procedure and processes for accessing data annually for the whole country. Participation in discussions, as potential end users of the accounts.
- **North-West University:** Groundwater expertise and student contributions.

Definition of Water Resources Accounting

- ▶ Field of water resource management and natural capital accounting
- ▶ The purpose of water resource accounts is to provide annual, standardised water resources estimates (statistics and indicators) at a range of catchment scales, in a manner that is spatially explicit (at quaternary catchment scale) to support a holistic landscape or system view of water resources (Stats SA, 2024).
- ▶ Based on hydrological modelling, the approach also aims to fill gaps between sparse point measurements and improve understanding of the impacts and influence of upstream land use and management of water (Stats SA, 2024).

Water Resources Accounting

- ▶ Based on hydrological modelling of the hydrological cycle: conversion of rainfall into evapotranspiration, runoff, soil water
- ▶ To complement the National Water Accounts, which uses the System of Environmental Accounting (SEEA) Water accounting framework, being focused on economics related to water
- ▶ Linkages between the National Water Accounts and National Water Resources Accounts should be to maximised



Previous work done on WRA in SA (1/4)

WRC Projects K5/2205 & K5/2512

CLARK, DJ (2015, 2019) Development and Assessment of an Integrated Water Resources Accounting Methodology for South Africa. Phase 1 and 2, WRC Reports 2205/1/15 & 2512/1/19

- Project objectives included review of water accounting frameworks.
- Development of a modified Water Accounting Plus (WA+) framework suitable for SA.
- A methodology was developed based on hydrological modelling,
- including water availability estimation and sectoral water use components.

Previous work done on WRA in SA (2/4)

Natural Capital Series 4: Sub-national Water Resource Accounts, 2015 to 2021. Statistics South Africa 2024, in collaboration with the South African National Biodiversity Institute and the University of KwaZulu-Natal's Centre for Water Resources Research.

- Creation of draft WRA for 3 catchments

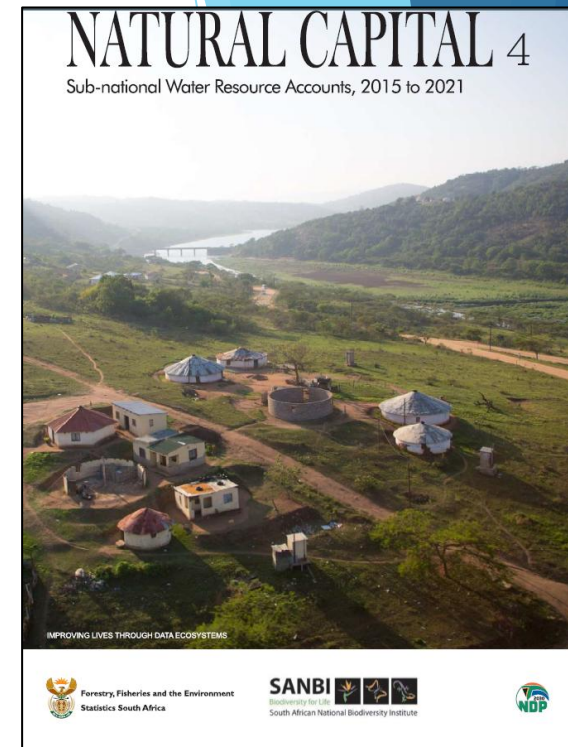
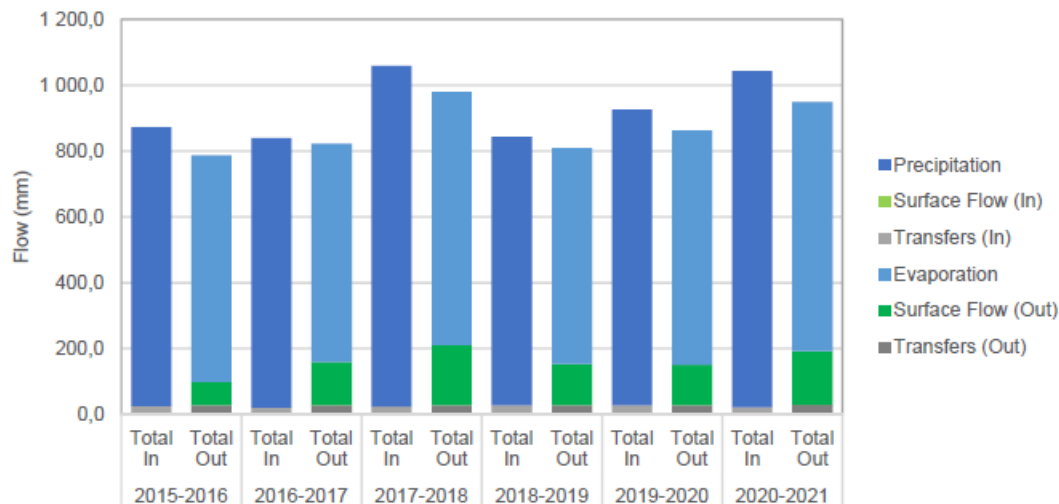


Figure 12 – Time series of catchment total inflows and total outflows for the uMngeni Catchment, as normalised depths (mm), 2015 to 2021



An example of a water resources flow account showing time series of catchment inflows and outflows (Statistics SA, 2024)

Previous work done on WRA in SA (3/4)

uMngeni Catchment	Total			Natural or semi-natural			Cultivated			Built-up			Waterbodies		
Area	(km ²)	% ¹		(km ²)	% ²		(km ²)	% ²		(km ²)	% ²		(km ²)	% ²	
	4 454,1	100,0		2 022,6	45,4		1 480,5	33,5		798,4	17,9		144,8	3,2	
Water resource details	Volume (Mm ³)	Depth (mm)	%	Volume (Mm ³)	Depth (mm)	%	Volume (Mm ³)	Depth (mm)	%	Volume (Mm ³)	Depth (mm)	%	Volume (Mm ³)	Depth (mm)	%
2015-2016															
Total In	3 884,3	872,1													
Precipitation	3 772,5	847,0	97,1	1 680,6	372,8	44,0	1 335,3	299,8	35,4	662,4	148,7	17,6	114,2	25,8	3,0
Inflows	111,8	25,1	2,9												
Q _{in SW}	0,0	0,0	0,0												
Q _{in GW}															
Q _{in Transfers}	111,8	25,1	2,9												
Total Out	3 502,1	786,3													
Total Evaporation (ET)	3 064,0	687,9	87,5	1 456,7	327,0	47,5	1 202,9	270,1	39,3	294,5	66,1	9,6	109,9	24,7	3,6
Landscape ET	3 001,7	673,9	98,0	1 456,7	327,0	48,5	1 193,9	268,0	39,8	241,1	54,1	8,0	109,9	24,7	3,7
Incremental ET	62,3	14,0	2,0	0,0	0,0	0,0	9,0	2,0	14,4	53,4	12,0	85,6	0,0	0,0	0,0
Interception ET	781,3	175,4	25,5	442,3	99,3	56,6	264,8	59,4	33,9	70,0	15,7	9,0	4,2	1,0	0,5
Transpiration ET	1 324,6	297,4	43,2	545,5	122,5	41,2	664,5	149,2	50,2	99,0	22,2	7,5	15,6	3,5	1,2
Soil Water ET	854,8	191,9	27,9	468,9	105,3	54,9	271,5	61,0	31,8	105,3	23,6	12,3	9,1	2,0	1,1
Open Water ET	103,3	23,2	3,4	0,0	0,0	0,0	2,1	0,5	2,1	20,2	4,5	19,5	81,0	18,2	78,4
Outflows	438,1	98,4	12,5												
Q _{out SW}	319,1	71,6	9,1												
Q _{out GW}															
Q _{out Transfers}	119,0	26,7	3,4												
Total Change In Storage	-382,2	-85,8		-53,1	-11,9		-31,8	-7,1		-254,4	-57,1		-42,9	-9,6	
DS _{raw}	-278,6	-62,6		3,0	0,7		2,9	0,7		-241,2	-54,1		-43,4	-9,7	
DS _{soilM}	-98,6	-22,1		-49,8	-11,2		-41,6	-9,3		-7,2	-1,6		0,0	0,0	
DS _{low}	-5,0	-1,1		-6,3	-1,4		6,9	1,5		-6,0	-1,4		0,5	0,1	
Internal Flows															
Interception	774,9	174,0		439,3	98,6	56,7	261,8	58,8	33,8	69,6	15,6	9,0	4,2	0,9	0,5
Surface Runoff	293,3	65,8		92,8	20,8	31,6	38,4	8,6	13,1	129,3	29,0	44,1	32,7	7,3	11,2
Infiltration	2 443,9	548,7		1 128,6	253,4	46,2	1 044,1	234,4	42,7	260,0	58,4	10,6	11,3	2,5	0,5
Pot. GW Recharge	179,4	40,3		64,4	14,5	35,9	66,5	14,9	37,1	48,5	10,9	27,0			
Baseflow	183,8	41,3		56,8	12,8	30,9	70,0	15,7	38,1	55,2	12,4	30,1	1,7	0,4	0,9
Irrigation	9,1	2,0		0,0	0,0	0,0	9,1	2,0	100,0				0,0	0,0	0,0

¹ Percentages in this column are the proportion of the total in the next higher level of aggregation, except for surface water and transfer inflows and outflows which are a proportion of Total In and Total Out (refer to Table 2).

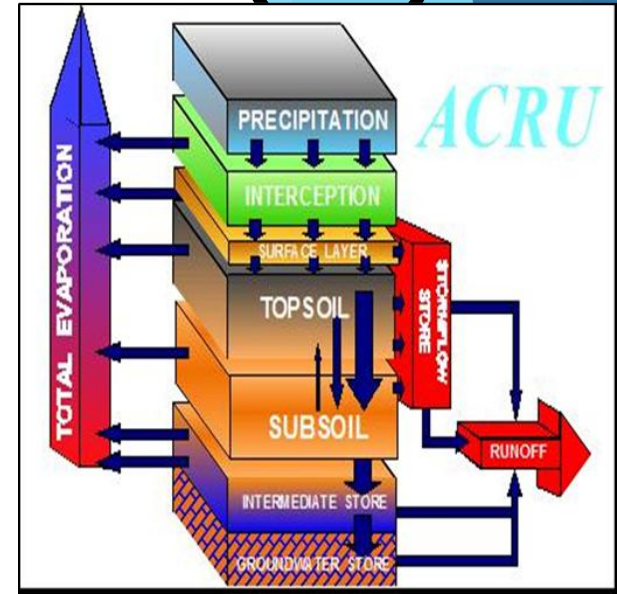
² Percentages in these columns are summed horizontally across the broad land cover classes, enabling comparison of variables across classes relative to the proportion of area extent per class.

An example of a water resources flow account disaggregated by land cover (Statistics SA, 2024)

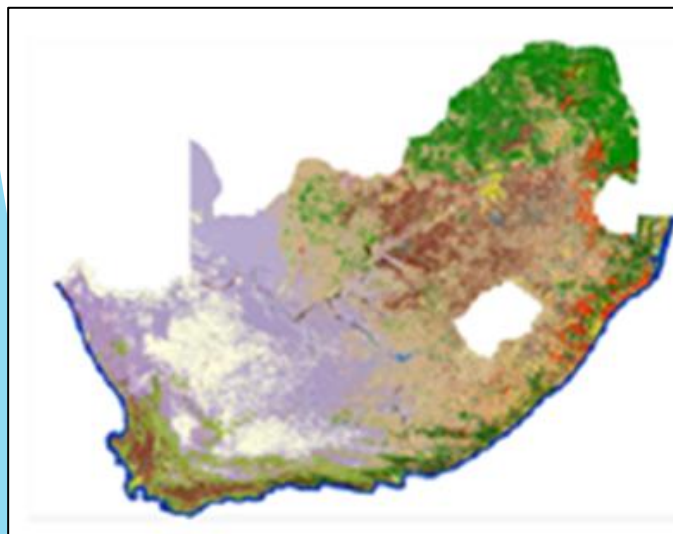
Previous work done on WRA in SA (4/4)

WRC Project C2022/2023-00887: Schütte et al., (in press)
Development of a System for Producing Modelled Annual Water Resource Accounts on a **National Scale** for SA

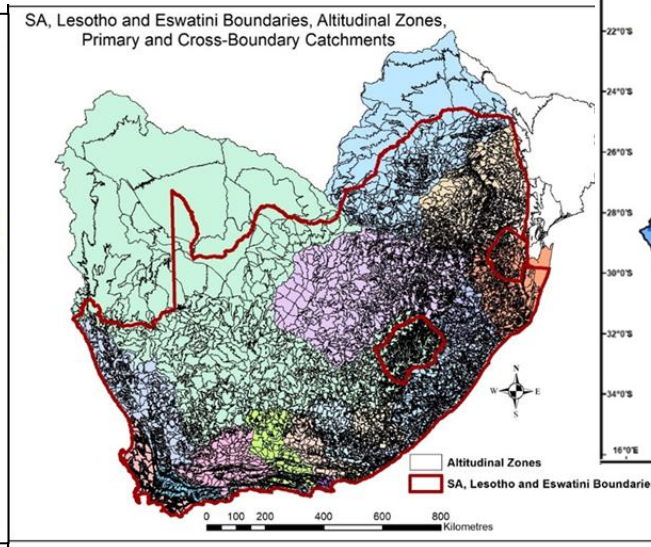
- Setting up a hydrological model for South Africa
- Inputs: remotely sensed climate datasets
- Inputs: national datasets, e.g. SANLC, AZ (Horan and Clark, 2024), soil hydrological properties
- 1946 Quaternary Catchments: 5 838 AZs: 40 866 HRUs
- Outputs include surface water flows (incl. baseflows)
- Recommendations: (i) remotely sensed rainfall needs to be bias corrected, (ii) inclusion of engineered flows



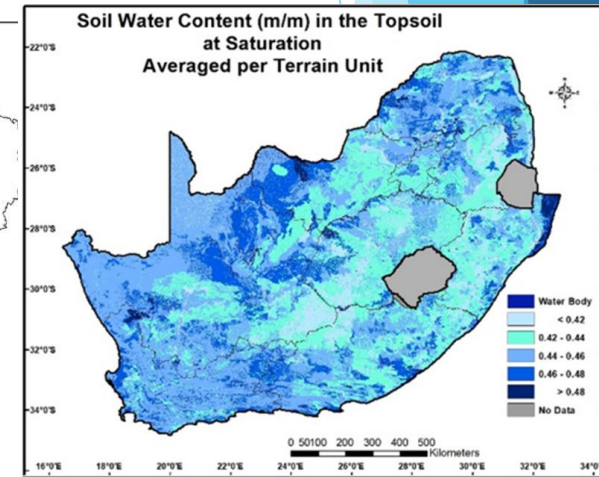
(after Schulze, 1995)



SANLC 2022 (DEA, 2024)



(Horan and Clark, 2024)



(Schütte et al, 2024)

Aims of this current Project

The aims include:

- ▶ To develop and configure an updateable operational water resource accounting system for SA, that provides spatial and temporal consistent summaries of the country's water resources, assisting to promote informed water resource management at a national and local scale.
- ▶ To determine water resources accounts that provides a quantification of water balances and fluxes in the hydrological cycle based on hydrological modelling.
- ▶ To report at a Quaternary Catchment and monthly resolution, scalable up to Primary Catchments and calendar/hydrological years.
- ▶ This includes estimates of water in rivers, water availability and sectoral water use components of the recent past.
- ▶ To make these WRAs available on an online platform.

Methods

- ▶ Builds on previous work
- ▶ Based on hydrological modelling
- ▶ Currently surface water (inclusive baseflow) setup, inclusive actual land cover
- ▶ To include engineered flows where national datasets are/become available (more later)
- ▶ To include groundwater components if possible
- ▶ To include water quality components if possible
- ▶ To do more extensive verifications of results

Climate Inputs

Model output quality depends on the quality of inputs

- ▶ Rainfall is probably the most important input into a hydrological model.
- ▶ First prize: a network of weather stations and freely available quality controlled daily climate and especially rainfall data, say for the previous year.
- ▶ But, this is unfortunately not available to us
- ▶ Alternative remotely sensed satellite-derived climate inputs. This needs bias-correction.
- ▶ To date received around 240 climate datasets of 240 climate stations from SAWS.
- ▶ Currently: develop bias correction methods
- ▶ Bias-corrected remotely sensed climate datasets.

Engineered Flow Information

- ▶ Required are national datasets.
- ▶ Location and monthly quantity of water used/transferred/abstracted/released, including:
 - water abstraction for urban or irrigation use,
 - inter-basin transfers,
 - water released from waste water treatment works,
 - water released from dams

Limited information received to date

This project requires detailed information regarding engineered flows!

Streamflow observations

Model output verification requires good quality observations

- ▶ A wide network of well maintained weirs
- ▶ Suitable also for high flows, otherwise exceeds rating
- ▶ Data should be over long periods, with few missing time slices
- ▶ Data should be quality controlled ✓
- ▶ Data freely available ✓

Building data platforms and systems for open science



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Thank you for listening

Project Team

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