IWMI
International Water
Management Institute

Technical Brief

Tracking water for countries and catchments: A new scale invariant water accounting framework for Africa

Summary

The increase in water scarcity calls for immediate actions leading to integrated water management and sustainable use of resources. The lack of hydro-monitoring networks poses a threat to managing water resources. Many nations formulate water resources management policies without a comprehensive grasp of the diverse cross-sectoral water utilisation, requirements, and shortfalls. Moreover, decisions taken by river basin organisations rely on flow data collected from a limited number of discharge stations.

Water security is the centrepiece of food security, national security, economic health, and societal well-being. To ensure equitable growth in all sectors and meet future demands, sustainable development of water resources is critical (Adeel, 2017). Yet, unsustainable and inappropriate practices in managing water resources have caused a decline in per capita water availability (Postel, 2000). Furthermore, the number of stations on the hydro-monitoring networks has decreased in recent years (GRDC, 2021). In Africa, water data scarcity is exacerbated by the already low density of active monitoring networks to maintain the hydrological services and train the technical staff (Hannah et al., 2011).

Transplanting tomato in the upper east region of Pwalugu in Ghana. (*photo*: Hamish John Appleby/IWMI)

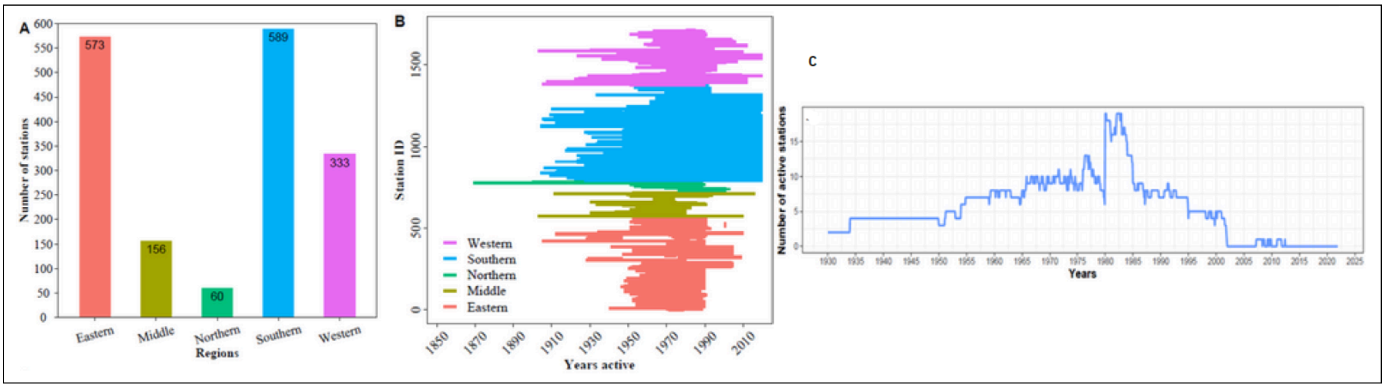


Figure 1. The decreasing hydro-meteorological stations in Africa. (A) the total number of discharge stations per region; (B) The start and end year of data availability of discharge for GRDC stations; (C) the temporal variability of active stations with data since the 1930s in Africa. (*Source*: Authors)

The International Water Management Institute's Digital Innovations for Water Secure Africa (DIWASA) initiative is generating reliable and systematic analysis-ready water data products on water use, demand, water availability, and scarcity using a new scale invariant water accounting plus (SIWA+) (Figure 2a-c).

The SIWA+ is built on the water accounting plus (WA+) approach (Karimi et al., 2013) that derives basin scale water availability and scarcity indicators using earth observation data products and limited in situ observations. The WA+ is an open-source Python programming-based model that uses a collection of remote sensing data products and in situ discharge (at basin outlet) to quantify water accounting indicators such as a) water yield, b) irrigation/rainfed water use, c) productive/unproductive water use, and other water availability indicators at the river basin scale.

To address the requirements of DIWASA at a continental scale, we modified the traditional water accounting approach to enable deriving water accounting data inputs and output products for Africa. This new approach is called Scale Invariant Water Accounting Plus (SIWA+). The SIWA+ is an adapted version of WA+ where water accounting indicators can be generated for any boundary (river basin, catchment, country or county). The SIWA+ can be explained using three different packages.

Pillar 1– Baseline SIWA+

Baseline SIWA+ is designed to generate inputs, raster outputs, and water accounts for continental Africa. The baseline SIWA+ is built on the traditional WA+ approach, but new modules such as the outlet discharge extractor (ODE) and desalination data extractor (DDE) have been added (Figure 2a).

These modules prepare the input datasets needed for the WA + model.

Pillar 2 – Rapid SIWA+

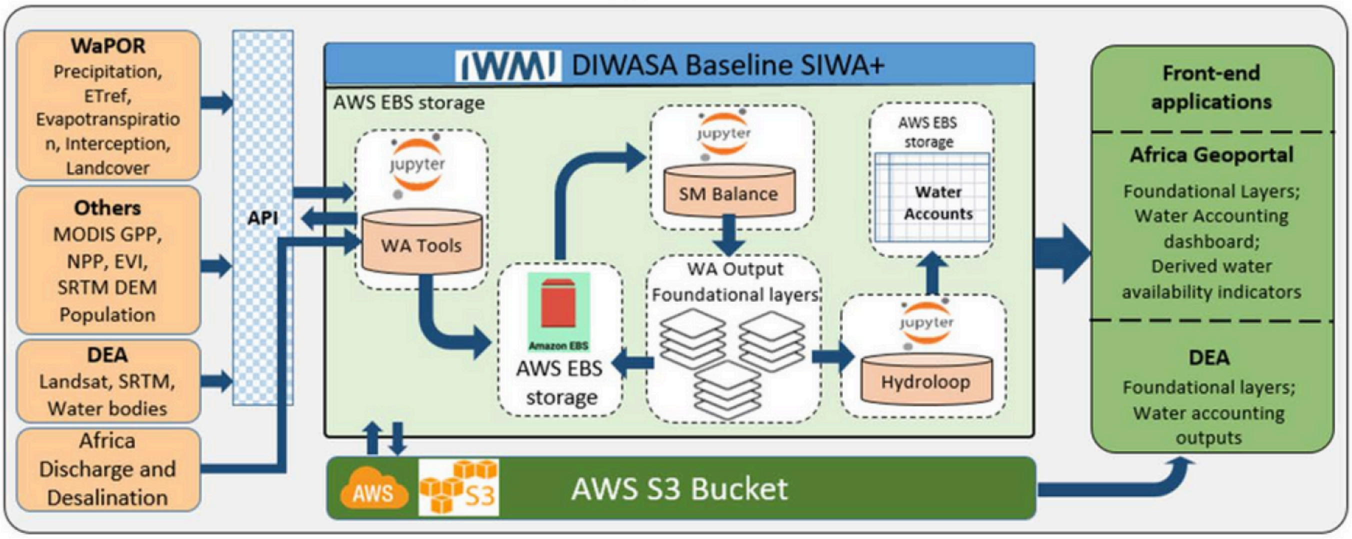
Rapid SIWA+ is designed to extract water accounts using continental water accounting data products (inputs and outputs) at 1-km resolution for any boundary (country or catchment). This package has a tool called rapid optimized sheet extractor (ROSE) that is built on two new modules – the raster data engine (RDE) and vector data engine (VDE) - that prepare required raster and vector data for the boundary of interest (Figure 2b). This package has two distinct advantages. Unlike the traditional basin WA+ model, this package enables the production of water accounts for any boundary within Africa using 1-km resolution, precomputed WA data available via open data cubes. This package eliminates the need to run traditional time-consuming water accounting tools (such as data download, processing, and soil moisture balance models), saving significant time and effort in producing water accounts.

Pillar 3 – Customizable and scalable SIWA+

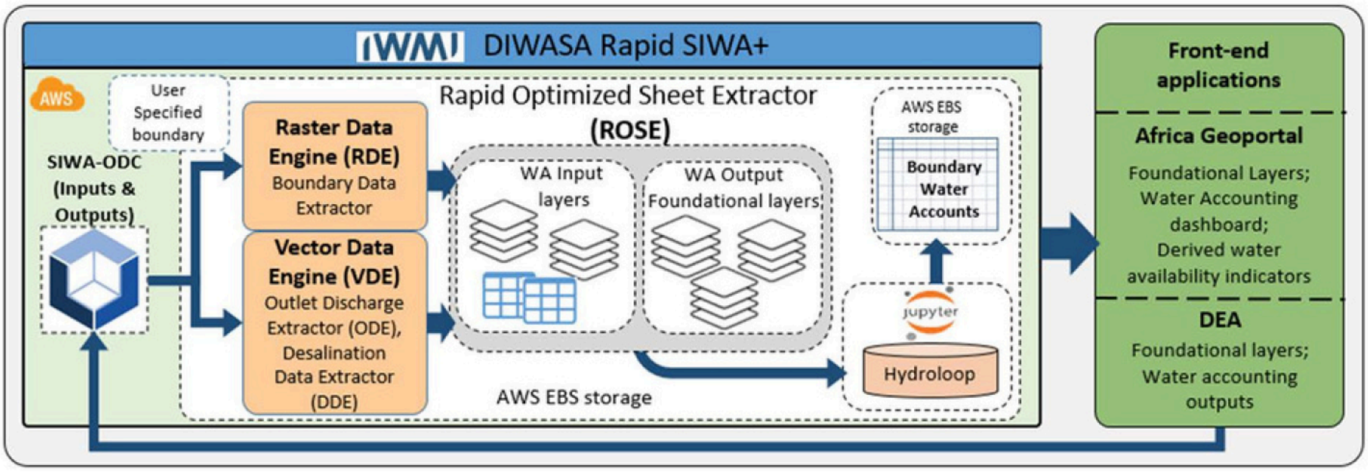
Customizable and scalable SIWA+ generates water accounts for country or catchment boundaries with userspecified inputs in Africa (Figure 2c). The user can add any particular data or set of datasets into the SIWA+, run the model at a user-specified resolution, and derive water accounts for any catchment, county, or country boundary. This package enables the production of water accounts and availability indicators at sub-national and sub-basin scales. While this package is built on the SIWA+ approach and data products for Africa, it also enables customization and changes to meet user-specific demands.

Medannet (in yellow) fetches water from the rope pump owned by her neighbor Ato Degusewa in Awassa, Southern Nations, Nationalities, and Peoples' (SNNP) Region, Ethiopia. (*photo*: Petterik Wiggers/IWMI)

(a)



(b)



(c)

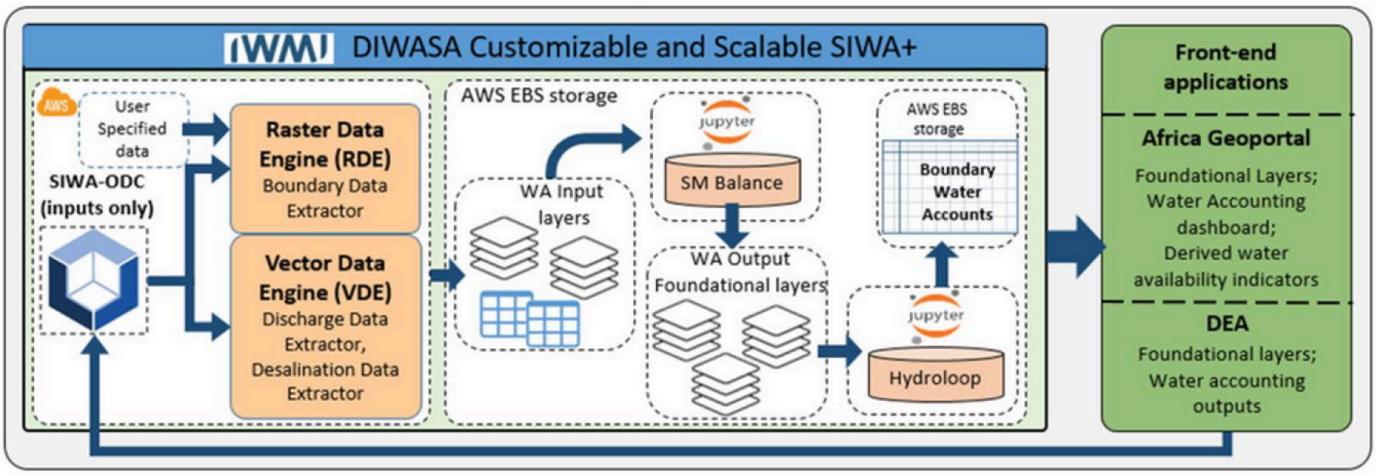


Figure 2. The open-source Scale Invariant Water Accounting Plus (SIWA+) framework setup on the Amazon Web Services platform: (a) Baseline SIWA+ approach that generates continental water accounting inputs and outputs at 1-km resolution for Africa; (b) rapid SIWA+ framework to extract water accounts using data obtained from baseline SIWA+ approach for any boundary (basin, catchment or country); and, (c) customizable and scalable SIWA+ approach for modelling water accounts using user-specifi ed data and any boundary. (*Source*: Authors)

The baseline SIWA+ approach generates consistent, systematic, and analysis-ready data products for Africa. The list of some data products generated is provided in Box 1. The suite of water data generated in this study provides several new insights into water availability and scarcity indicators at the continental scale. Open-source codes enable repeatable and rapid water accounting assessments without much effort.

The SIWA+ data on the open data cubes improves access to water data for generating several new use cases and applications for integrated water resources management.

DIWASA Derived products

1. Per capita water availability
2. Evaporative stress index
3. Blue water stress index
4. Green water stress index
5. Falkenmark's water stress index
6. Criticality ration (water use to availability)
7. Agricultural water stress index
8. Water Depletion index
9. Drought index
10. Basin closure index

DIWASA Monthly Inputs/Outputs

11. Precipitation data
12. Number of rainy days
13. Total evapotranspiration data
14. Total runoff data, surface runoff, and deep drainage)
15. Total interception losses
16. Soil moisture data
17. Blue and Green evapotranspiration data
18. Evaporation and Transpiration data
19. Change in storage (ΔS)

Box 1. List of monthly products (inputs, outputs, and derived products) using baseline SIWA+ approach.

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Project

This output was generated as part of the Digital Innovation for Water Secure Africa (DIWASA) Project. DIWASA aims to advance water security across Africa by improving the availability and accessibility of reliable water data, strengthening institutional capacities and deploying cutting-edge digital innovations. It is reshaping how data, technology and partnerships intersect to enhance water management across the continent.

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