International Water Management Institute

Project Brief

Tracking water for countries and catchments: A new multi-scale continental water accounting framework for Africa

The increase in water scarcity calls for immediate actions leading to integrated water management and sustainable use of resources. Despite the importance, 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 utilization, requirements, and shortfalls. Moreover, decisions taken by river basin organizations rely on flow data collected from a limited number of discharge stations. calls for immediate actions leading to integrated water management and sustainable use of resources. Despite the importance, 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 utilization, requirements, and shortfalls. Moreover, decisions taken by river basin organizations rely on flow data collected from a limited number of discharge stations.

Water security is the centerpiece 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). The unsustainable and inappropriate practices in managing water resources have caused a decline in per capita water availability (Postel, 2000). 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 and the lack of funds to maintain the hydrological services and train the technical staff (Hanna et al., 2011).

Transplanting tomato in the upper east region of Pwalugu in Ghana. *(Photo: HamishJohn Appleby/IWMI)*

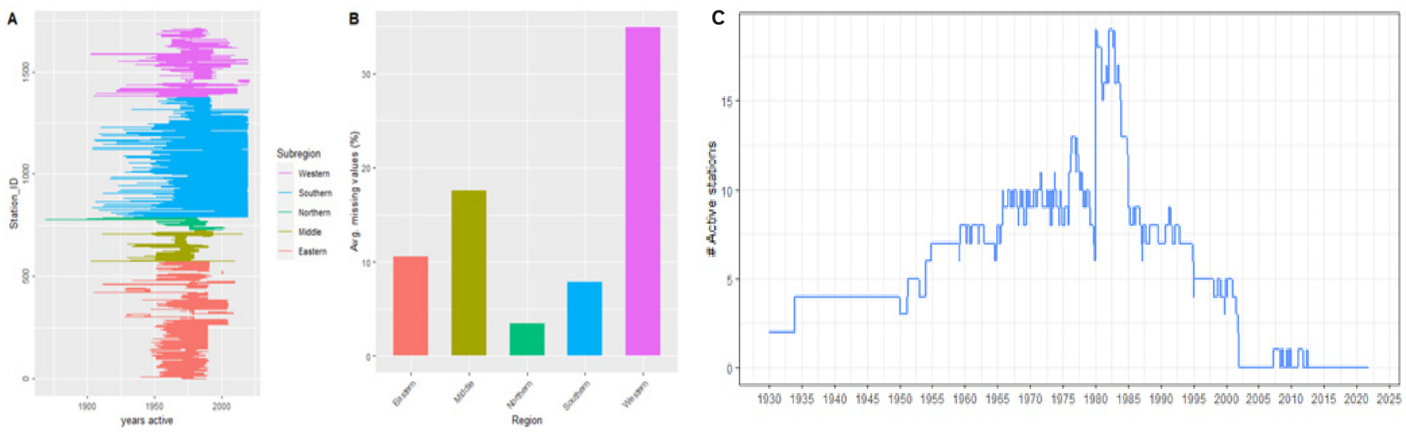


Figure 1. The Reducing hydro-meteorological stations in Africa. (A) The start and end year of data availability of discharge for GRDC stations; (B) the total number of discharge stations per region; (C) the temporal variability of active stations with data since the 1930s in Africa.

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 multi-scale continental water accounting plus (CWA+) framework To overcome the challenges of water data scarcity in managing water resources, (Figure 2). The CWA+ 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 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 the continental water accounting plus approach (CWA+). The CWA+ is an adapted version of WA+ where water accounting indicators can be generated for any boundary (catchment, country, or county). The CWA+ can be explained using three different packages.

Package 1 – Baseline CWA+

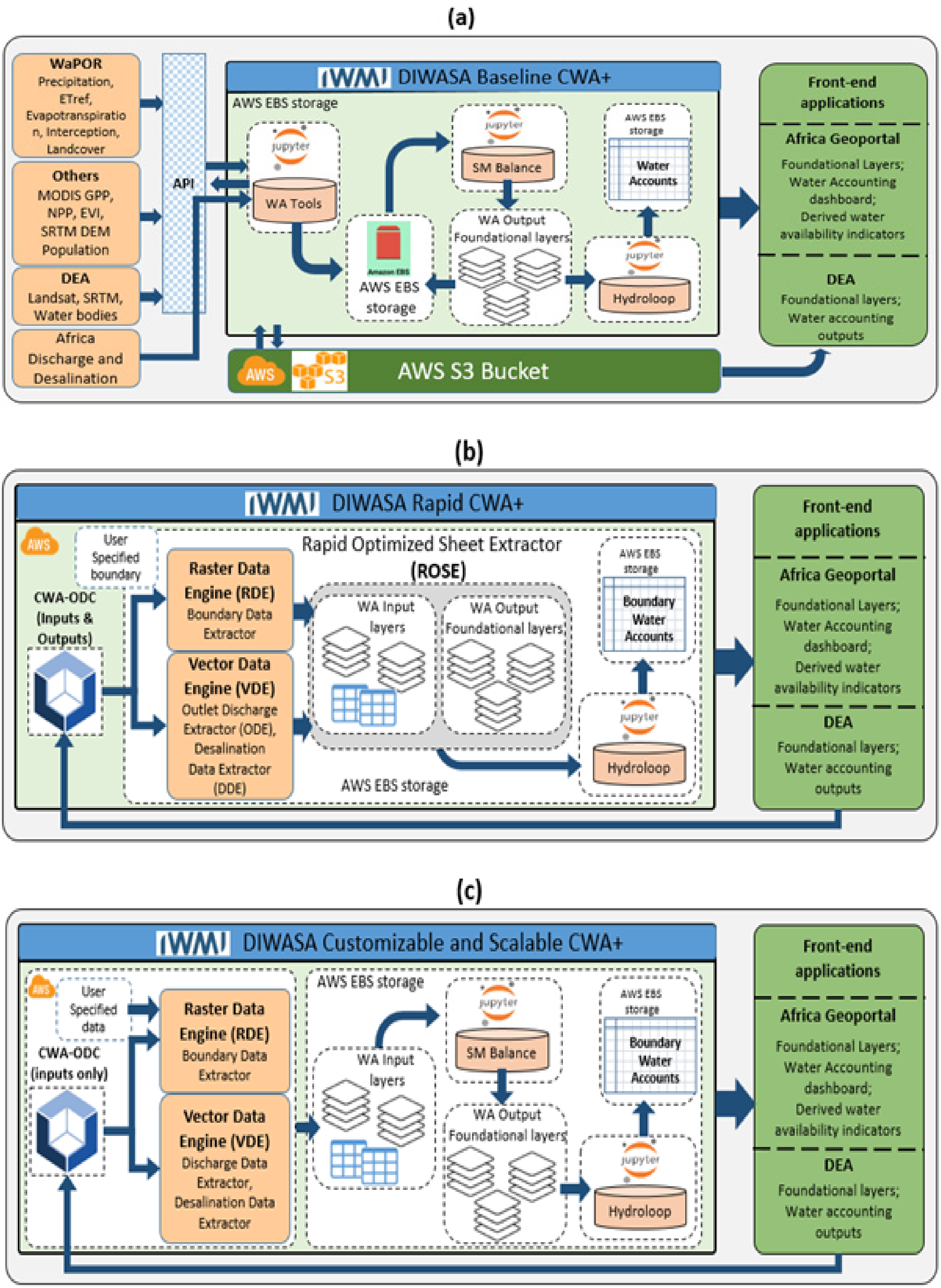
This is designed to generate inputs, raster outputs, and water accounts for continental Africa. The baseline CWA+ is built on the traditional WA+ approach, but new modules such as outlet discharge extractor (ODE) and desalination data extractor (DDE) have been added. These modules prepare the inputs needed for the WA+ model.

Package 2 – Rapid CWA+

This 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. This package has two distinct advantages: 1. Unlike the traditional basin WA+ model, this package enables the production of water accounts for any boundary within Africa using 1-km resolution pre-computed WA data available on an open data cube. 2. This package eliminates the need to run traditional time-consuming water accounting tools (such as data download, processing, and soil moisture balance models). Hence saves significant time and effort in producing water accounts.

Package 3 – Customizable and Scalable CWA+

This generates water accounts for boundary (country or catchment) with user-specified inputs in Africa. The user can add any particular data or set of datasets into the CWA+, run the model at a user-specified resolution, and derive water accounts for any boundary (catchment, county, or country). 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 CWA+ approach and data products for Africa, it also enables customization and changes to meet user-specific demands.



(a)
WaPOR
Precipitation, ETref, Evapotranspiration, Interception, Landcover
Others
MODIS GPP, NPP, EVI, SRTM DEM
Population
DEA
Landsat, SRTM, Water bodies
Africa
Discharge and Desalination
API
IWMI DIWASA Baseline CWA+
AWS EBS storage
jupyter
WA Tools
jupyter
SM Balance
AWS EBS storage
Water Accounts
Amazon EBS
AWS EBS storage
WA Output
Foundational layers
jupyter
Hydroloop
AWS
S3
AWS S3 Bucket
Front-end applications
Africa Geoportal
Foundational Layers; Water Accounting dashboard; Derived water availability indicators
DEA
Foundational layers; Water accounting outputs
(b)
IWMI DIWASA Rapid CWA+
AWS
User Specified boundary
CWA-ODC (Inputs & Outputs)
Raster Data Engine (RDE)
Boundary Data Extractor
Vector Data Engine (VDE)
Outlet Discharge Extractor (ODE), Desalination Data Extractor (DDE)
Rapid Optimized Sheet Extractor (ROSE)
WA Input layers
WA Output Foundational layers
AWS EBS storage
Boundary Water Accounts
jupyter
Hydroloop
AWS EBS storage
Front-end applications
Africa Geoportal
Foundational Layers; Water Accounting dashboard; Derived water availability indicators
DEA
Foundational layers; Water accounting outputs
(c)
IWMI DIWASA Customizable and Scalable CWA+
AWS
User Specified data
CWA-ODC (inputs only)
Raster Data Engine (RDE)
Boundary Data Extractor
Vector Data Engine (VDE)
Discharge Data Extractor, Desalination Data Extractor
AWS EBS storage
WA Input layers
jupyter
SM Balance
WA Output Foundational layers
AWS EBS storage
Boundary Water Accounts
jupyter
Hydroloop
Front-end applications
Africa Geoportal
Foundational Layers; Water Accounting dashboard; Derived water availability indicators
DEA
Foundational layers; Water accounting outputs

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)

DIWASA Derived products

1. Per capita water availability
2. Evaporative stress index
3. Bluewater 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

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

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

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