International Water Management Institute

Technical Brief

High-Resolution River Flow Data to Strengthen Water Security in Africa

Summary

VegDischarge v1, also known as AfriDischarge v1, is a high-resolution continental discharge dataset designed to transform how water resources are understood and managed across Africa. Developed through the integration of the USGS VegET hydrological model and the mizuRoute river routing model, it provides monthly and annual discharge data (2001–2021) for more than 64,000 river segments. The dataset supports decision-making from continental to basin and country levels, enabling applications in water accounting, agriculture and climate resilience planning, water infrastructure and hydropower development. With VegDischarge v2 under development covering over 600,000 river segments, offering even greater spatial detail and analytical power.

Key Highlights

- Comprehensive coverage: Over 64,000 river segments currently mapped, with expansion to 600,000 underway, significantly enhancing Africa's hydrological data resolution.
- Applications: Supports basin- and country-level water accounting under IWMI's Digital Innovation for Water Secure Africa (DIWASA) program, demonstrating broad relevance for research and policy.
- Interactive access: The AfriDischarge Dashboard (http://afridischarge.iwmi.org/app/) provides dynamic, map-based exploration of river networks, visualization of monthly time series and climatologies, and easy data downloads.
- Hydropower screening: Monthly discharge records help identify river segments with strong, reliable flows suitable for planning, aiding investment and infrastructure prioritization.

What are the challenges and needs for hydrological data in Africa?

Africa's water security is constrained by sparse hydro-meteorological networks across its 63 transboundary basins, limiting data for managing water resources, forecasting floods and droughts, and planning under climate and population pressures. Reliable hydrological data are vital to assess water availability, basin health, and human impacts, yet decades of data scarcity have hampered modeling accuracy and sustainable management.

VegDischarge v1 (Akpoti et al., 2024) addresses this gap by providing high-resolution discharge data for over 64,000 river segments across Africa. The dataset delivers a detailed, consistent view of river flow, enabling evidence-based decisions on water management, infrastructure, and climate adaptation, and advancing resilience and sustainability across the continent.

How was the VegDischarge v1 data produced?

VegDischarge v1 was generated through a cloud-based integration of the VegET hydrological model (Senay et al., 2023) and the mizuRoute routing model (Mizukami et al., 2020) on Amazon Web Services (AWS). VegET, developed by the USGS, uses Earth observation datasets—such as soil properties, reference evapotranspiration, land surface phenology, and precipitation—to simulate surface runoff and deep drainage at 1-km resolution. These outputs were routed through mizuRoute, which applies several algorithms (e.g., Diffusive Wave (DW), Kinematic Wave (KW), Kinematic Wave Tracking (KWT), Muskingum-Cunge (MC), and Instantaneous Response Function (IRF)) to model water movement through over 64,000 river segments across Africa.

How was the discharge data evaluated across Africa?

VegDischarge v1 was evaluated using statistical metrics, including Nash–Sutcliffe Efficiency (NSE), Kling–Gupta Efficiency (KGE), Normalized Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Coefficient of Determination (R^2), to assess model accuracy and predictive skill. The evaluation compared simulated discharge with observations from 242 gauging stations across Africa obtained from the Global Runoff Data Centre (GRDC).

Results showed strong agreement between simulated and observed discharges climatologies (Figure 1), demonstrating the model's ability to capture seasonal and spatial variability across diverse hydrological settings. While some under- and overestimations were noted in complex basins like Nile—partly due to unmodeled human water use. Regional analyses using different routing algorithms (KW and KWT) further confirmed their robustness, highlighting both strengths and areas for refinement in simulating Africa's hydrological processes.

Spatial distribution of VegDischarge v1

VegDischarge v1 provides a continental river discharge from 2000–2021, revealing spatial patterns (Figure 2). Flows peak in southern basins during November–April and in northern basins during May–October, while major rivers such as the Niger and Nile maintain year-round discharge. Most river segments show low-flow conditions, particularly in arid and semi-arid regions like the Sahel, underscoring widespread water scarcity and drought risk. The dataset also captures the significant outflows of major rivers, notably the Congo and Nile, which sustain regional ocean circulation and ecosystems, offering valuable insights for water resource management and infrastructure planning across Africa.

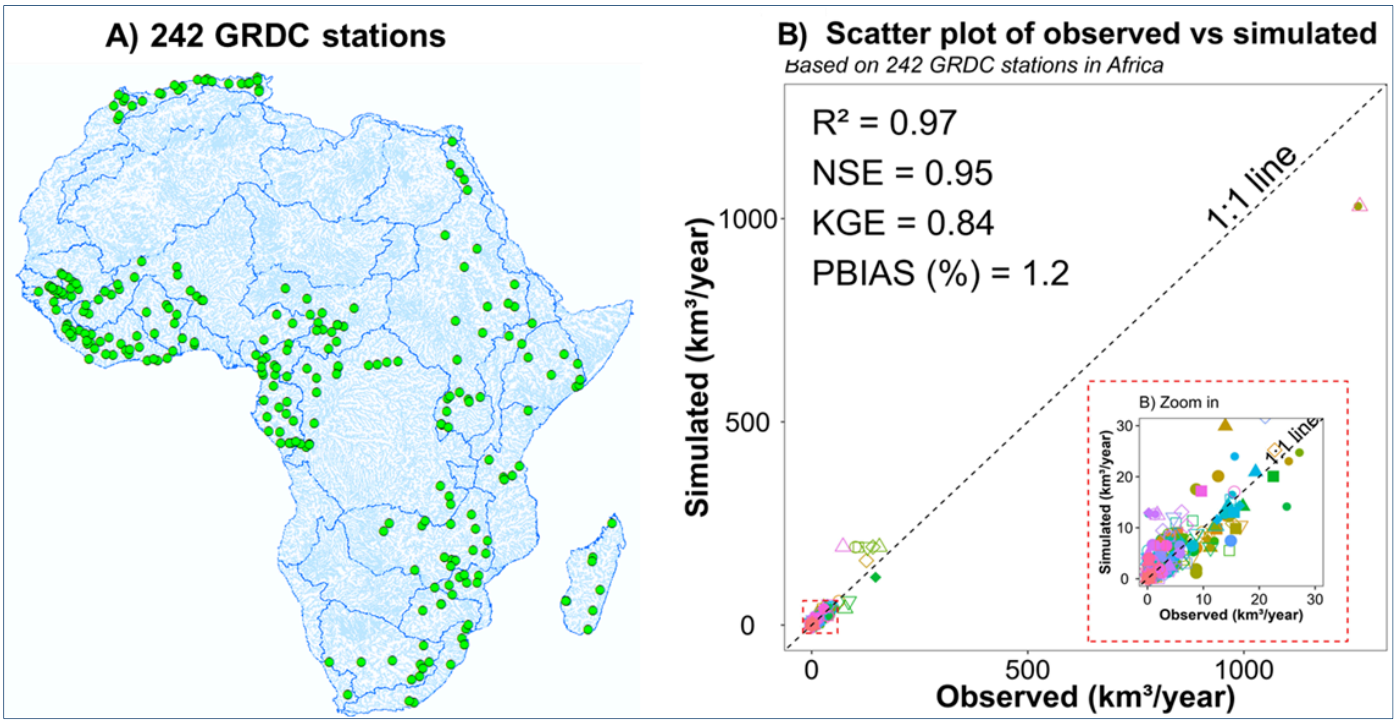

Figure 1. Comprehensive validation of the VegDischarge v1 across Africa Using GRDC data (Akpoti et al., 2024). This Figure contrasts observed annual total discharge data from 242 GRDC stations with simulated values from the VegET/mizuRoute model, reflecting the model's high accuracy in replicating discharge across varying hydrological contexts and time frames within the African continent. The inset (B) zooms in on stations with lower discharge volumes, ensuring a granular analysis of model performance in smaller basins.

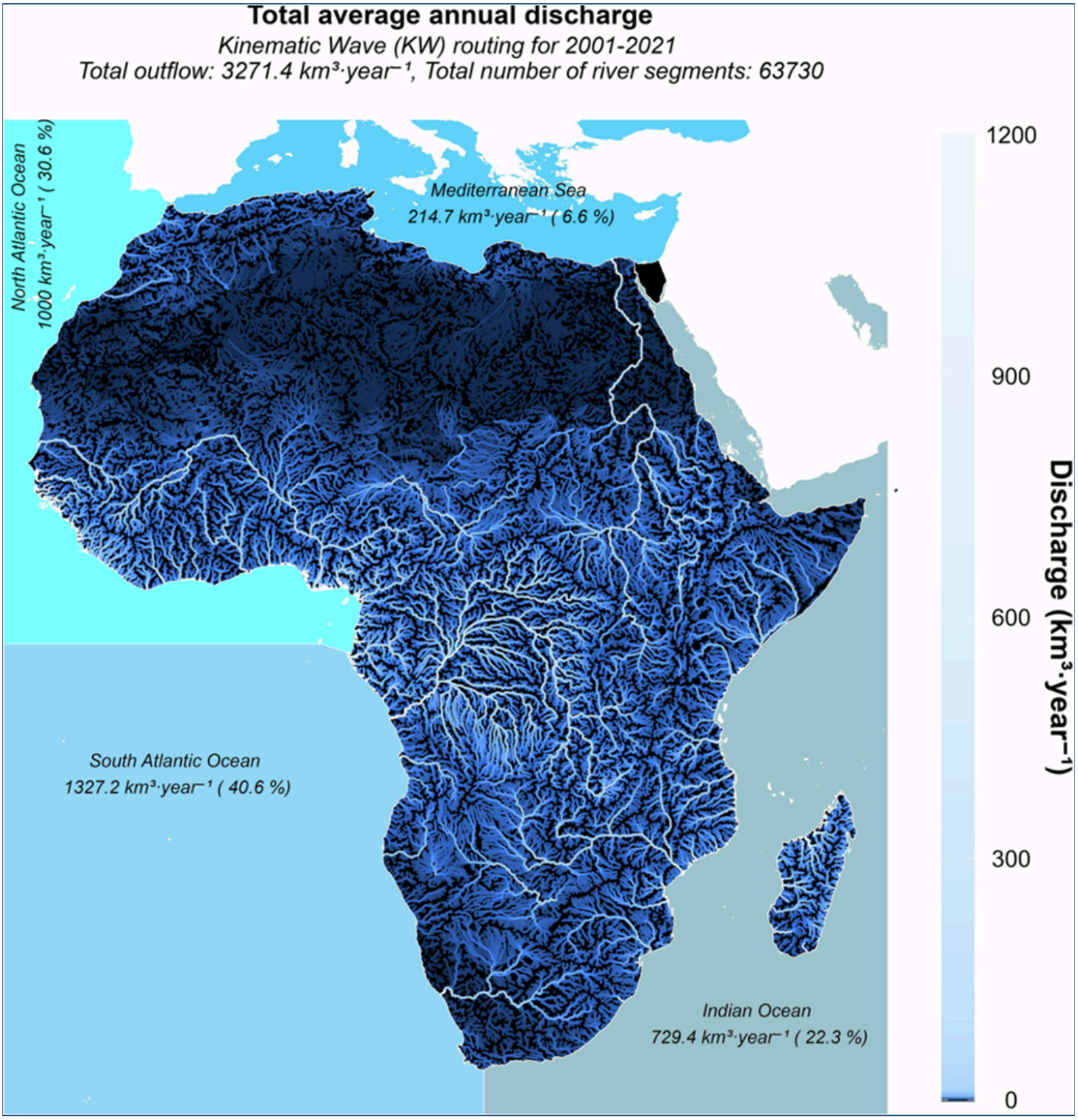

Figure 2. Total annual average discharge from Africa to adjacent oceans (2001-2021) (Akpoti et al., 2024). This map delineates the discharge of African rivers into the Mediterranean Sea, South Atlantic Ocean, and Indian Ocean, revealing the proportional contributions of each basin to the adjacent marine environments. The predominant outflow to the South Atlantic Ocean is contrasted with the lesser, yet significant, discharges into the Mediterranean and Indian Oceans.

Applications of VegDischarge v1

- The dataset on gridded surface runoff and deep drainage as well as annual total discharge can be freely accessed through the U.S. Geological Survey ScienceBase via the DOI link: https://doi.org/10.5066/P14H6TFY52.
- **AfriDischarge dashboard** (http://afridischarge.iwmi.org/app/): interactive, segment, basin and country-level exploration of VegDischarge v1 (2001–2021)—map and query any river reach, download monthly time series, view climatologies and trends, and export figures.
- **Hydropower planning & potential screening (Box 1):** use AfriDischarge monthly time series (2001–2021) to identify and rank river segments with strong, reliable naturalized flows for run-of-river opportunities. As illustrated for the Congo Basin, long-term mean discharge can be translated into indicative capacity classes for prioritization, then refined with site-specific head measurements, environmental-flow requirements, infrastructure constraints (access, transmission, storage), and social-safeguard considerations.

Box 1. Screening hydropower potential with AfriDischarge

Expanding reliable, low-carbon electricity remains a central development challenge in Africa: in 2022 about 685 million people still lacked electricity and roughly 570 million of them were in Sub-Saharan Africa. Hydropower is—by generation—the world's largest renewable electricity source and a key provider of system flexibility to integrate growing wind and solar, so credible hydrology is pivotal for planning.

AfriDischarge can be used to turn continent-wide monthly river-flow records into decision-ready shortlists of run-of-river prospects by flagging segments with strong, reliable flows for pre-feasibility, corridor studies, and investment sequencing. The Congo Basin of the DRC Congo (Figure 3) illustrates this approach well given its very high natural flows, though site-specific head, environmental-flow needs, and social safeguards still must be assessed.

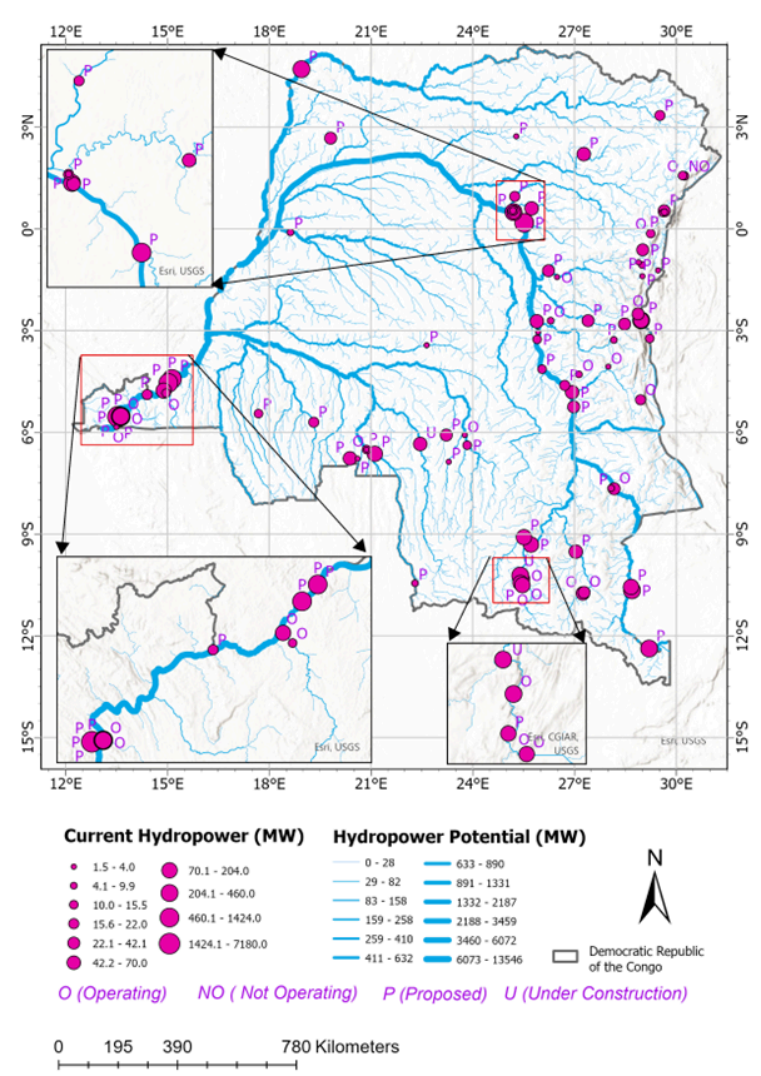

Figure 3. Indicative hydropower potential (MW) by river segment in for DRC Congo, computed from VegDischarge v1 long-term mean discharge (2000–2021) using screening parameters of 50 m hydraulic head and 0.85 turbine efficiency; segments are grouped into potential classes and shown alongside an infrastructure inventory (operational, not operational, proposed, under construction)--infrastructure status data derived from the RePP Africa geodatabase (Peters et al., 2023).

Next steps for VegDischarge Development

Building on the success of VegDischarge v1, which provides discharge data for over 64,000 river segments across Africa using the Hydrologic Derivatives for Modeling and Applications (HDMA) data (Verdin, 2017), the upcoming VegDischarge v2 will expand simulations to more than 600,000 river segments.

This next version will use the high-density MERIT river network (Lin et al., 2021), offering finer spatial detail and improved hydrological accuracy. By leveraging enhanced terrain data, VegDischarge v2 (Figure 4) will deliver more precise insights for water resource management, environmental planning, and water security across Africa's diverse landscapes.

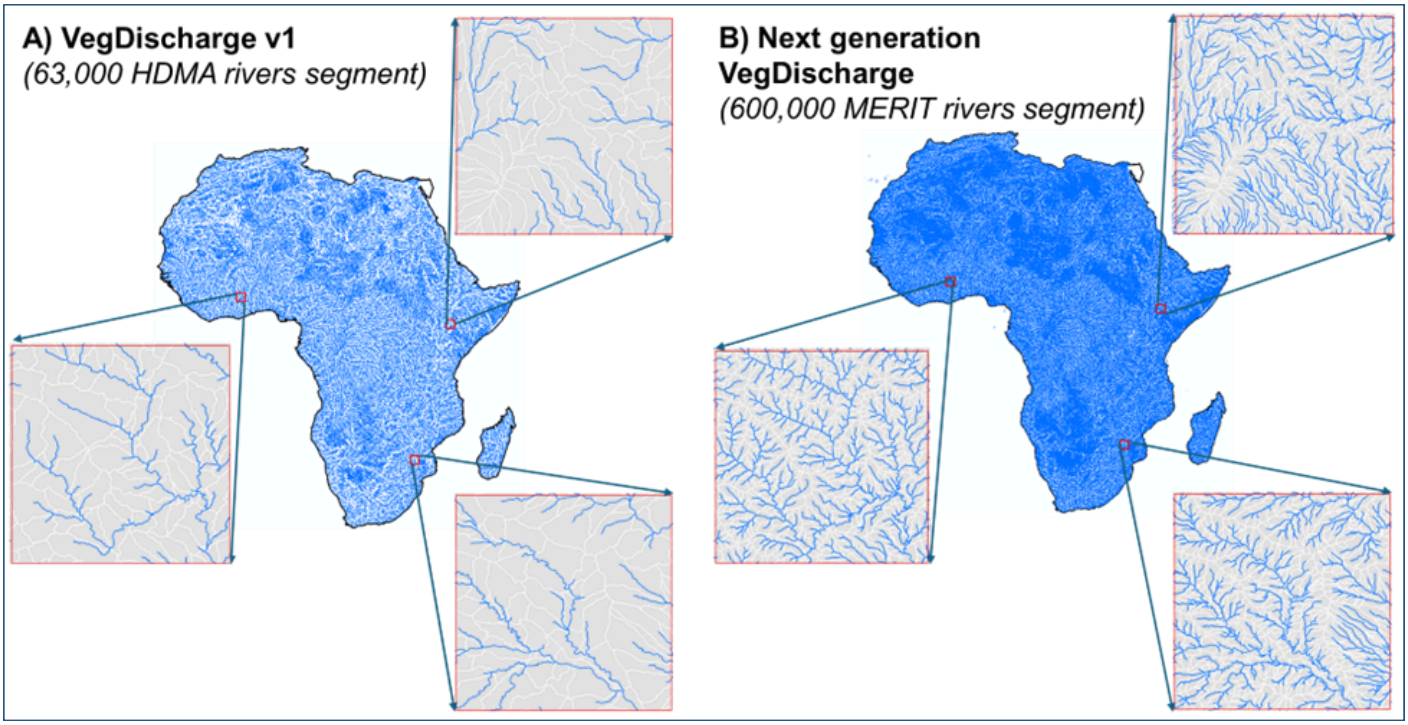

Figure 4. Illustration of the current discharge data river network density with planned net generation data.

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