



International Water
Management Institute

Tackling Irrigation Development and Water Management Crises in Africa

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Acronyms and Abbreviations

AU	African Union
AWARE	Early Warning, Early Action, and Early Finance
AWD	Alternate Wetting and Drying
AWM	agricultural water management
CAADP	Comprehensive Africa Agriculture Development Programme
DIWASA	Digital Innovations for Water Secure Africa
DT	Digital Twin
FAO	Food and Agriculture Organization of the United Nations
FLID	farmer-led irrigation development
IPADT	Irrigation Performance Assessment and Diagnosis Tool
IWMI	International Water Management Institute
PV	photovoltaic
SDGs	Sustainable Development Goals
SWC	soil and water conservation
WHO	World Health Organization

Summary

Water management presents significant challenges in Africa due to problems that link food security, poverty, ecosystem degradation, population growth, urbanization, and climate change, each influencing the other. Central to this is the challenge of irrigation development, including inadequate infrastructure, poor operational and maintenance practices, and limited access to innovative solutions in public sector-led schemes. Despite the potential to boost agricultural productivity and become a profitable sector, challenges related to land tenure, energy constraints, environmental and sustainability issues, market and economic barriers, and social resistance have hindered the promotion and expansion of commercial irrigation in most African countries. Averting these crises requires holistic and transformative approaches towards commercial and state-led irrigation that attract investments in and for irrigation development, as well as fit-for-purpose water management strategies. The need for large-scale irrigation infrastructure in Africa remains and is likely to increase in the coming decades. In most cases, the actual size of state-led irrigable land realized has been significantly smaller than planned, resulting in smaller plot allocations than theoretically thought possible. This has negatively impacted poverty alleviation and food security efforts where farmer-led irrigation development (FLID) is only beginning to emerge. In this regard, and in line with the African Union's (AU) agenda, the development and expansion of both, larger irrigation infrastructure as well as FLID, supported by robust policy reforms and community-driven water stewardship, are considered a solution to intensify agricultural production, support rural economic development, and enhance resilience to climate variability and change.

Agenda 2063 of the AU aims to enhance water productivity in both rainfed and irrigated agriculture for productive use, as well as utilize treated wastewater for agricultural and industrial purposes. The AU 2020 strategic plan emphasized the importance of irrigation as a risk-mitigating factor for building resilience in smallholder settings. So far, efforts have been limited to targeted investments, while the rehabilitation and revitalization of existing infrastructure remain insufficient. Of the 39 million hectares (ha) of land considered suitable for irrigation, only a fraction of the area (approximately 19%) has been placed under irrigation. It is essential to note that in many countries FLID accounts for a greater share of land under irrigation than public sector-led schemes. The sustainability of irrigation investments is anchored on co-design and co-implementation, which in turn fosters local ownership. Irrigation must be viewed as a socio-technical investment that addresses both the hardware and software elements of irrigation.

Despite costly investments, the sub-optimal use of many public schemes has resulted in a considerable and increasing yield gap. Thus, many irrigation schemes continue to operate below capacity due to inadequate operation and maintenance (O&M) frameworks, misaligned institutional mandates, and limited farmer engagement, underscoring the urgent need for improved agricultural practices and governance mechanisms. Institutional designs for irrigation tend to be top-down and not built on local water governance mechanisms. In most places, significant areas with irrigation infrastructure are only discontinuously cultivated, while others are permanently abandoned. In transboundary cases, documented evidence suggests investing in a win-win regional policy approach to foster cooperation and integration at the national scale across economic communities. This effort, if implemented successfully, will increase and enhance opportunities for developing cascaded irrigation systems and realizing irrigation potential at multiple scales—across formal and informal irrigation subsectors. Irrigation investments should also offer opportunities for Gender Equality and Social Inclusion (GESI) as a mechanism for transforming African society whilst providing nutritious foods and income opportunities. The youth bulge phenomenon in Africa can be translated into a youth dividend by engaging young people in irrigation schemes with forward and backward economic linkages. This will provide hubs of employment within rural areas. Land and water tenure have significant implications for those with access to water and the various bundles of rights that different water users hold.

Addressing Africa's irrigation development and water management crises requires an integrated approach that combines technological innovation, robust policy reforms, and farmer-led or community-driven water stewardship, with a focus on inclusion to build resilience against the impacts of climate variability. This invited lead paper was prepared and presented at the 6th African Regional Conference on Irrigation and Drainage (ARCID) in Abuja, Nigeria. It outlines key solutions based on shared knowledge and understanding of irrigation development and water management challenges, in line with the strategic development pathways adopted by the AU. An overview of the water management crises in Africa, along with key descriptions of irrigation development and investment, as well as emerging solutions that include the contributions of IWMI and its partners, are highlighted. Finally, a call for action is outlined to grow the irrigation sector in Africa sustainably.



1. Introduction

Agriculture is the largest water consumer both in Africa and globally. With rainfed crops dominating African agricultural systems, the continent's economies are particularly vulnerable to water-related challenges, including climate change-induced declines in crop yields and growing food demand. Water scarcity remains a major driver of crop yield gaps in smallholder farming systems (Van Ittersum et al. 2013) and as such, addressing food security requires the development of effective irrigation strategies (Giordano et al. 2019). Globally, irrigation contributes approximately 40% of food production, making it a cornerstone of agricultural productivity (Puy et al. 2021).

In Africa, irrigation could play a more crucial role in enhancing food production, increasing land productivity, and improving the livelihoods of smallholder farmers than it has so far (Ringler et al. 2020; Frija et al. 2009). Agenda 2063 of the AU aims to enhance water productivity in rainfed and irrigated agriculture by 60%, capture at least 10% of rainwater for productive use, and recycle 10% of wastewater for agricultural and industrial purposes (AU 2013). In 2020, the AU developed an irrigation development and agricultural water management (AWM) framework that outlined the different food production pathways across multiple scales (AU 2020). The strategy emphasizes the importance of irrigation as a risk-reducing factor for building resilience in smallholder settings. Given that African economies are largely agrarian and climate-dependent, irrigation potentially promotes food and nutrition security across multiple scales in Africa. The context for water management and irrigation development in Africa is complex, resulting in a set of interconnected problems that are both complex and challenging, linked to food security, poverty, ecosystem degradation, and climate change (see Figure 1). As these problems are interrelated, where one influences the others and vice-versa, effective solutions must consider their combined impact and work for all.

Key intervention indicators of Agenda 2063 include increasing water productivity from rain-fed agriculture and irrigation by 60% compared to 2013 levels, harvesting at least 10% of rainwater for productive use, and recycling at least 10% of wastewater for agricultural and industrial purposes. Member States are requested to promote irrigation development through appropriate policies and implementation capacity to meet set targets (AU 2020). To unlock the full potential of irrigation for resilience and food security, it is important to integrate water and climate information services into AWM strategies. These tools enable more precise targeting of investments, enhance preparedness for climate extremes, and foster sustainable intensification of irrigated agriculture.

Recognizing Africa's vision and the complexities of AWM, which encompasses irrigation and drainage, this invited lead paper was prepared and presented during the 6th African Regional Conference on Irrigation and Drainage (ARCID) in Abuja, Nigeria. The paper outlines key solutions based on shared knowledge and understanding of irrigation development and water management challenges. It begins with an overview of the water security in Africa and water management crises, followed by descriptions of irrigation development and investment, as well as emerging solutions that highlight the contribution of the International Water Management Institute (IWMI) and its partners. The discussion concludes with a call for action to sustainably grow the irrigation sector in Africa.

Hunger

- With **95% of agriculture** in Sub-Saharan Africa relying on fluctuating rainfall, African agriculture is drought-prone, impacting food supply and vulnerability for **the 41% of the population** living in affected areas.
- More than **150 million people in Africa are facing severe to extreme hunger** due to soaring food prices, conflict, and climate change

Ecosystem Breakdown

- By the 2080s, the proportion of arid and semi-arid lands in **Africa is likely to increase by 5-8%**.
- The proportion of untreated wastewater entering the environment in Africa remains alarmingly high, with estimates suggesting that up to **90% may be discharged without treatment** in many regions.

Poverty & Exclusion

- Flood-related shocks have been associated **with a 35% decrease** in household consumption and a significant rise in extreme poverty rates.
- By 2030, **up to 118 million people could be pushed into extreme poverty** (living on less than \$1.90/day) due to climate-related shocks if no adequate response measures are implemented (WMO, 2021)
- **Women and girls are, in most cases, more impacted**, as adult women are the primary water collectors (46% in Liberia to 90% in Cote d'Ivoire).

Climate Beyond 2°C

- More than **half of Africa's commercially important freshwater fish** species are projected to face extinction risks (IPCC, 2022).
- By 2050, climate change impacts could cost African nations an estimated **USD 50 billion annually**.
- Water demand in Africa is projected to increase **by 283% between 2005 and 2030**.

Deep Uncertainty

- Water data and information **are widely disconnected from the challenges** that increasingly confront water governance and climate action. The result is a risk of lock-in to water insecurity, especially where climates are most complex, needs and vulnerabilities are highest, and capacities are lowest.

Figure 1. The complex interconnected challenges of water security in Africa. Source: IWMI internal document



An irrigation canal under the Kpong Irrigation Scheme in Ghana was constructed to supply water to a pumping station for a privately owned banana plantation (photo: IWMI).

2. Irrigation Development in Africa

At the heart of the complex and interconnected problems lie the challenge of irrigation development. As explained in the preceding sections, the potential of irrigation in Africa is high, however realizing this potential has become a major challenge. In Africa, the development and expansion of irrigation infrastructure has been considered a solution to intensify agricultural production, support rural economic development, and enhance resilience to climate variability and change. As a result, the need for irrigation infrastructure remains and is likely to increase in the coming decades. So far, Africa has lagged in terms of sustained irrigation development and realizing its vast irrigation potential. Achieving sustainable irrigation expansion also requires improved spatial data systems and integrated planning tools that match water availability with land suitability and socio-economic feasibility. Without such information, irrigation investments risk inefficiency, inequity, and ecological degradation. While approximately 19% of Africa's land area is considered under irrigation (Owusu et al. 2024), majority of irrigation systems are farmer-led. A recent estimate indicated that about 5% of Africa's land area is highly suitable for irrigation, and 9% is moderately suitable (Itangishaka et al. 2025).

Efforts are currently limited to targeted investments aimed at expanding irrigated areas, while rehabilitation and revitalization of existing infrastructure are lacking (Wiggins and Lankford 2019). A potential option for buffering climate variability in Africa is groundwater. Significant potential exists in the semi-arid Sahel and East African regions, which could support poverty alleviation if groundwater is developed sustainably and equitably using solar photovoltaic (PV) pumps (Altchenko and Villholth 2015; Schmitter et al. 2018).

State-supported irrigation developments, which occurred through the construction of dams and associated surface water canal irrigation infrastructure, have been limited to a range of 400 ha to 100,000 ha (Higginbottom et al. 2021). In most developments, emphasis has been on promoting low-value crops, and the weak management frameworks have reduced

the economic viability of most schemes. Additionally, the actual amount of irrigable land realized has been smaller than planned. As a result, either fewer farmers received land within schemes, or the irrigable plots were smaller than promised. These outcomes negatively impact poverty alleviation and food security, particularly where new infrastructure disrupts pre-existing livelihood systems. Investments in medium- to large-scale infrastructure projects, such as surface reservoirs and storage options, remain crucial in regions with high mean annual runoff. For instance, Southern Africa receives an annual runoff of approximately 99,000 cubic kilometers (km³), and only 0.43% of it is harvested for use (Nhamo et al. 2024). The remainder flows freely into the ocean. Thus, investing in additional dams is an imperative investment to realize irrigation potential. In the event that over-damming occurs, i.e., when the limit of feasible dam construction is reached, investments should be directed toward regional water transfer strategies (Nhamo et al. 2024). While regional transfers can enhance resilience and water equity, they also pose governance, ecological, and geopolitical challenges, necessitating inclusive stakeholder engagement and shared benefit frameworks to ensure long-term success (Zeitoun and Mirumachi 2008). A few examples include: (i) Lesotho Highlands Water Project (LHWP), which diverts 780 million cubic meters (Mm³) per annum from Lesotho to the south through dams, tunnels, and reservoirs (Turton and Ashton, 2004) and (ii) Senegal River Development Organization, which involves the construction of the Manantali Dam (Mali) and Diama Dam (Senegal/Mauritania) for regional water sharing (Van der Zaag & Carmo Vaz 2003). This transboundary project involves the countries of Senegal, Mali, Mauritania, and Guinea. The evidence suggests that investing in a win-win regional policy approach that fosters cooperation and integration at the national scale across Regional Economic Communities (RECs) increases and enhances opportunities for cascaded irrigation development and the realization of irrigation potential across multiple scales.

3. Water Management Crises in Africa

Africa is set to be on the receiving end of extreme weather events that could potentially exacerbate food insecurity, malnutrition, and child stunting (Global Nutrition Report 2022). Water management crises in Africa present a complex challenge driven by the simultaneous pressures of water scarcity—exacerbated by climate extremes—inadequate water infrastructure, a lack of data, insufficient capacity, and weak water governance structures that are usually top-down in nature. The increasing incidence of droughts and floods are two extremes of the water management crises, manifested by either too little or too much water (Kreibich et al. 2022). In Africa, these events displace over half a million people annually, which results in multiple hazards across different nations (see Figure 2). Prolonged droughts, intensified by climate change, have led to significant declines in agricultural productivity, particularly in regions that rely on rain-fed agriculture. At the same time, extreme precipitation events have resulted in devastating floods that displace communities and disrupt local economies.

In the Horn of Africa, five consecutive failed rainy seasons between October 2020 and December 2022 have left over 23.5 million people in Ethiopia, Kenya, and Somalia acutely food insecure (OCHA 2023). Conversely, devastating floods across Western and Central Africa in 2022 and 2023 affected over 1.5 million people in Chad alone and more than 1 million people in Nigeria, with hundreds of thousands more displaced across Niger and South Sudan, underscoring the growing intensity of climate-related disasters (IFRC 2024). The root causes of these crises are multifaceted. Inadequate infrastructure, coupled with poor operation and maintenance, and limited access to well-functioning irrigation and drainage infrastructure, are just a few examples to mention. Africa invests only about USD 500 million annually in water through public budgets, which is well below the estimated USD 64 billion required to meet the Pan-African “Water Vision for All” and the Sustainable Development Goals (SDGs). Moreover, 53% of African countries demonstrate low levels of implementation of integrated and coordinated approaches to water management, development, and sanitation services (AIP 2024). Furthermore, only 6% of cultivated land is formally equipped for irrigation despite having over 39 million ha of suitable land (You et al. 2011). This gap reflects institutional inefficiencies and fragmented water governance, which largely do not build upon the local farmer-led irrigation management wisdom. Smallholder farmers are the primary victims of climate-induced vulnerabilities, significantly impacting their social, environmental, and economic status (Mabhaudhi et al. 2018). Poor governance frameworks and underinvestment in sustainable water management practices further exacerbates the problem.

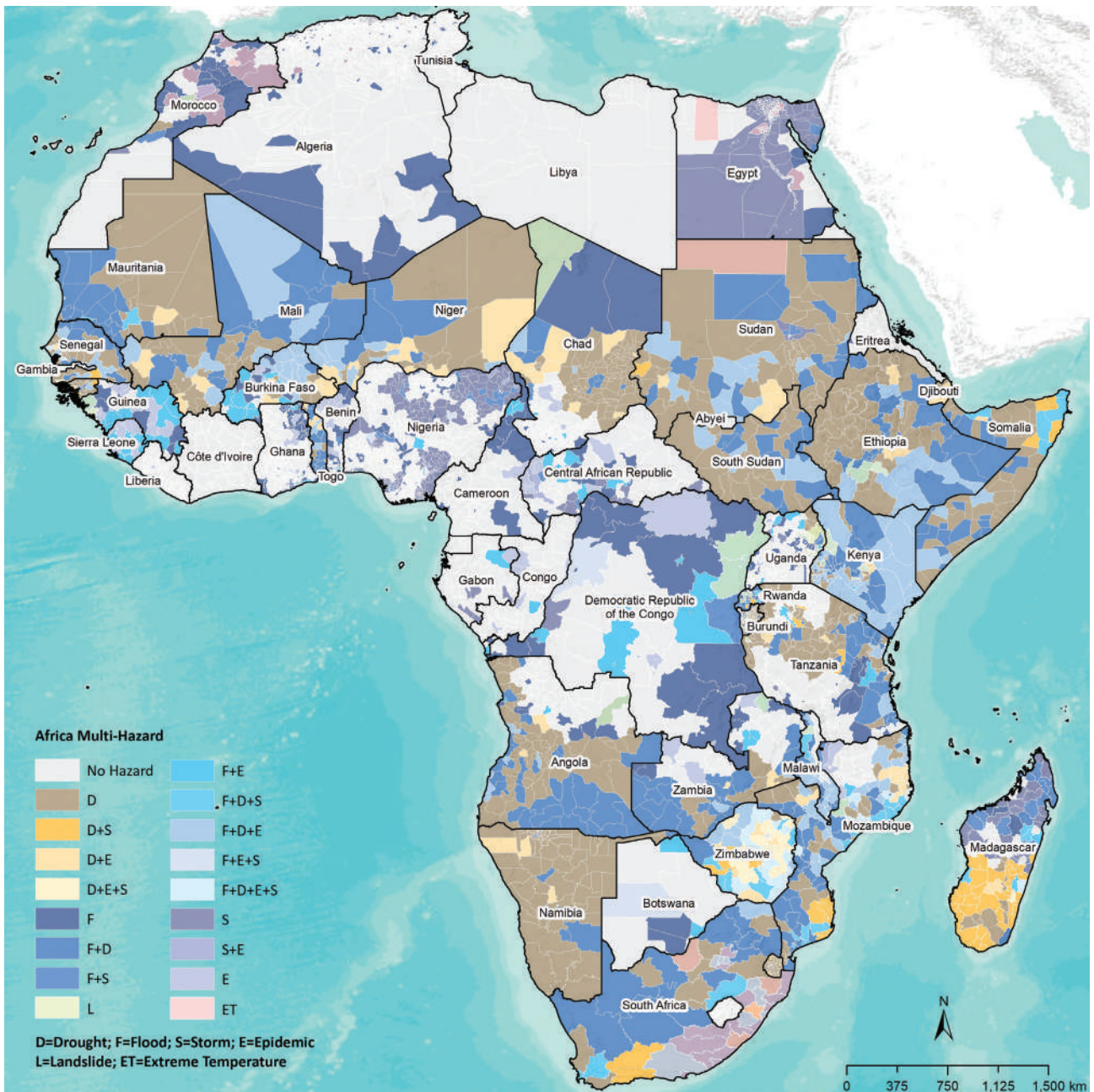


FIGURE 2. Multi-hazards affecting African countries.
Source: IWMI/DIWASA

4. Irrigation Investment in Africa

The investment costs of irrigation projects per unit area in Africa are the highest globally. Unrealistically large proposals, driven by optimism bias and political incentives, led to the suboptimal use of many schemes after they were constructed. A lack of the necessary technical expertise, limited local knowledge, and irregular financial flows have impacted the long-term operation and maintenance of multiple schemes. The large-scale bilateral and multilateral funding flows for irrigation investments are mostly directed toward governments bypassing donors and direct support to farmers. Postconstruction scheme deterioration contributes to a considerable and increasing yield gap. Several common failures are attributed to changes in local hydro-climatology, inadequate maintenance, and land tenure issues. Higginbottom et al. (2021) conducted a performance evaluation of 79 irrigation schemes in Sub-Saharan Africa, with 55% located in West Africa and 32% in Nigeria. Results indicated that the schemes have consistently failed to deliver their proposed irrigated

agricultural land areas. The study highlighted that the deterioration of scheme performance was weakly associated with scheme size and climate variability. As evidenced by the two largest schemes in Mali (Office du Niger) and Sudan (Gezira), more autonomous operations by farmers enabled the transition away from declining yields (Higginbottom et al. 2021). Sub-Saharan irrigation investments can yield strong returns and significantly impact agricultural growth under the right conditions such as large-scale investment projects focusing on a broader area of irrigation, support provided to small-scale irrigation schemes, and investments in good planning, design, and project administration. Other factors include maximizing farmers' investment, conjunctive use of surface and ground water, and the right choice of crops (Inocencio et al. 2007).

The Dakar 2013 Declaration on Irrigation and Water Resources Management outlines a commitment to expand the irrigable area from 400,000 ha to 1,000,000 ha (by the end of 2025) for the six Sahel countries (Burkina Faso, Chad, Mali, Mauritania, Niger, and Senegal) (World Bank Group 2017). Recent assessments in 2024, however, indicate that with an investment cost of USD 2 billion, the area of land equipped with irrigation infrastructure is limited to only 12.5% (125,000 ha). According to the *press release on the High-Level Forum on Irrigation in the Sahel* (CILSS 2025) shared with IWMI for validation, significant areas with irrigation infrastructure are only discontinuously cultivated, while others are permanently abandoned. The underlying causes of failures include poor construction standards, inadequate management, and unsatisfactory operation and maintenance (O&M) of irrigation systems. The “*build-neglect-rehabilitate*” syndrome has depleted most government coffers, making O&M highly costly, while the adoption of innovative practices remains limited due to financial and technological constraints. Weak governance, inadequate capacities, limited private sector involvement, and structural challenges—including insecure land tenure, equity issues, and gender disparities—all hinder progress. This analysis primarily reflects conditions within donor-supported and government-led irrigation developments.

At the smallholder level, the productivity and profitability challenges in irrigated agriculture stem from reliance on subsistence farming, inadequate crop diversification, underdeveloped value chains, and weak market linkages—resulting in low profitability and persistent poverty. The AU's Agenda 2063 calls for increased interventions to boost irrigation development and sustainable AWM to enhance agricultural production and productivity. In 2020, the AU approved a framework (see Figure 3) and defined pathways for irrigation development and investment to integrate: (i) overcoming the lack of investment, (ii) rehabilitation of existing infrastructure, (iii) prioritizing the needs of smallholders, and (iv) strengthening governance. The newly adopted 10-year strategy and action plan for the Comprehensive Africa Agriculture Development Programme (CAADP) (2026-2035) envisions sustainable and resilient agrifood systems for a healthy and prosperous Africa. CAADP advocates transformative, holistic approaches that span the entire agri-food value chain, from production to consumption.

The CAADP Strategy notes that “... sustainable water management is a critical driver of agricultural transformation in Africa, especially in regions facing water scarcity. Efficient water management practices, including drip irrigation, rainwater harvesting, and water recycling, are essential for maintaining agricultural productivity in the face of climate change and population growth. Access to reliable and sufficient water resources is a key determinant of crop yields and food and nutrition security” (AU 2024). This calls for a transformative and holistic approach to attract investments in irrigation and “fit-for-purpose” water management strategies (Smith et al. 2024). The approach combines technological innovation, robust policy reforms, community-driven water stewardship, and a focus on inclusion. Holistic approaches prevent siloed interventions, which are highly likely to accumulate trade-offs and unintended consequences rather than fostering desired synergies (Endo et al. 2018). Thus, investing in water-centric projects (such as dams, irrigation infrastructure, technologies, etc.) is critical, and focusing on energy-related projects and their impact on irrigation development in Africa is necessary. Ensuring inclusive energy security guarantees irrigation expansion through the provision of reliable, alternative energy-powered irrigation systems (Xie et al. 2021).

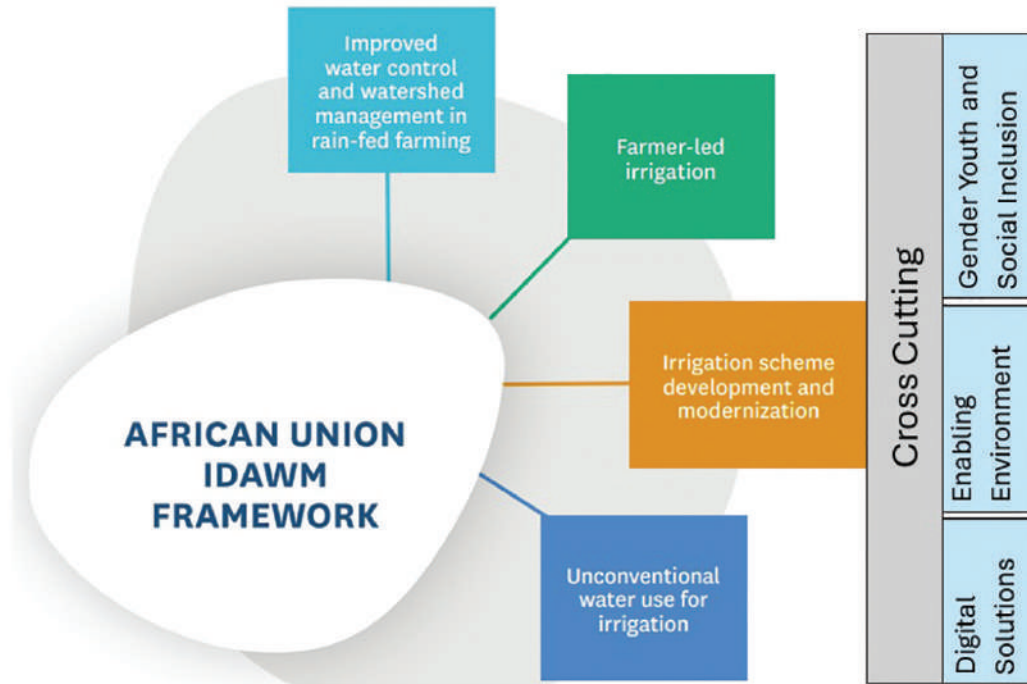


FIGURE 3. Development Pathways for the Irrigation Development and Agricultural Water Management (IDAWM) framework.
 Source: Adapted from AU, 2020



A water harvesting structure located at Potrikrom, Ahafo-Ano South in the Ashanti region of Ghana, serves as a water storage facility under the Inland Valley Irrigation Scheme (photo: IWMI).

5. Irrigation Development Pathways

Several irrigation and water management solutions abound globally and are relevant to Africa. IWMI, in collaboration with its partners, has developed and delivered several solutions at scale in Africa and elsewhere. While collective action is crucial to delivering the necessary solutions, implementation practices depend largely on land use plans, cropping systems, and prevailing local socio-cultural and economic contexts.

The following sections describe the relevant solutions developed and practiced by IWMI following the AU-IDAWM-defined pathways and other cross-cutting actionable themes.

5.1 Improving Water Control and Watershed Management in Rainfed Farming

Water conservation strategies, including soil moisture storage and rainwater harvesting practices, help retain soil moisture, reduce evaporation, and improve water infiltration, which is especially important for rainfed production practices in the arid and semi-arid regions of Africa (Birhanu et al. 2019). Watershed management is crucial for safeguarding water sources and mitigating soil erosion. Proper management of watersheds ensures that water is available for irrigation downstream while also safeguarding ecosystems. AU (2020) highlighted that the adoption of soil and water conservation (SWC) practices to intensify production is a key technical success factor for building resilience and improving livelihoods. Through its Water, Land, and Ecosystem (WLE) program, IWMI, along with its partners, supported the implementation of SWC practices in northern Ethiopia, aiming to prevent soil erosion, recharge groundwater, and maintain water quality (see Box 1). Watershed management can thus provide vital water sources and provide long-term benefits for agriculture by preserving fertile topsoil and improving the sustainability of irrigation systems.

Box 1. IWMI case report



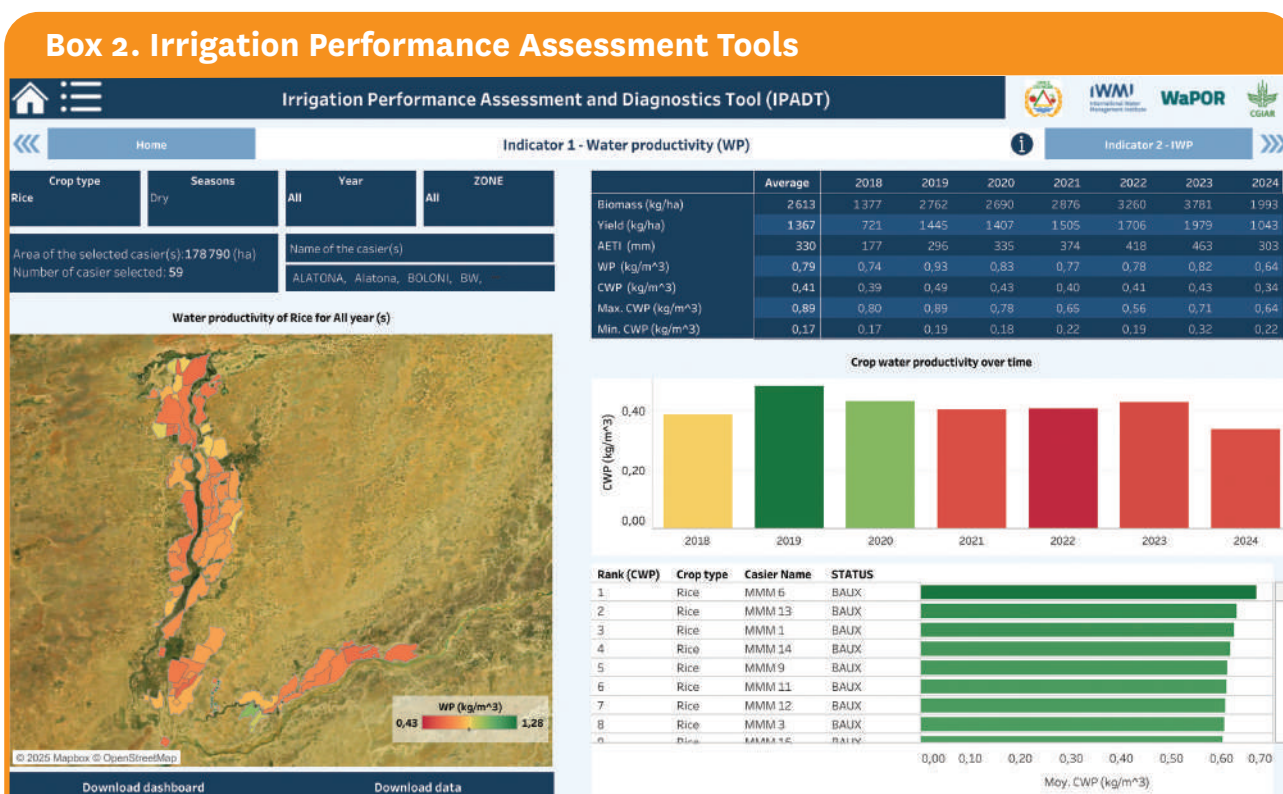
Rehabilitation of the Yewol watershed in northern Ethiopia (photo: IWMI).

A once-degraded and low-productive Yewol watershed in northern Ethiopia was restored and revitalized through a watershed program run by local communities, with technical support provided by IWMI and other partners. By mobilizing local communities, 7,500 ha of land (which is the entire watershed) have been terraced with rock hedges and contour farming practices. Benefits included a reduction of soil loss to 0.5-5.5 t/ha/yr from 50-140 t/ha/yr. Other benefits included an increased recharge of groundwater and an increase in irrigable land by fivefold. In upstream hillslopes, potato farming enabled youth to earn more cash. In downstream areas, the increased availability of irrigable land helped the community to expand irrigation areas. The lessons and successes from the Yewol mountain watershed enabled the revitalization of degraded and unusable land in other parts of the country (Birhanu et al. 2024).

5.2 Irrigation System Performance

As part of the Water Productivity through Open access of Remotely sensed data (WaPOR) project, IWMI developed an Irrigation Performance Assessment and Diagnosis Tool (IPADT) for Ethiopia (IMISET), Mali (Office du Niger), and Mozambique (Chokwe and Xai-Xai). IPADT utilized open access, high-resolution, and near-real-time satellite data and was developed through a co-creation approach, engaging end-users, beneficiaries, and key stakeholders to ensure that it tailored to national priorities and local contexts. Irrigation performance is assessed through IPADT using a range of indicators, enabling the diagnosis of water resource efficiency within the irrigated perimeter. It helps to make decisions in allocating water resources more effectively, efficiently, and equitably across irrigation zones. It also provides evidence-based support for decisions related to irrigation and drainage infrastructure rehabilitation (see Box 2). IWMI also developed the Multidimensional Digital Inclusiveness Index (MDII) to evaluate and enhance the digital inclusiveness of tools and platforms, particularly in promoting resilient food, water, and land systems (Martins et al. 2024).

Box 2. Irrigation Performance Assessment Tools



The Irrigation Performance Assessment and Diagnostics Tool (IPADT) Dashboard.

IPADT was developed in a co-design and co-development process. It provides functionalities to assess and visualize irrigation performance indicators up to the tertiary level. The tool uses WaPOR data layers combined with in situ measurements. Additional irrigation performance tools are being developed under the Digital Innovations for Water Secure Africa (DIWASA) project in Ethiopia (Amibara) and Ghana (Bontanga). The Water Accounting Tool quantifies blue water withdrawal and irrigation water use at the continental level in Africa. A cropland map distinguishing between rainfed and irrigated croplands in Africa is also made available to support agricultural water management and food security (Owusu et al. 2024).



FLID investment on a smallholder farmer field in Ethiopia (photo: IWMI).

5.3 Catalyzing Inclusive Farmer-Led Irrigation Development (FLID)

Investing in small-scale and farmer-led irrigation options offers an affordable and adaptable alternative for improving water management (Harmon et al. 2023). These systems enable local communities to manage their irrigation needs more effectively, leading to increased agricultural productivity and enhanced resilience to climate variability. Over the years, FLID has been an integral part of the farming system among smallholders, providing low-cost solutions to improve food production, alleviate poverty, and stimulate rural entrepreneurship and innovation. Despite its slow progress, FLID has attracted increased attention from government institutions, donors, and development organizations. The World Bank's FLID guide (Izzi et al. 2021) provides governments with practical strategies to catalyze and expand farmer-led irrigation development, making it a faster, more sustainable, and more inclusive process (IFAD 2024). In Ethiopia, Ghana, and Mali, IWMI championed the delivery of the FLID guide; thus, farmers persistently filled the gap where public-led irrigation services were absent and improved on them where they were present. Presently, World Bank-supported FLID investments have been extended to Angola, Kenya, Madagascar, Nigeria, Somalia, Uganda, and Zambia.

The user-friendliness of farmer-led irrigation systems in Africa can benefit from the relatively untapped groundwater potential in many countries. To promote FLID sustainably without groundwater depletion, the World Bank has recommended several pathways (Izzi et al. 2021), including bundling incentives for farmers to access groundwater irrigation with regulations to prevent over-extraction, promoting community-level groundwater management and advancing cost-effective water-saving technologies, online meteorological services, and soil management tools. Enhancing groundwater literacy through experiential learning and workshops, strengthening government oversight of groundwater, and managing solar irrigation expansion in Sub-Saharan Africa, are also recommended. Improved water management under the FLID system can be achieved through smart irrigation solutions that support informed decision-making on both the amount and timing of water application (see Box 3).

While challenges such as limited access to finance, training, and infrastructure exist, the opportunities for scaling up FLID were significant, particularly through sensitive government support and the use of solar-powered irrigation systems (Minh et al. 2024). Catalyzing FLID through private sector engagement and scaling it up, to make it a faster, more

sustainable, and inclusive process, requires a collective effort among stakeholders. In Africa, FLID has the potential to transform food systems by enhancing climate resilience, increasing and diversifying agricultural production, reducing poverty, and supporting the empowerment of youth and women. In Ghana, FLID has been expanding rapidly for several decades, and informal irrigation covers more than ten times the area as the public and commercial-led sectors (Delinthe and Zwart 2022). Catalyzing FLID expansion requires joint efforts from multiple stakeholders, sustainable and inclusive strategies, and the strategic leveraging of existing opportunities across the business, research, and implementation spaces (e.g., in Ghana, multistakeholder processes helped foster collaboration and growth). Scaling up farmer-led irrigation development requires well-functioning irrigation value chains and the adaptive scaling process. Additionally, large-scale irrigation schemes also drive small-scale irrigation to benefit from a more favorable environment (policies, techniques, and stakeholders) (Woodhouse et al. 2016). The most reliable model of irrigation development combines both scales.

Box 3. Smart irrigation solutions

Drip and micro-irrigation systems optimized through irrigation sensors and low-cost **Alternate Wetting and Drying (AWD)** methods offer significant potential for improving water-use efficiency and enhancing agricultural productivity. These systems can reduce water wastage by delivering water directly to plant roots, minimizing evaporation and runoff, and leading to higher crop yields. Emerging opportunities exist to scale up these solutions through solar-powered technologies (Birhanu et al. 2023). **Solar-powered irrigation** pumps offer a sustainable and cost-effective alternative to diesel-powered systems in Africa, harnessing abundant solar energy to enhance agricultural productivity while reducing greenhouse gas emissions (Schmitter et al. 2018). These systems provide a reliable source of irrigation, particularly in remote and off-grid areas where access to conventional energy sources is limited. **Precision irrigation and smart water management** systems utilize sensors, satellite imagery, and artificial intelligence (AI) to facilitate real-time monitoring and informed decision-making in agriculture. Smart sensors collect data on soil moisture, temperature, and crop health, providing farmers with precise information to optimize water usage (Sishodia et al. 2020). These sensors can transmit real-time data via wireless networks to mobile devices, allowing for remote monitoring and efficient water allocation (Bwambale et al. 2022). Although not all smallholder farmers have access to the most advanced technologies, the use of a few technologies, such as drip systems and AWD, enable crop yield increments by 30% (Amankwaa-Yeboah et al. 2024), with significant water and labor savings (Adimassu et al. 2020).



Alternate Wetting and Drying (AWD) (photo: IWMI).



CSWS and Card Reader



CSWS and Wi-Fi Readers

Blue - Wet Soil	Green - Moist soil	Red - Dry soil	Flashing yellow - connect the sensor	Flash red - Replace the battery
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5.3.1 Adaptive scaling and partnerships

IWMI’s research identified and tested models for scaling farmer-led irrigation. The adaptive scaling process brings together multiple components of activity and partners, including, but not limited to, farmers, women’s self-help groups, local governments, the private sector, and local financing institutions. The process involves co-designing and piloting contextually relevant innovation bundles, developing strategies for their scaling pathways or strategies, influencing policy, and accelerating the transition to scale for innovations that have demonstrated early impact (see Figure 4). IWMI has developed an agricultural water management innovation scaling tool to accelerate investment in innovative irrigation solutions by involving the private sector. The tool enhances the scaling of irrigation and water management technologies by analyzing the enabling environment, including people, markets, policies, and power dynamics. It identifies enablers and hinderers of adoption, offering a structured guide to design adaptive, context-specific strategies that support sustainable water management (Minh et al. 2024). Current operational toolkits developed and used by IWMI and its partners to aid decision-making in FLID are presented below:

- Tools to facilitate scaling partnerships: bundling innovations, market and gender segmentation, private sector partnership facilitation, client credit and fit assessment, demand-supply linkage, and multi-stakeholder dialogues.
- Diagnostic tools for decision-making: innovation suitability mapping, systemic analysis, enabling environment analysis.
- Financing ecosystem analysis and financing: mechanism design, multi-stakeholder landscape analysis, best-fit capacity building design.
- Scaling and impact assessment: performance assessment for scaling partnerships for sustainability, innovation bundle profiling.



FIGURE 4. Multiple pathways to scaling innovation for agricultural transformation. Source: IWMI internal document



Wastewater use on a farmer's field in the MENA region (photo: IWMI).

5.4 Promoting Water Reuse

Water reuse is a crucial strategy for enhancing water security, improving soil fertility, and supporting sustainable food production, particularly in regions facing water scarcity. Prioritizing wastewater irrigation in urban and peri-urban areas offers productive, healthy, and environmentally friendly solutions with significant potential for public-private partnerships. IWMI has significantly contributed to safe wastewater use through global assessments, research-driven policy integration, and technical support. Research into the safe reuse of wastewater in agriculture has had a global impact, informing food safety guidelines developed by the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO). IWMI's collaboration with WHO and FAO in formulating guidelines for water reuse, sanitation safety planning, field school curricula, and water quality in agriculture has strengthened global frameworks for safe wastewater management and reuse in agriculture (Drechsel et al. 2023; WHO 2016). Beyond policy influence, IWMI has developed tools and technologies to facilitate the safe reuse of wastewater in urban and peri-urban agriculture (see Box 4). This work has strongly influenced national irrigation and sanitation policies in Ghana and Sri Lanka, ensuring safer and more effective wastewater application in food production (Amerasinghe et al. 2013).

Box 4. IWMI case report

In Ghana, IWMI supported the development and adoption of multiple pathogen barriers from farm-to-fork where polluted water is used in FLID (Amoah et al. 2011). Small-scale and low-cost on-farm storage ponds and riverbank filtrations received the highest potential for acceptance (Keraita et al. 2014). IWMI also contributed to the development of a national irrigation policy that supports wastewater use and national guidelines on fertilizer subsidies, incorporating waste-based composts. The research has also supported the establishment of three new public-private partnerships that can safely transform organic and human waste into fertilizer, as well as supported an aquaculture business using treated wastewater. Through initiatives such as the City Region Food System (CRFS) Toolkit and the Milan Urban Food Policy Pact monitoring system, IWMI has provided city planners and agricultural stakeholders with structured approaches to integrating wastewater use into food production. In Egypt, IWMI provided technical support for using treated wastewater to bridge the gap between available water and national demand resulting from the country's persistent water scarcity. Additionally, IWMI has developed more than 20 business models based on real-world cases that explore resource recovery from organic waste, sewage sludge, and wastewater for irrigation and aquaculture (Otoo and Drechsel 2018).

Many more models are presented in this series to support sustainable food systems and promote circular business opportunities:

<https://www.iwmi.org/publications/resource-recovery-reuse/>

5.5 Mobilizing Inclusive Finance and Investments in Irrigation Development

The majority of farmers in Africa lack the financial capacity to invest in irrigation systems, which hinders their productivity and resilience to climate change. Women farmers and youths face even greater barriers in accessing finance for irrigation. Providing subsidies for irrigation infrastructure and offering access to credit through low-interest loans or microfinance schemes can help farmers overcome these financial barriers. Mobilizing investments and fostering public-private partnerships (PPPs) are crucial for improving irrigation and water management in Africa. Encouraging private sector involvement is key in attracting investment into irrigation projects. Private companies can bring in the necessary capital, technical expertise, and innovation to scale up irrigation systems across the continent. Governments can incentivize private investments through tax breaks, streamlined regulatory processes, and risk mitigation measures, creating an environment conducive to private sector involvement. Blended finance models represent a promising approach to expand irrigation coverage by combining public funds with private capital. Access to credit has significant and positive effects on crop productivity and household income (Merrey and Lefore 2018). This strategy enables governments to de-risk investments and encourage private sector participation while leveraging public funds for long-term, sustainable development (see Box 5).

Box 5. IWMI case report:

In Ethiopia, IWMI supported the development of national policies towards tax exemptions on solar pumps and agricultural machinery (Child et al. 2021). The approach ensured that small-scale farmers with tax exemption could benefit from modern irrigation technologies, contributing to food security and poverty reduction. In Zambia, IWMI's led program, Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA), is collaborated with financial lending institutions to develop gender-sensitive credit scoring, enabling farmers to access solar pumps and other essential inputs (Prebemu Enterprises Ltd 2024). In Ghana, IWMI teamed up with Pumpteck, a national distributor of solar irrigation equipment to make small-scale irrigation equipment available to smallholder farmers (IWMI 2023). Innovative financial models, such as pay-as-you-go and pay-as-you-own options, allowed resource-poor and resource-limited farmers in Ghana to use pumps and pay for each unit of water accessed as well as pay in installments to own it.



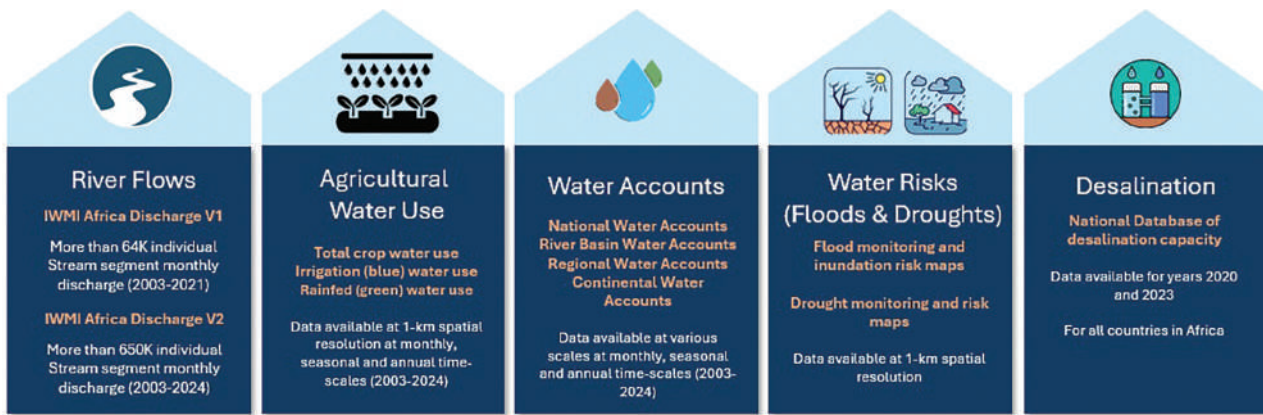
Demonstration of irrigation solutions using solar systems (photo: IWMI).

5.6 Cross-Cutting Solutions

5.6.1 Deploying digital solutions

Data has been a chronic impediment to water management, planning, and investment in Africa. Addressing irrigation challenges requires integrating modern digital solutions. Tools such as remote sensing, real-time monitoring, and data analytics can optimize water allocation and streamline the maintenance of irrigation infrastructure, enhancing overall system efficiency. At IWMI, new technologies are rapidly closing the data gap for river discharge, monitoring of crop water use, national, basin, and continental water accounts, flood and drought monitoring, and early warning. A few examples are presented below:

Digital Innovations for Water Secure Africa (DIWASA): In partnership with Digital Earth Africa (DEA) and others, IWMI's DIWASA is developing a suite of new tools that integrate remote sensing, modeling, open data cube, Digital Twin (DT), and AI technologies (see Figure 5). These tools enable more precise investment targeting, enhance preparedness for climate extremes, and foster sustainable intensification of irrigated agriculture. They deliver data and information to support better governance and reduce investment risks.



Total average annual discharge
 Kinematic Wave (KW) routing for 2001-2021
 Total outflow: 3271.4 km³·year⁻¹, Total number of river segments: 63730

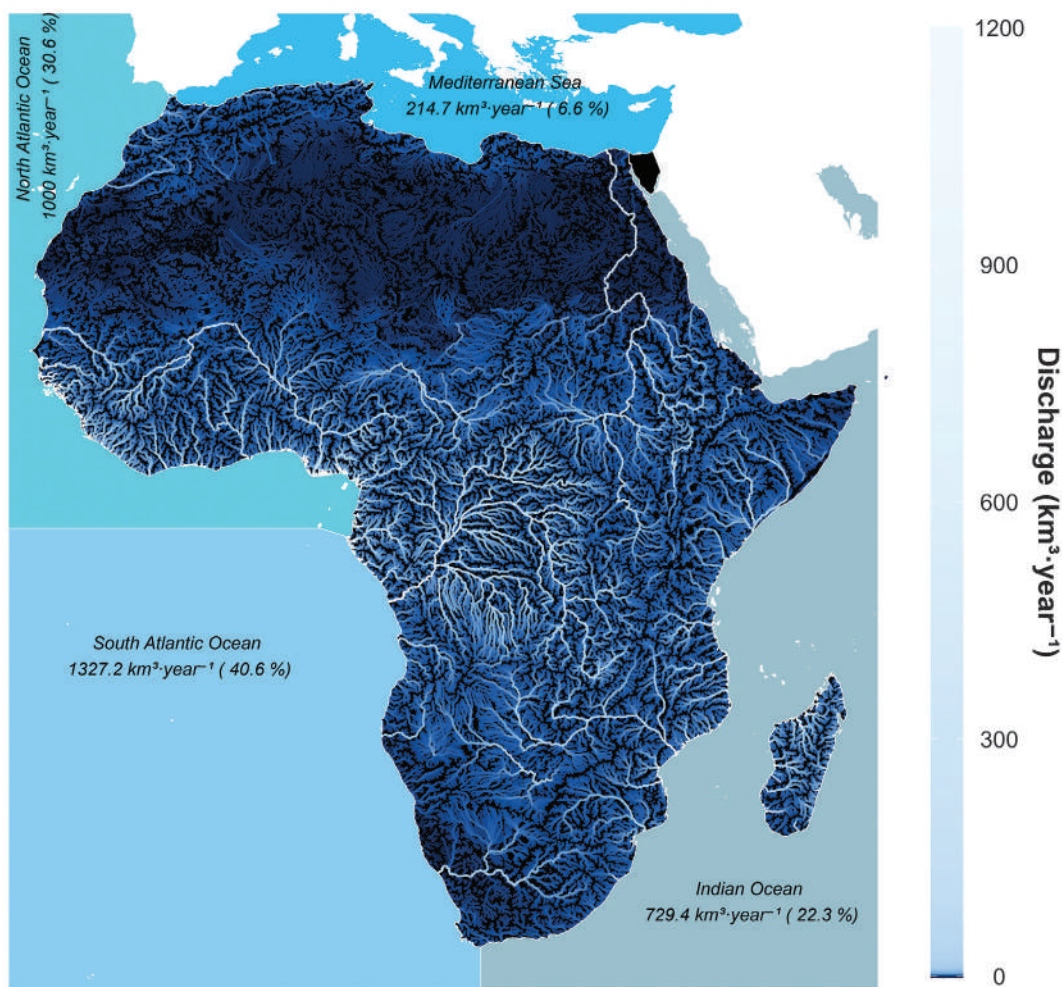


FIGURE 5. Water Data generated at multiple scales for Africa through IWMI's Digital Innovation for Water Secure Africa (DIWASA)
 Source: Akpoti et al. 2024

Irrigation suitability mapping: Achieving sustainable irrigation expansion requires improved spatial data systems and integrated planning tools that match water availability with land sustainability and socio-economic feasibility. To unlock the full potential of irrigation, resilience, and food security, an Early Warning, Early Action, and Early Finance (AWARE) platform was rolled out to aid farmers and investors in managing risks. The AWARE platform integrates water and climate information services into AWM strategies. The AWARE dashboard enables the dissemination of early warnings, contingency planning, and anticipatory action for drought and flood disaster management (see Figure 6).

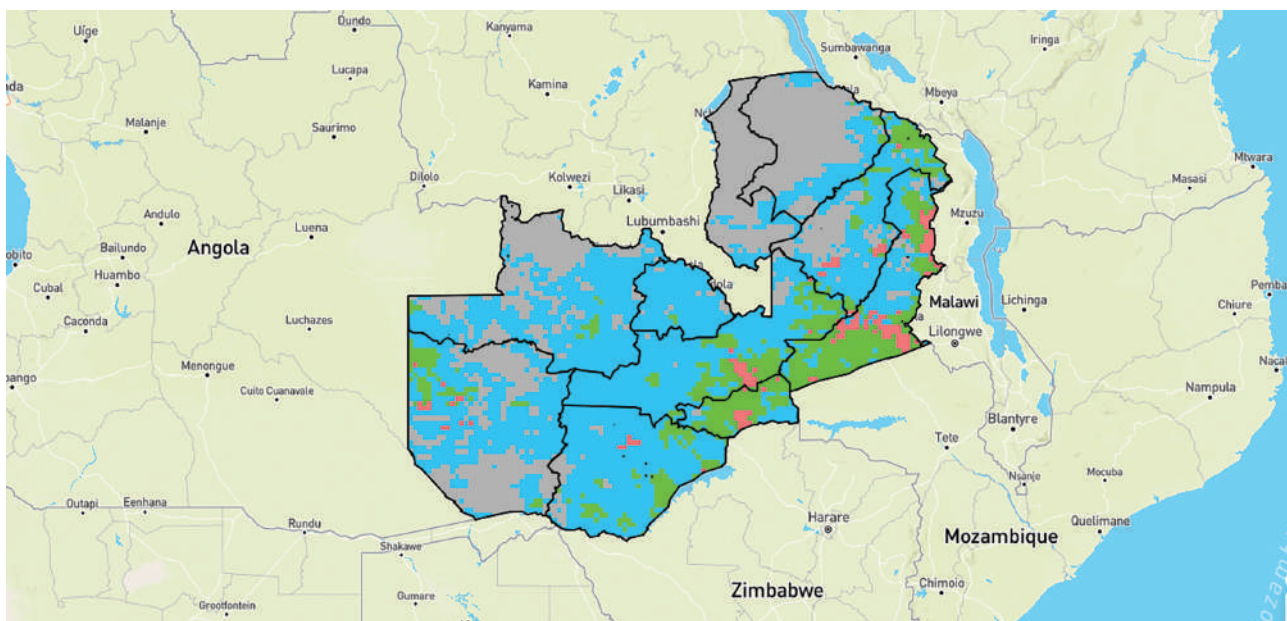
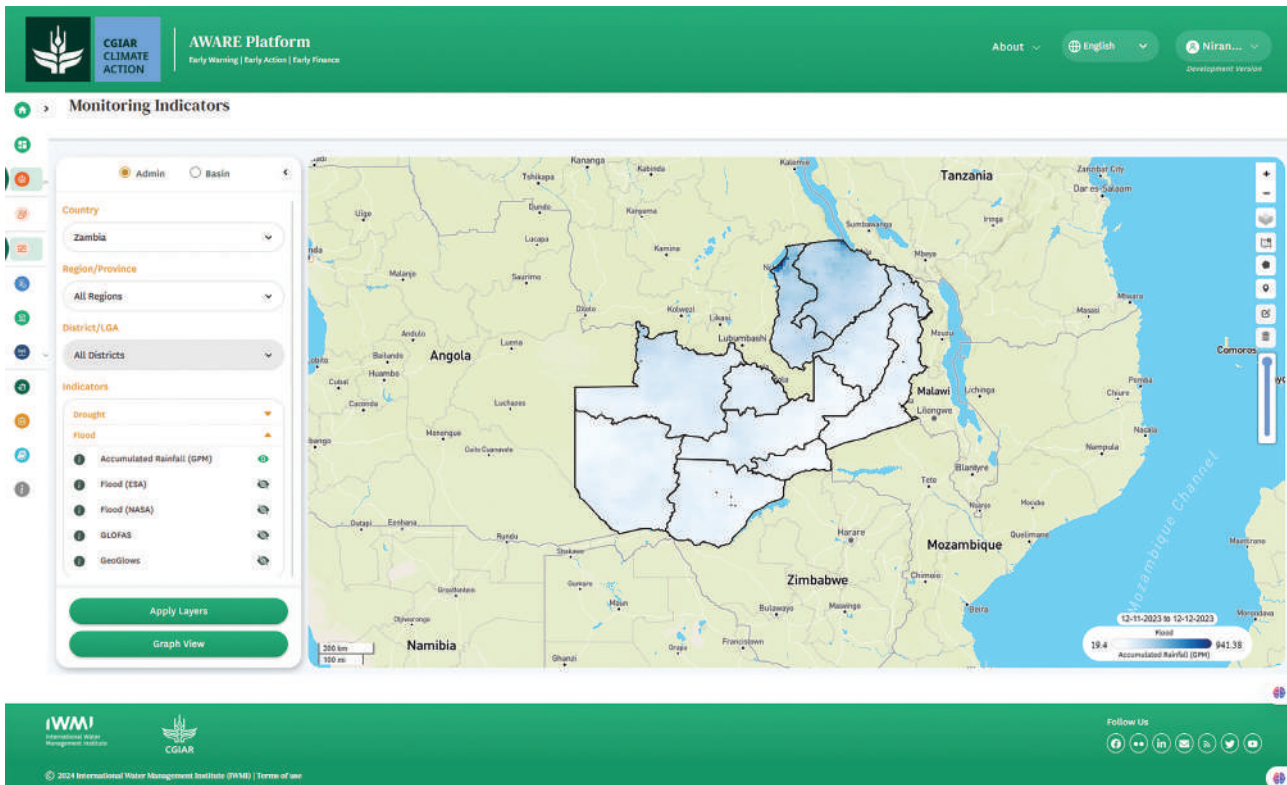


FIGURE 6. Visualization of rainfall accumulation (left) and dry spell conditions in Zambia (right) using the AWARE platform
 Source: Alahacoon and Amarnath 2023

IWMI developed a Vegetable Irrigation for Climate Resilience Toolkit (VICT). This online geospatial tool helps to identify suitable irrigation technologies to support irrigation investments targeting vegetable production within sustainable water use limits during a crisis. The VICT tool is already operational in Ethiopia and Mali and is being scaled to other African countries (Burkina Faso, Ghana, and Zambia). The Solar Suitability Mapping framework was developed to determine the feasibility of solar photovoltaic (PV) irrigation pumps using multi-criteria analysis in an open-source geographic information system (GIS). The framework was successfully validated in the cases of Ethiopia (Minh et al. 2024) and Mali (Birhanu et al. 2023). Based on the accessibility of water resources (mainly small reservoirs and shallow wells), land use systems, and the technical capacity of pumps, the framework enables the upscaling of solar PV pumps for smallholder farmers as a climate-smart technology. An example of an irrigation suitability map for vegetables in Ghana is indicated in Figure 7.

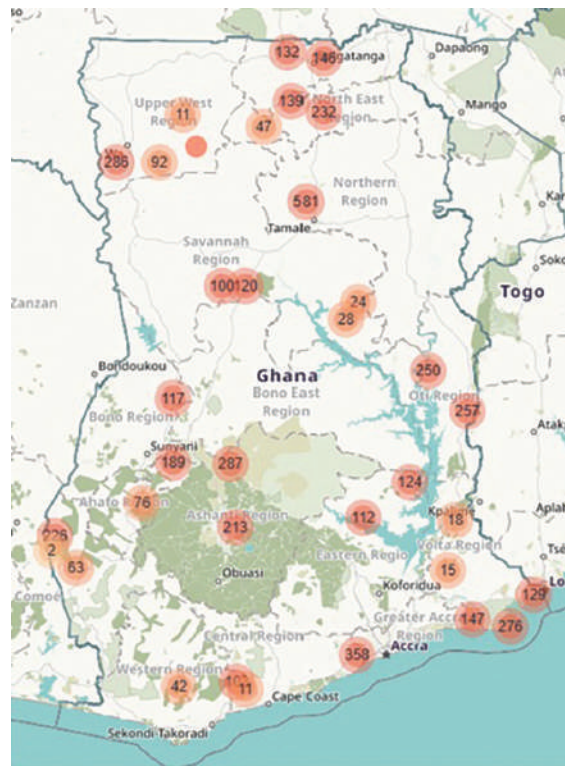
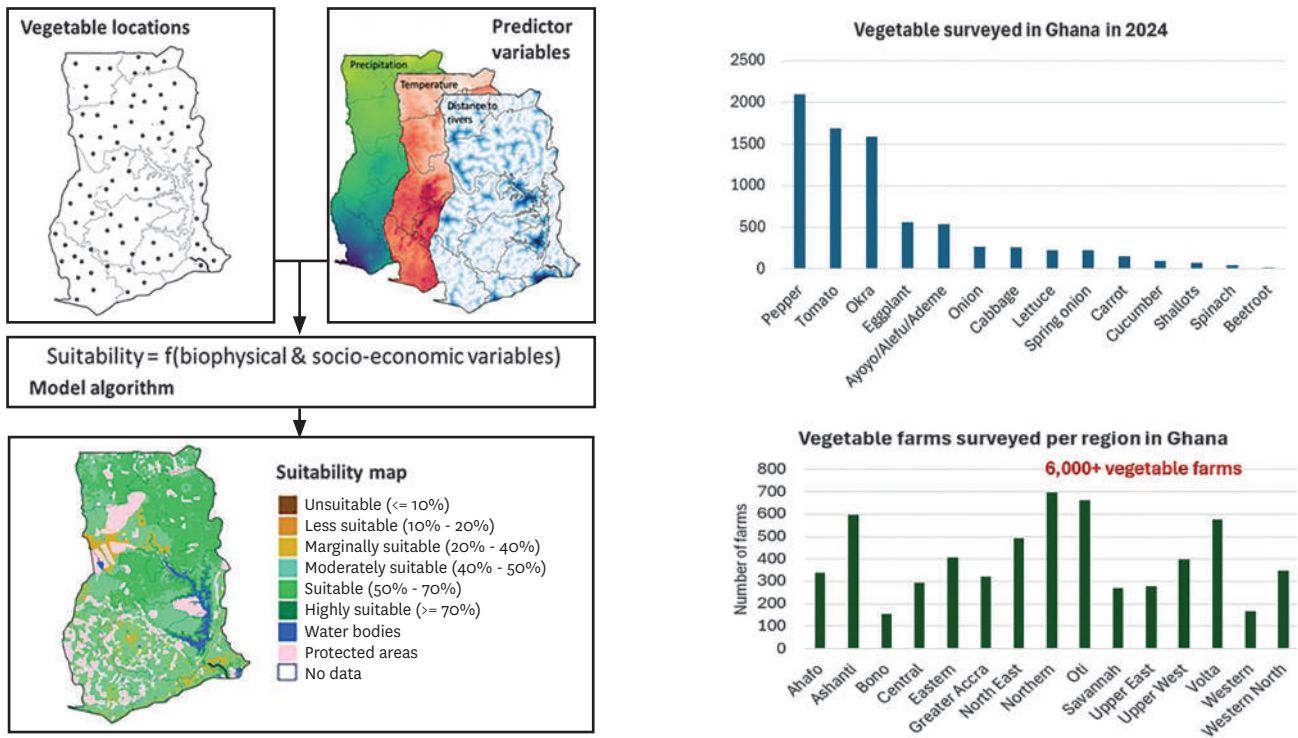


FIGURE 7. Irrigation suitability map for vegetables in Ghana
Source: IWMI internal document

Digital Twin (DT) for water management: DT is a digital representation of reality that enables an understanding of basin dynamics, offering monitoring, forecasting, and scenario analysis for informed decision-making (see Figure 8). IWMI provides seasonal water availability forecasts and operationalizes environmental flows using modular scientific products for the Limpopo Basin. DT integrates citizen science data to empower local communities to contribute data, closing information gaps and enriching water management insights across the region. Additionally, DT integrates an AI-powered virtual assistant that translates complex science into timely, accessible insights, democratizing access to trustworthy AI for decision-makers in the Global South.

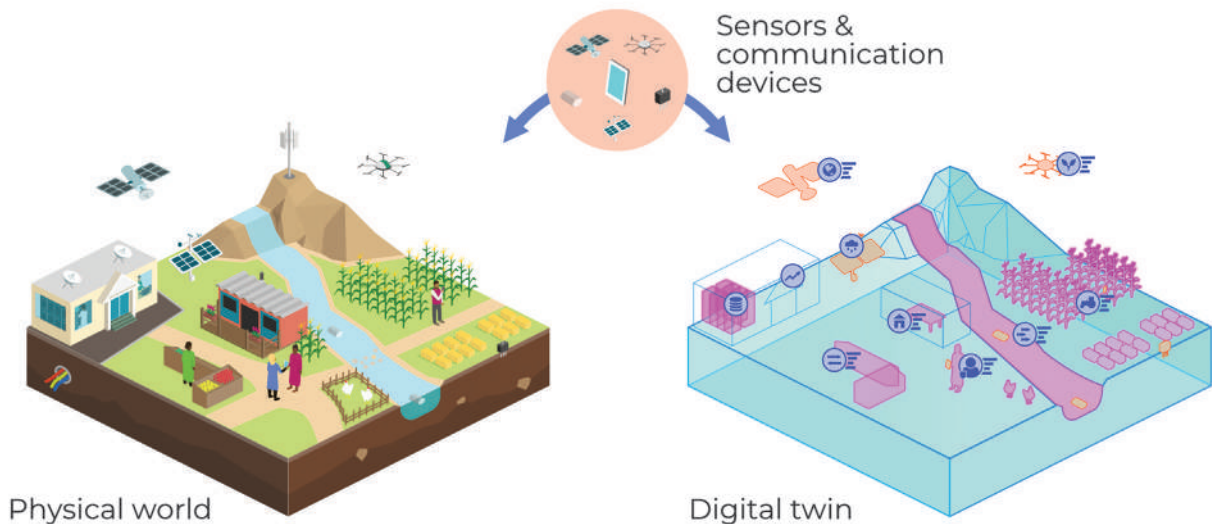


FIGURE 8. A Digital Twin virtually represents the entire river basin. Image: CGIAR Initiative on Digital Innovation
 Source: Botai et al. 2023

5.6.2 Agricultural Water Management (AWM) – an enabler for sustainable development

AWM is a vital force that extends far beyond water and food. Given that agriculture uses more than 70% of freshwater with draws—solutions for AWM open the potential for change across multiple SDGs. AWM is also linked to energy solutions. IWMI promotes the use of an integrated nexus framework that links AWM to the complexities of sustainable development (see Figure 9). This involves considering and balancing the various objectives and differing interests of the multiple dimensions, sectors, and stakeholders involved in AWM. By championing this holistic vision, AWM can spark innovative and equitable solutions that honor local socio-economic contexts and institutional frameworks. Doing so can pave the way for sustainable development and bolster climate resilience, ensuring our planet and its people flourish together.

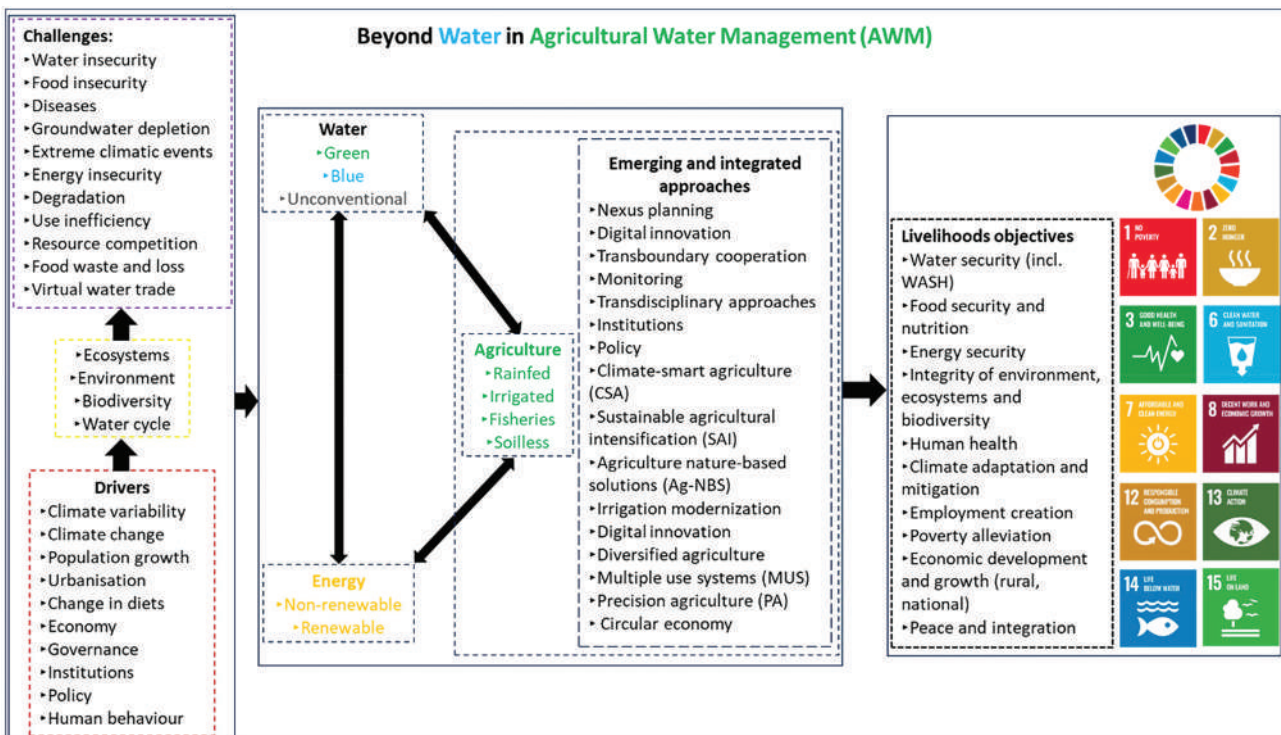
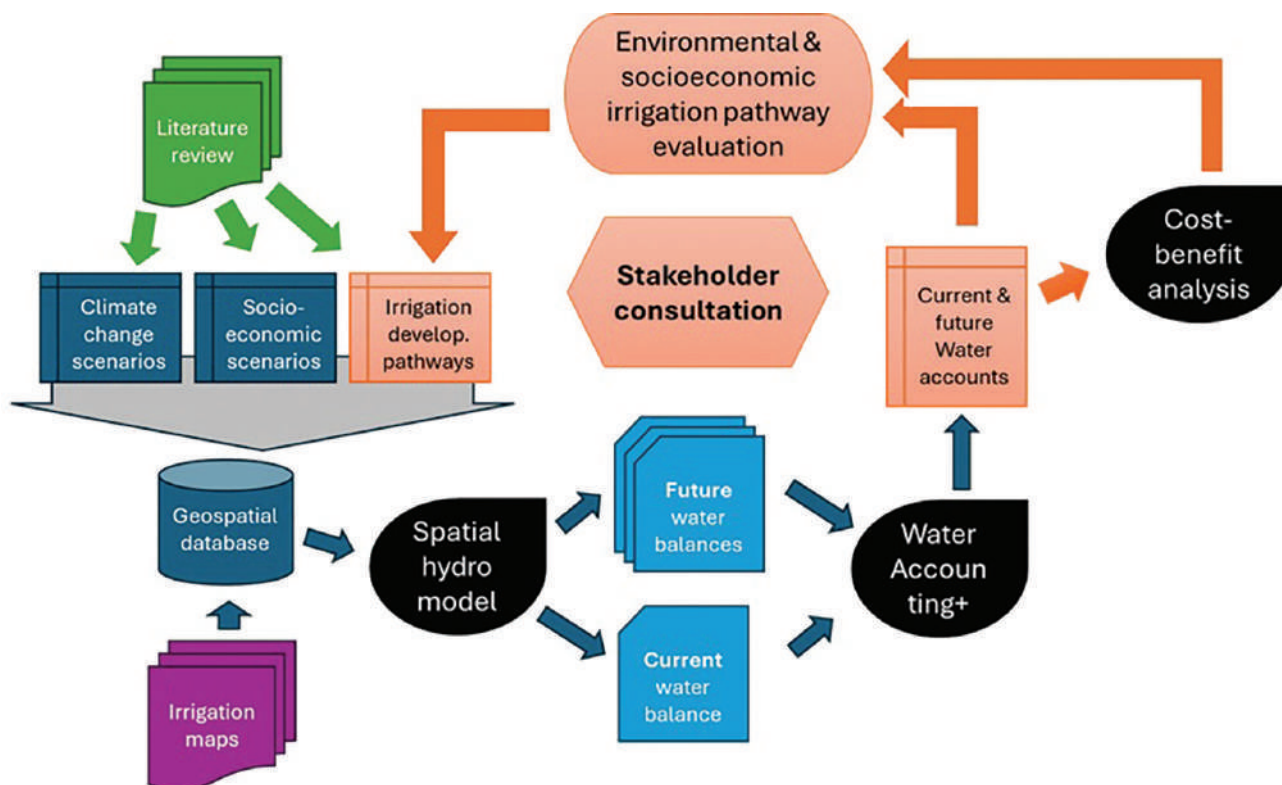


FIGURE 9. A nexus-based framework linking agricultural water management to other equally important processes
 Source: Smith et al. 2024

5.6.3 Irrigation planning under climate change

A critical topic that is not adequately addressed is planning irrigation under changing climate conditions. While irrigation contributes to adaptation and resilience, we must recognize that future hydrological regimes are uncertain and dynamic, with increasingly impossible risks to calculate. It is therefore important to select irrigation development pathways that will be robust in the future. To be successful within a wide range of possible climate futures, IWMI supports the irrigation development and rehabilitation in the Lake Chad Basin. Activities include integrating climate scenarios and water accounts, assessing future water balances, and testing the robustness of irrigation planning (see Figure 10).



Sustainable Irrigation Development – Lake Chad

Goal: Sustainable irrigation development plan for the Lake Chad basin
Assessing water budget within environmental and hydrological boundaries

Tools deployed:

- Irrigation mapping
- Climate change scenarios
- Irrigation development pathways
- Spatially distributed CWaTM model
- Water Accounts
- Economic modelling

FIGURE 10. Irrigation development and rehabilitation pathways for the Lake Chad Basin problem
Source: IWMI internal document

5.6.4 Promoting gender, youth, and social inclusion in irrigation management

Irrigation plays a crucial role in transforming agricultural development. However, its benefits are not always equally distributed due to systemic barriers to accessing irrigation resources (Nhamo et al. 2024). For instance, the lack of secure land rights restricts women's ability to make independent decisions about land use and investment in irrigation infrastructure (Harmon et al. 2023). Women farmers often have limited access to essential resources, including credit, inputs (such as fertilizers and seeds), extension services, and information about irrigation technologies and practices. They may also lack the collateral required to secure loans for irrigation investments. Additionally, women are often underrepresented in Water User Associations and other irrigation management institutions (Haddout et al. 2024). Even when women are included as members, their voices and perspectives may still be marginalized in decision-making processes regarding water allocation, infrastructure development, and management rules. Thus, promoting gender equality in irrigation management is critical for achieving equitable agricultural development and water security in Africa, where women form 50–80% of the agricultural workforce. Tackling disparities require addressing socio-cultural norms, institutional biases, and imbalances in resource allocation that perpetuate inequality. For instance, in Ghana, IWMI recommended quarters for women in the Water User Associations, which have since been approved.

Under the Feed the Future Innovation Lab for Small-Scale Irrigation (FTF-ILSSI) Project, IWMI utilized gender-sensitive irrigation technologies and strategies tailored to local contexts to empower women and enhance agricultural productivity in Ethiopia, Ghana, and Tanzania. Additionally, transformative approaches that challenge social norms and institutional biases, while enhancing women's participation and leadership in irrigation management, have been successfully employed in irrigation projects in Ethiopia to implement gender mainstreaming strategies. By addressing the existing gender inequalities in irrigation management, Africa can unlock the full potential of irrigation to drive agricultural transformation, enhance livelihoods, and build climate resilience sustainably and equitably. Recognizing and valuing the contributions of women as key stakeholders in the irrigation sector is fundamental to achieving these goals.

5.6.5 Supportive policies and an enabling environment for irrigation development

To enhance irrigation development in Africa, supportive policies must address systemic barriers while fostering sustainable and inclusive growth. IWMI has played a pivotal role in advancing these goals through research, on-the-ground projects, and policy advocacy. For example, in Ethiopia and Tanzania, water-lifting tools and wetting front detectors have been tested to optimize irrigation efficiency while addressing gender disparities in access to technology. In Ghana, community-owned irrigation systems and FLID have been promoted, enabling farmers to lead infrastructure development. In Ethiopia, IWMI worked with a treadle pump manufacturer to design a pump that women preferred in one of the rural communities. To build on the gains achieved, IWMI recommends these enabling conditions:

- Governments should establish clear and inclusive regulations for water resource management, including groundwater monitoring and sustainable usage.
- Private entrepreneurs should provide affordable credit and subsidies for small-scale irrigation systems, such as solar or treadle pumps, which can empower farmers.
- Collaboration between governments, donors, and private companies is essential to scale irrigation infrastructure.
- Training programs for farmers and technicians on irrigation maintenance and water management ensure long-term sustainability.
- Hybrid laws that bridge formal and informal water laws should be crafted.

6. Call for Actions to Grow the Irrigation Sector Sustainably

For too long, Africa has been hindered by water scarcity, outdated infrastructure, and the ever-growing threat of climate change. These challenges have stalled agricultural progress, and millions of smallholder farmers continue to struggle. However, these struggles do not stem from a lack of ambition but rather from limited access to sustainable irrigation and efficient water management systems. The African proverb states, “If you want to go fast, go alone. If you want to go far, go together.” Now is the time for collective action to propel change in the African irrigation sector. Delayed responses are no longer tenable. The time for decisive action is now. Thus, the following interventions are recommended:

- **Well-targeted government investment:** Governments across Africa must allocate resources to improve water infrastructure, thereby overcoming the inefficient irrigation crisis that affects agricultural productivity and food security. Additionally, governments should create an enabling and conducive environment for sustainable farmer-led irrigation investments through laws, subsidy programs, removing import barriers, and a competitive agricultural sector.
- **Leveraging private sector capital:** Private investors and business sectors must step forward to finance transformative irrigation projects that empower farmers and strengthen communities. Private investment in water-smart technologies can help scale up irrigation systems, benefiting millions of farmers across the continent. The private sector can play a pivotal role in bringing innovation and much-needed capital to irrigation initiatives. In this vein, supporting public-private partnerships to attract additional financial resources for irrigation investments is vital.
- **Holistic agricultural water management (suite of options):** The success of irrigated agriculture in Africa in achieving food self-sufficiency and reducing poverty requires more than just the construction, operation, and maintenance of irrigation infrastructure and equipment. Governments must lead the way by prioritizing policies that promote smart water management and investing in sustainable irrigation systems.
- **Innovative applied research:** Researchers and innovators must continue to develop affordable, scalable solutions to make water accessible to all and enable adaptive management. Innovations must be at the heart of the solution to increase irrigation efficiency and minimize the impact of irrigation development on water availability and nature.
- **Innovative water solutions:** Sustainable practices, such as reusing water, harvesting rainwater, and conserving soil moisture, need to be widely adopted. Additionally, the development and rehabilitation of irrigation schemes are required within the future hydrological and environmental boundaries in response to climate change.
- **It is all about people:** Communities and farmers must be the driving force behind change. Empowered communities must demand better water governance and contribute to the local management of water resources. Africa’s future will be built on the shoulders of its farmers. As the saying goes, “Wisdom is like a baobab tree; no one individual can embrace it.” It will take collective wisdom to overcome irrigation and water management challenges in Africa.
- **Seeing opportunities beyond crisis:** Africa has the resources, the talent, and the drive to lead the world in water-smart agriculture. We have the power to turn this crisis into an opportunity. Through collective efforts—mobilizing finance, innovation, and political will—we can transform Africa’s water management landscape. Let us build a continent where every drop of water counts, farmers can thrive, and no one goes hungry due to a lack of water for irrigation. The future lies in our hands. Let us shape it into one of abundance, resilience, and prosperity for all.
- **Innovative water solutions:** Finally, IWMI, as a global leader in irrigation and water management, can guide the technical group to gain deeper insights into more effective irrigation investment strategies and more affordable water management options, thereby empowering communities and farmers to be the driving force in Africa.

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