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Water for Food Security: The Contribution of CGIAR in Addressing Global Agricultural Water Challenges

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Background

Water is a fundamental input for food production and is used extensively across all agricultural activities, including crop cultivation, livestock production, aquaculture, and food processing. Substantial investments have been made to expand water supply capacity for agriculture, which has made a significant contribution to agricultural production growth (FAO, 2021).

At the same time, the intensive use of water in agriculture and related processes creates significant pressures on water resources and aquatic ecosystems. Water scarcity and pollution are among the major water-related challenges associated with global food production, which are directly relevant to SDG 6 (Clean Water and Sanitation) (United Nations, 2015).

1. Water scarcity

Water scarcity refers to situations in which water supply is insufficient to meet demand, often leading to competition or even conflict over water allocation. Such scarcity may reflect physical limits to water availability or economic barriers that prevent effective access to available water. In recent years, the concept of water demand has expanded beyond human socio-economic needs to include the requirements of ecosystems. Withdrawals from surface water reduce river flows, while abstraction from aquifers lowers groundwater tables; both processes pose significant risks to the health of aquatic ecosystems.

Agriculture is the largest user of freshwater, accounting for approximately 70% of global withdrawals (FAO, 2024), primarily for irrigation, as well as for livestock production and agribusiness. Pressure from agriculture on water resources has continued to increase. It is estimated that half of global irrigation expansion since the beginning of this century has occurred in regions already experiencing water stress (Mehta et al., 2024).

2. Water pollution

Agriculture is also a major source of diffuse water pollution. Excessive application of chemical fertilizers and pesticides leads to nutrient runoff and leaching, contributing to the eutrophication of rivers, lakes, and coastal waters. Soil erosion generates sediment pollution, which degrades water quality and damages aquatic ecosystems. In areas with intensive livestock production, untreated manure can contaminate water bodies with nutrients, organic matter, and pathogens. Aquaculture can also contribute to water pollution through the discharge of nutrient-rich effluents, uneaten feed, chemicals, and organic waste, which can degrade water quality and alter aquatic ecosystems if not properly managed.

Overall, agricultural water challenges are diverse, interconnected, and often difficult to manage, requiring systematic and coordinated efforts to address them.

Water research at CGIAR

CGIAR is a global partnership of 15 research centers dedicated to advancing science for food systems transformation. Its mission is to reduce rural poverty, enhance food security, improve nutrition and public health, and promote the sustainable use of natural resources in climate crisis.

To achieve these objectives, CGIAR maintains a research portfolio that has continuously evolved over time. This portfolio is structured around system-wide research programs, action areas, and initiatives implemented across CGIAR centers. Several of these large-scale research efforts either focus explicitly on water or address water as a major cross-cutting theme. Examples include the Water, Land and Ecosystems (WLE) program (2017–2021), the CGIAR Initiative on NEXUS Gains and National Policies and Strategies (2022–2024), as well as the Climate Action science program and the multifunctional landscapes science program (2025–present).

In addition, water-related research is embedded across many other CGIAR programs, reflecting the inherently cross-sectoral nature of water challenges.

- CGIAR plays a significant role in advancing water-related research in the Global South

CGIAR-supported studies are conducted across a wide range of countries. Figure 1 illustrates the geographic distribution of countries included in CGIAR research projects, based on the compiled project-level dataset. Consistent with CGIAR's mandate and development-oriented focus, the majority of study locations are concentrated in the Global South, particularly in low and middle income countries.

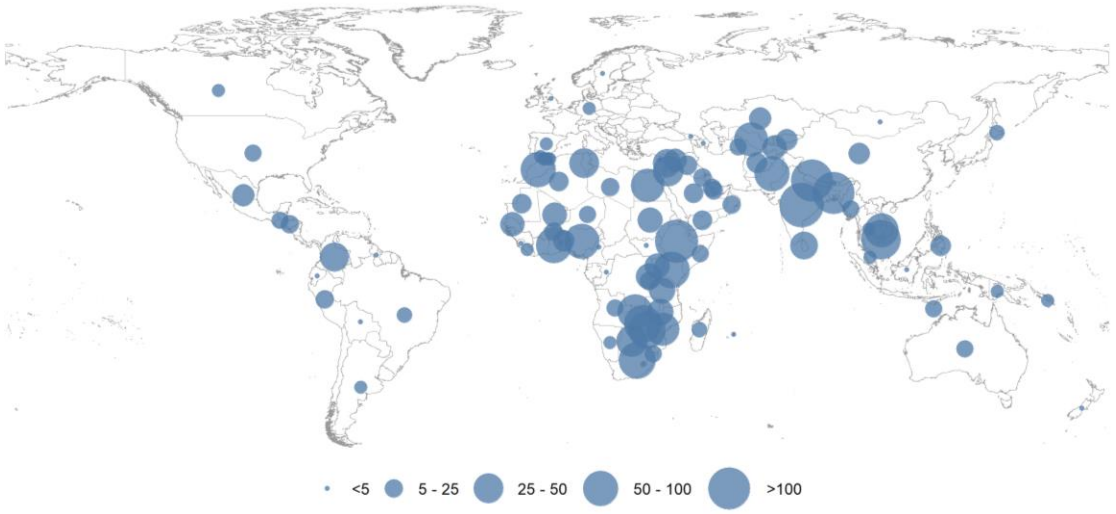
Regions with particularly strong CGIAR research presence include Africa, South Asia, Southeast Asia, central Asia and Latin America. These areas are confronted with some of the world's most severe agricultural water-related issues. The concentration of CGIAR studies in these areas demonstrates CGIAR's commitment to supporting water science in locations where agricultural livelihoods are highly vulnerable, and where better water management can bring significant gains in development, food security, and climate adaptation.

- CGIAR provides holistic solutions to address water-related challenges in global food production

Addressing water-related challenges in global food production requires coordinated efforts across multiple disciplines. CGIAR adopts a holistic research approach that spans the full pathway from innovation to impact. This approach includes the development of water-related technologies that drive tangible changes on the ground through improved irrigation practices, enhanced water-use efficiency, and climate-resilient production systems. CGIAR research also generates data and knowledge products—such as models, decision-support tools, and spatial analyses—that inform planning, policy formulation,

and investment decisions. In parallel, socioeconomic research examines the institutional, governance, and equity dimensions of water management, shaping how technologies and knowledge are adopted, how resources are governed, and how benefits are distributed across different social groups.

Figure 1: Geographic distribution of countries included in CGIAR research projects



Source: CGIAR Dashboards

Table 1: CGIAR Water-Related Research Categories and Example Studies

Research category	Example studies
Technologies	• Development and field testing of water-saving irrigation practices to improve water productivity in crop systems. • Evaluation of climate-resilient cropping and irrigation strategies to reduce yield losses under increasing water scarcity. • Assessment of soil–water–crop interactions to optimize irrigation scheduling and nutrient management. • Introduction and adaptation of small-scale and solar-powered irrigation technologies for smallholder farmers in water-constrained regions.
Data & knowledge	• Generation of spatial datasets and maps on water availability, irrigation potential, and water-related risks to support planning and investment decisions. • Development of decision-support tools and models integrating climate, hydrology, and crop water demand. • Scenario and foresight analyses assessing future water demand and supply under climate and socioeconomic change. • Compilation of open-access databases and indicators to monitor water use, efficiency, and sustainability across regions.
Socioeconomics	• Analysis of water governance frameworks, policies, and institutional arrangements affecting water allocation and management. • Studies on adoption barriers and incentives for water-saving technologies among farmers and water user groups. • Gender and social inclusion research examining equitable access to water resources and irrigation benefits. • Assessment of economic and distributional impacts of water management interventions at household, community, and regional levels.

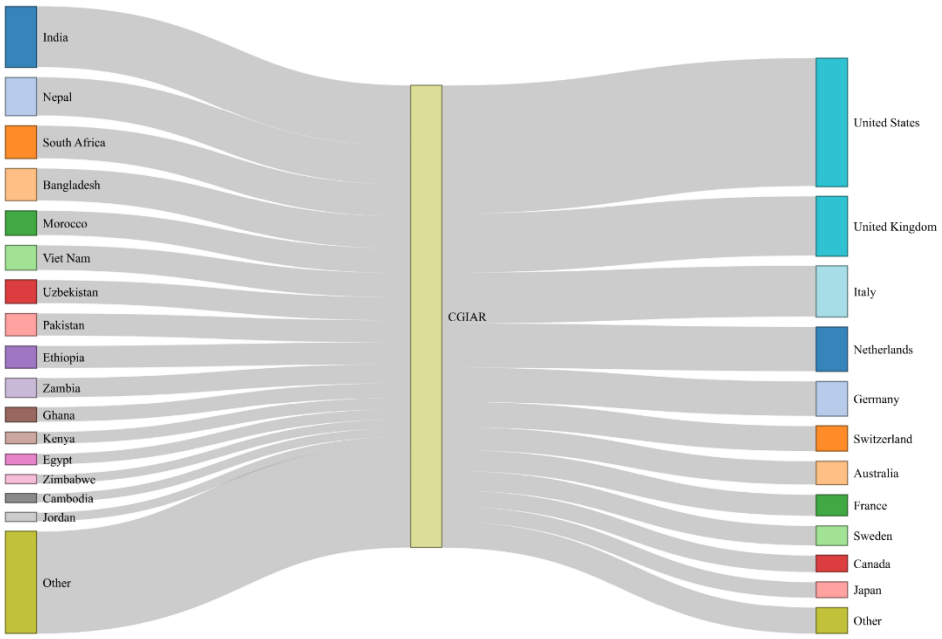
Source: CGIAR dashboards, CGSpace and Web of Science

More insights and opportunities

Challenges to water resources arising from food production occur worldwide, but they are often more acute in countries of the Global South. Effective solutions to these challenges are highly context-specific, requiring adaptation to local agroecological, socioeconomic, and institutional conditions. In many Global South countries, however, the research and innovation capacities needed to address these challenges remain relatively limited. Addressing such capacity gaps requires strong international collaboration, consistent with Sustainable Development Goal 17, which emphasizes partnerships as a core mechanism for achieving sustainable development outcomes (United Nations, 2015).

Figure 2 illustrates the partnerships between CGIAR and its collaborating institutions across CGIAR research projects, based on the countries in which the collaborating institutions are located. CGIAR is positioned at the center of the diagram, with partner countries connected by lines whose widths represent the volume of collaborations across CGIAR research projects. Major partner countries from the Global South are shown on the left; these countries host institutions that provide local context, support the scaling up of innovations, and help ensure adoption by farming communities. CGIAR also partners with institutions in the Global North, shown on the right side of the diagram; these institutions often play leading roles in fundamental science and advanced technology development.

Figure 2: Conceptual network of CGIAR research partnerships



Source: CGIAR Dashboards

The figure highlights CGIAR's unique strategic role in global agricultural water research. As a global research coalition with deep roots in developing countries and strong links to leading research institutions in developed economies, CGIAR facilitates the flow of scientific knowledge, technologies, data, and methodologies from institutions with higher research and innovation capacity to locations where such capacity is most needed, while ensuring that solutions are informed by local knowledge and on-the-ground realities.

Through these partnerships, and combined with the strong research capabilities of CGIAR centers themselves, CGIAR has delivered significant impacts by translating agricultural water research into measurable development outcomes.

Box 1: CGIAR water research delivering impact at scale

Story 1. Embedding nexus-based water governance across the Niger Basin

CGIAR research has played a pivotal role in transforming how water-related investments are planned and governed in the Niger Basin. Through the CGIAR Initiative on NEXUS Gains, researchers supported the Niger Basin Authority (NBA) in adopting a Water–Energy–Food–Ecosystems (WEFE) Nexus approach that explicitly accounts for cross-sectoral trade-offs and synergies. In 2022, the NBA formally adopted WEFE Nexus guidelines, and these have since been institutionalized in the Authority's Operational Plan for 2025–2033. Covering nine West African countries and a basin population exceeding 160 million people, this policy shift provides a foundation for more coordinated, sustainable, and climate-resilient water development across one of Africa's most important transboundary river systems. By moving nexus thinking from analysis into official planning frameworks, CGIAR research is shaping long-term water governance and investment decisions at basin scale.

Story 2. Turning floods into groundwater storage in the Ganges Basin

In India's Ganges Basin, CGIAR-supported innovation is helping communities address the twin challenges of destructive floods and chronic water scarcity. Research led by the International Water Management Institute (IWMI) advanced Underground Transfer of Floods for Irrigation (UTFI), a Managed Aquifer Recharge approach that diverts excess monsoon floodwater into aquifers for later use. Extensive field evidence and stakeholder engagement demonstrated UTFI's effectiveness, leading national and subnational governments to incorporate the approach into large-scale water conservation programs. To date, more than 11,800 recharge structures have been constructed with public investment of approximately USD 60 million, increasing groundwater availability by up to 8 percent in participating areas. This example illustrates how CGIAR water research can translate local innovation into government-led action, strengthening climate resilience and water security for rural communities at scale.

Source: CGIAR Dashboards

While CGIAR research projects primarily operate in the Global South, it is important to recognize that investments in agricultural water research in these regions also generate significant benefits beyond their immediate contexts. From a knowledge-generation perspective, the water cycle is global in nature, meaning that water challenges across regions are inherently interconnected. Research conducted in the Global South deepens understanding of global water systems, strengthening the capacity to simulate water availability, assess risks, and inform water management decisions worldwide.

In terms of research impacts, water-related shocks in major food-producing regions—many of which are located in the Global South—have far-reaching global consequences. These shocks contribute to food price volatility, disrupt international supply chains, and increase the risks of humanitarian crises and forced migration. By improving water productivity and promoting sustainable water management in developing regions, CGIAR research helps reduce these systemic risks and supports greater global stability.

At present, the world is facing rapidly intensifying challenges in agricultural water management. Population growth and rising food demand, climate change, and increasing competition among water users are placing unprecedented pressure on water resources. In the foreseeable future, agriculture will remain the largest consumer of freshwater globally, and its ability to adapt to water scarcity and climate variability will be a defining factor for food security and environmental sustainability.

Given the scale and urgency of these challenges, and the broad benefits generated by agricultural water research, there is a clear need to increase investment in water-related research, and in CGIAR in particular. One major opportunity lies in advancing integrated water resources management (IWRM) approaches that recognize the interconnections among water, food, energy, and ecosystems. By promoting coordinated planning and management across sectors and scales, IWRM-oriented research can help balance competing water demands, reduce trade-offs between agricultural production and environmental sustainability, and enhance the resilience of water systems under climate change.

In parallel, rapid advances in artificial intelligence (AI) and data-driven methods are opening up transformative opportunities for agricultural water management. AI-enabled tools can improve the monitoring and forecasting of water availability, climate risks, and crop water requirements; support precision irrigation and decision-making at farm and basin levels; and enhance the efficiency and targeting of policies and investments. A particularly promising application is the development of digital twins of agricultural water systems—virtual representations that integrate real-time data, biophysical models, and socio-economic information to simulate system behavior under alternative management and climate scenarios. When combined with CGIAR's extensive field presence, long-term datasets, and partnerships in the Global South, these technologies can accelerate the translation of scientific insights into scalable, context-specific solutions.

Such investments offer high returns by strengthening food security, reducing climate and water-related risks, protecting ecosystems, and enhancing global resilience. Supporting CGIAR's agricultural water research is therefore not only a development imperative, but also a strategic investment in shared global interests.

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REFERENCES

FAO. 2021. The state of the world's land and water resources for food and agriculture – Systems at breaking point. Synthesis report 2021. Rome. https://doi.org/10.4060/cb7654en

FAO. 2024. AQUASTAT Core Database. Accessed on November 21, 2025. https://www.fao.org/aquastat/en/databases/maindatabase/ Licence: CC-BY-4.0.

Mehta, P., Siebert, S., Kummu, M., Deng, Q., Ali, T., Marston, L., Xie, W. and Davis, K.F., 2024. Half of twenty-first century global irrigation expansion has been in water-stressed regions. Nature Water, 2(3), pp.254-261.

United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015, A/RES/70/1. United Nations, New York.