CGIAR
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DIGITAL TRANSFORMATION

IWMI
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Workshop Report

The Future of Food, Land and Water Systems in the Face of Digital Technologies

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About the CGIAR Accelerator for Digital Transformation

The CGIAR Digital Transformation Accelerator aims to be a thought leader in digital and data science research across food, land, water, and climate systems, accelerating the delivery of research and digital services responsibly using data and tools such as AI, and improving decision-making based on evidence and insights into complex systems.

Citation

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Disclaimer

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Front and back cover: AI-generated scenario illustrations created by participants during the workshop. *Source*: Gemini (Banana)

Content

Summary

The Future Scenarios Workshop on Digital Futures brought together experts from CGIAR centers and partners to explore how rapidly evolving digital technologies may reshape food, land, and water systems in the Global South. Using a participatory foresight and human-centered design approach, participants identified signals and drivers of change—such as the evolution of AI, water governance, geopolitical tension, and labor shifts, and combined them into scenario frameworks to guide the Digital Transformation Accelerator (DTA) and CGIAR's broader digital strategy over the coming years. The exercise resulted in three detailed and contrasting future worlds: Green India Revolution 2.0, where automation and AI transform agriculture but create new social divides; We Are The Water, where transboundary water governance and decentralized cooperation redefine sovereignty; and Open Source, Open Borders, where migration and open digital ecosystems fuel grassroots innovation and resilience.

Across these explorations, several cross-cutting insights emerged. Digital transformation holds the potential to improve productivity, inclusion, and sustainability, but also poses new risks related to inequality, ethical use of data, and energy and water dependence. These future worlds show that digital transformation is not only a technological shift but a restructuring of power, determining who controls data, whose knowledge shapes decisions, and whose interests are prioritized across FLW systems. To navigate these futures, CGIAR and its partners are advised to invest in inclusive digital innovation, anticipate and study ethical risks, and strengthen cross sectoral collaboration with actors shaping technological and energy infrastructures to address systemic challenges such as water scarcity. The next phase will translate these foresight insights into strategic action, embedding scenario thinking into CGIAR's research, policy, and investment agendas to guide responsible digital transformation across food, land, and water systems worldwide.

Workshop participants from four CGIAR Centers, four science programs and ten nationalities created the future scenarios. Photo credit: Daniela Arce.

Introduction

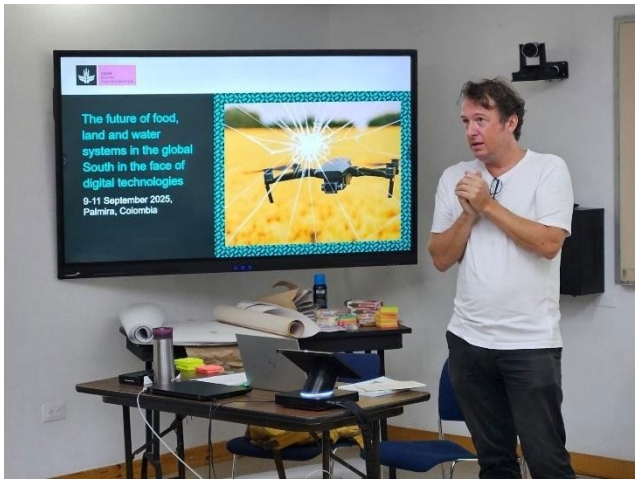
The Digital Futures Area of Work (AoW) 3 within CGIAR´s Digital Transformation Accelerator (DTA) convened this workshop to anticipate how rapidly evolving digital technologies might reshape Food, Land, and Water (FLW) systems in the Global South, and to ensure that CGIAR and its partners can make research and investment choices today that remain relevant across multiple plausible futures. Rather than assuming current tendencies in the development and use of digital technologies will remain the same, the exercise explored how different drivers of change could unfold, what trade-offs might emerge, and how collective action can guide these transformations toward more equitable outcomes. A total of 22 CGIAR researchers and designers from 6 different CGIAR centers, 4 science programs and 10 nationalities came together from 9 to 11 September 2025 at the Palmira Campus in Colombia.

What makes this initiative different from traditional foresight is it´s human-centered approach. Every scenario explores the lived realities of farmers, communities, policymakers and researchers to showcase how people might live, make decisions, and adapt in rapidly changing environments, thereby acknowledging the unequal realities and diverse worldviews of different groups which each experience and shape digital change in very different ways, depending on their starting points. This aligns with Digital Futures' mandate to combine foresight and speculative design to co-create inclusive visions of digital transformation that consider youth and other underrepresented groups, while assessing trends that could reshape job markets and livelihoods across food, land, and water systems.

This work directly supports CGIAR's strategy to accelerate responsible digital transformation across programs and regions where CGIAR operates. It contributes to shaping an institutional understanding of how digital transformation could influence agricultural research and development, policy, and innovation ecosystems in the years ahead. Through scenario analysis, CGIAR and its partners can better test strategies under uncertainty, identify where inclusion may be at risk, and direct investments toward solutions that are impactful, feasible, and centered on people.

Andrew Jarvis, director of Future of Food at the Bezos Foundation, gave an inspiring talk on the first day of the workshop to share his thoughts about aspects of the food system that are changing. In his key messages, he highlighted how vital it is to explore areas related to food systems that are considered to have ´high impact and high uncertainty´: ¨When developing portfolios, you want to put your effort in understanding these areas, because that´s where your work will enable to reduce risk and have a high impact¨, thereby emphasizing the precise intention of the scenarios exercise.

This perspective aligns strongly with the probes approach promoted under Area of Work 3 of CGIAR´s Digital Transformation Accelerator. Probes are designed precisely to explore those high impact and high uncertainty spaces through small, rapid, and safe to fail experiments that reveal what works in practice. Instead of committing resources to large solutions that depend on multiple conditions changing at once, probes allow CGIAR to test specific assumptions, learn from real contexts, and reduce uncertainty early in the innovation cycle.



Andrew Jarvis sharing thoughts about contextual drivers changing FLW systems. Photo credit: Benavente, G

Methodology

This foresight exercise consisted of the participatory development of explorative scenarios (Figure 1) based on multiple scenario matrixes with two axes of uncertainty[1][2], complemented by a human-centered design approach[3]. Explorative scenarios are defined here as "multiple plausible futures described in words, numbers and/or images"[4]. The process started off with defining the scope of the exercise and identifying stakeholders from different backgrounds and disciplines with a high level of knowledge and expertise in food, land and water systems ensuring a diverse group of participants from geographic regions where CGIAR and the Digital Transformation Accelerator operate. Looking ahead, we plan to complement this CGIAR-focused workshop with region-specific participatory sessions that bring together diverse local stakeholders, across gender, ages, socio-economic groups, and social positions—to strengthen contextual grounding and broaden representation.

In preparation of the futures exercise, participants identified and shared **signals of change**, concrete evidence of emerging future possibilities—such as small innovations, niche products, new policies, or surprising current events that illustrate how digital technologies might transform food, land, and water systems in the near future, including those revealing social and equity trends that shape who will be most affected by digital transformation.

During a face-to-face workshop, these signals served as input and inspiration to identify contextual **drivers of change**; factors, issues, or trends that generate change for many elements of a system, affecting the future. The drivers were **clustered** and prioritized according to their level of uncertainty and potential impact, resulting in six **critical drivers** shaping the future of food, land, and water systems in the Global South. In some cases, image capturing AI was used to name clusters.

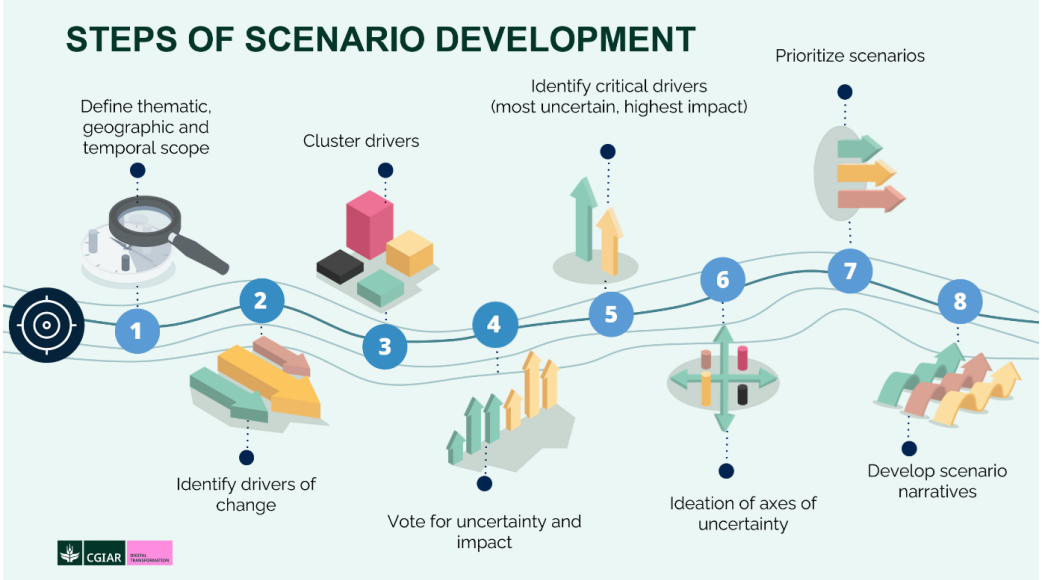


Figure 1. Steps of scenario development used during this process. Credit: Veeger, M

Working in heterogeneous groups, supported by the insights about the future shared during the ideation process of signals and drivers of change, participants experimented with combining drivers and defining **axes of uncertainty**, iterating this process until resulting in three diverse sets of scenarios that challenge existing assumptions and

[1] Wilkinson, A., Eidinow, E., 2008. Evolving practices in environmental scenarios: a new scenario typology. Environ. Res. Lett. 3, 045017

[2] Vervoort, J. M., Thornton, P. K., Kristjanson, P., Förch, W., Ericksen, P. J., Kok, K., et al. (2014). Challenges to scenario-guided adaptive action on food security under climate change. *Glob. Environ. Change* 28, 383–394. doi.org/10.1016/j.gloenvcha.2014.03.001

[3] Pace, L. A., Bruno, C., & Schwarz, J. O. (2025). Personas in scenario building: Integrating human-centered design methods in foresight. *Futures*, *166*, 103539. https://www.sciencedirect.com/science/article/pii/S0016328725000023?via%3Dihub

4. P.W.F. van Notten, J. Rotmans, M.B.A. van Asselt, D.S. Rothman. An updated scenario typology. Futures, 35 (2003), pp. 423-443.

address gaps in current thinking about the impact and use of digital technologies. From this initial experimental phase, three sets of scenarios were selected and refined to ensure relevance. From each set, the scenario considered most challenging or insightful was fully developed into a **narrative** storyline describing the future world and the sequence of events that led to it.

Special attention was given to telling each story of the future through the perspectives of four fictional **personas**: a farmer, a rural community leader, a policymaker, and a CGIAR researcher. What does life look like for them in each future scenario? What challenges do they face, and what decisions do they make? Applying this human-centered design approach resulted in rich, engaging narratives highlighting the different, sometimes challenging, points of view of key stakeholders in the food system. Future iterations of this work could involve participatory scenario workshops with farmers and extension staff to gather first-hand insights about these personas. In all cases, AI was used to generate illustrations of the scenarios and personas (Google Gemini). Narratives were written by participants themselves. Some groups used AI to generate a script to present the scenarios in the form of a news broadcast, which was based on the scenario narrative.

In the final stage of the exercise, all scenarios were analyzed to identify future **challenges** and **opportunities**, leading to recommendations for actions that CGIAR can take in the next few years to seize potential opportunities and mitigate anticipated risks.

Apart from the summary, this report is written entirely by the authors.

Researchers engaged in the co-creation process of scenario narratives. Photo credit: Veeger, M.

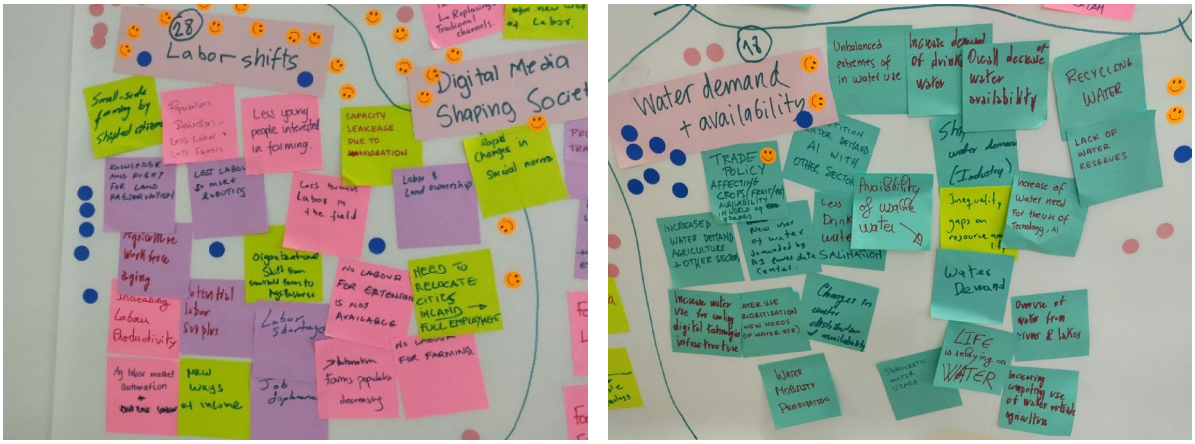
Drivers of change

The identification of drivers of change is considered a crucial step in scenario development. It starts when we look around us and notice what is changing. These signals of change, sometimes still weak, give us an idea of what will come, and help us to imagine what things might be different in the future, and how. They are concrete, compelling evidence of future possibilities, such as small innovations, niche products, emerging policies, or surprising events happening now that suggest a different future is possible.

In the weeks leading up to the workshop, the AoW3 team under DTA held regular weekly meetings. Future scenarios were a recurring topic in these sessions, where participants explored their purpose, strategic relevance, and potential to guide long-term thinking in food, land, and water systems. These discussions helped establish a common understanding and set the stage for the participatory foresight process.

Two weeks before the workshop, stakeholders started identifying signals of change for the future of food, land, and water systems in the face of digital technologies. These were collected and shared on a digital whiteboard. Annex 2 gives an overview of these signals, varying from the 3D printing of meat to drones addressing labor shortages in agriculture and intelligence (AI) creating water shortages as well as revolutionizing water research.

Alongside the signals of change captured earlier, several keynote speakers shared their thoughts on the future of food, to set the tone towards participants initiated the scenarios development process by identifying drivers of change; contextual factors, issues, or trends that generate change for many elements of a system, affecting the future. The difference between drivers and signals of change is that signals are the changes that we see, whereas drivers are the underlying causes for these changes. Drivers are essential to scenario development because they form the bases for the axes of uncertainty, which define and give structure to scenarios.



Clustered drivers of change are prioritized for impact and uncertainty and later used by participants to define axes of uncertainty. Photo credit: Veeger, M.

The group identified and clustered about 18 drivers of change (Figure 2). Some drivers were overlapping and therefore united to show the possible axes emerging from them. Stakeholders then voted for the drivers considered most uncertain and with the highest impact, resulting in the final list of critical drivers. These were then used to develop axes of uncertainty and the scenario matrixes. More details on the following steps of scenario development can be found in the methodology section.

Scenarios and insights about the future

After prioritizing six critical drivers of change, participants worked in mixed groups to develop sets of future scenarios. In an agile, experimental, and reflexive process, each group had the liberty of trying out different combinations of drivers to develop a set of scenarios, starting with a driver they considered most relevant or interesting, and then combining it with another critical driver from a different STEEPLE[5] group.

To define an axis of uncertainty, members of each group took inspiration from the prior step by looking carefully at the ideas given for drivers of change to identify themes to explore in each axis, as well as possible directions of change or extreme states within each axis (Figure 2). Using the following list of criteria, each group checked if the resulting set of four scenarios made an insightful set of scenarios:

- Do the scenarios challenge our current perspectives? (Will they provide new perspectives on the future of food, land and water systems in the face of digital technologies in the Global South?)
- Are all scenarios different from each other? If this is not the case, drivers might be too similar and need to be adjusted
- Are they plausible? (Considering that we want to push our idea of plausible, since this is where we create interesting scenarios)

Each team explored different combinations of drivers and defined axes of uncertainty, repeating the process with feedback from the facilitating team until producing a set of scenarios that complied with all criteria.

From this exploratory stage, three sets of scenarios were chosen and refined for their relevance after constructive feedback from the facilitating team. From each set, the scenario judged to be the most provocative, insightful or revealing was then fully developed into a narrative outlining a possible future world, the series of events leading up to it, and what the scenario meant for four key figures (*personas*). The names given to personas are fictional.

After developing the scenarios, each was analyzed to identify the challenges and opportunities they entail for the future and their users. As a result, recommendations were formulated for CGIAR and partners to mitigate challenges and move towards the opportunities explored in each scenario, considering the development and decision-making around research plans, investments and collaborations in the next 5 years.

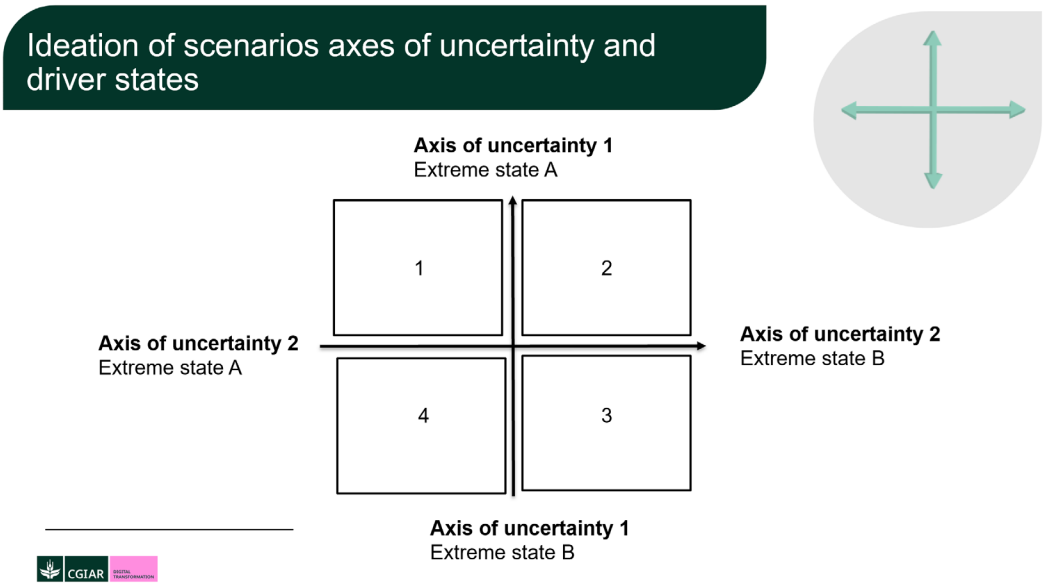


Figure 2. Ideation of scenarios axes of uncertainty and driver states. Source: Veeger, M.

[5] STEEPLE: Social, Technological, Economic, Environmental, Political, Legal, and Ethical factors

Green India Revolution 2.0

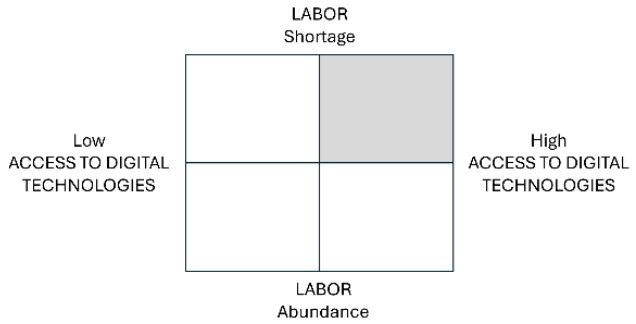


Figure 3: Scenario matrix of which ´Green India Revolution 2.0´ is part of (labor shortage, high access to digital technologies). Source: Veeger, M.

Scenario description

´Green India Revolution 2.0´ depicts a future that departs from a shortage of labor and a high access to digital technologies (Figure 3).

Global South context: Food is cheap in countries that have highly diversified renewable electricity production (such as wind and solar, and potentially also nuclear energy production), yet expensive in countries that do not. Such energy sources are more resilient towards climate extremes. Food is more expensive in countries that did not invest in such energy production.

Overall scenario: In 2040 the agricultural labor force is not sufficient to farm all agricultural lands. There are however still many farmers, who farm their plots in an efficient way by using open access digital tools (such as weather forecasting apps, drones, etc). They have a good income by producing high crop yields in an efficient way. The remaining agricultural lands are farmed by corporations by means of high automatization including robotics. The whole food production system is energy intensive (Figure 4).

Figure 4. Illustration of the scenario Green India Revolution 2.0. Credit: AI generated by workshop participants (Gemini, Banana)

Country scenario: The Indian agri-food system in 2040 has processed food globally through highly automated production throughout the entire supply chain (80% of national production), offering it at low prices and dominated by Robotics Foods Inc. Few highly capable farmers use digital tools for efficient food production, yet also require much electricity input.

Personas

Figure 5. Illustration of the persona Anika from the scenario Green India Revolution 2.0. Credit: AI generated by workshop participants (Gemini, Banana)

Farmer: Anika, a potato farmer from Maharaja India (Figure 5): ¨I am fortunate that my grandpa decided to leave the farm to me while all my siblings went to become IT engineers in Bangalore. With the ability to have access to all technology and especially AgriLLM, incorporating my grandpa´s traditional knowledge on Agriculture, I am now rich, super-rich. I invested in high tech storage room to reduce my food loss to zero, therefore contributing to circular economy. Although I don't have enough water, I am able to do deficit irrigation, due to the great federated platform of climate data and other modalities, enabling me to double harvest my potato. I am so proud that my unemployed brothers now work in data clearing that I contribute to the cloud.

Rural community leader: ¨Despite having many people that are high earners in our village, most of them have decided to move to big cities to find new working opportunities. Due to a huge decrease in the price of smartphones and the cost of communication, almost everyone in the village spends their time on their phones and people no longer gather in squares -most of them are chatting with their phones, even within the same household, or the same room. Since influencers are still a thing, we decided to hire Japalo (over 6 million subscribers) to come and talk to us about Agritourism, motivate people to come back to our village, give a few examples on how tomato and lemons were grown in 2025, as well as ancient agricultural practices¨.

Figure 6. Illustration of the persona Tunji from the scenario Green India Revolution 2.0. Credit: AI generated by workshop participants (Gemini, Banana)

CGIAR researcher: Tunji, a Nigerian bean breeder, developed a successful breeding program as a CGIAR researcher, which was scaled, adopted, and accelerated by AI throughout the world (Figure 6). ¨Now that AI can do my job, prioritization is no longer needed from me, I'm considering becoming a farmer and get back to my little village and pledge it my own field. I can now focus on becoming a 1 % earner by becoming a smart farmer. I will make sure to install solar panels before I commence my farming transformation, to ensure I will be 100% electricity independent.¨ AI is accelerating breeding, and with robot automation and phenotyping CGIAR is transforming from a research breeding institute to a prompting tech company, leading in Agri prompting. ¨There is no more funding for my projects because all the data is accessible and farmers already have a better advantage¨

Policymaker: ¨Fiscal numbers are great coming from big agribusiness¨, says Parvati, the Indian Minister of Energy. ¨My colleagues at Labor Ministry are worried about the massive unemployment by youth especially¨

The road to this future

Private companies invested a lot in robotics in 2035, and now in 2040 farmers with public funded tools have access to automation tools. In 2030 private companies started approaching farmers to sell the technology and in 2035 they purchased those tools given that the infrastructure was already there. Also, the strong presence and access to AI policies and all sorts of documentation on AI standardization made it possible for both private and public sector to feel secure about the decision of investing in technology development.

In 2040 India has a highly diversified, low carbon non-water intensive green energy. Electricity was available in all parts of the country, which was key to power the “Next Level Farming” Revolution. In 2035 Solar, Wind and Geothermal Energy was providing more to the Electricity Grid and was reaching every farmer community. The first clean nuclear plant was built. In 2030 India started diversifying from non-water intensive sources of energy, investing in wind, solar and geothermal. India also setup the India Institute of Clean Nuclear Energy to explore alternative energy sources.

Multinational tech companies with agrifood system infrastructure investment reached a breakeven point in profit returns. Since 2035, the Indian government receives better tax contributions from farming communities and corporations, giving them subsidies in supportive technologies in return.

Opportunities and risks of this scenario

Opportunities

- Food is cheap and produced sufficiently to feed a global population
- Food is produced in an efficient way (optimized water and nutrient inputs) on existing agricultural lands. No expansion of agricultural lands causing deforestation
- Water for agriculture is used very efficiently
- Farmers are now wealthy
- Food is cheap in countries that invested in energy security with diversified renewable energy sources, yet more expensive in countries that didn’t
- Circular economy – food loss after harvesting is reduced to almost zero. As farmers have capital, they can invest in methods to reduce food loss, such as on farm storage room for crops

Risks

- Cybersecurity has become a national priority for defense purposes
- This scenario shows an energy dependent society. Energy demand has increased drastically to support the highly electrified digital tools, data centers, AI and robotics. This has the risk of a high carbon and water footprint, requiring the investment of diversified renewable energy sources accelerating from 2025 onwards. Decentralized energy production on farms is a good practice. There is a need for large investment in electricity grids. Climate extremes affect reliable energy supply
- Risk of monocultures due to large corporate farming, reducing the resilience of food production against due to pests and diseases
- High rates of unemployment in many different sectors. Risk of societal upheaval, when many people have no income
- The repurposing of objectives of the research institute and reduction of personnel, including the need for reduction of CGIAR staff due to lack of funding
- New types of unemployment
- Broken and fragile society as a consequence of corporate monopolies and loss of food sovereignty
- Data management regulations aim to limit information power, even though servers.
- Hardware black market for tech tools

Recommendations

Recommendations for CGIAR policy, investments and research in the next 5 years, based on this scenario

Diversification of renewable energy will be key for countries with a highly digitalized agriculture sector that seek future food security.

FAIR standards for data should be universal: data should be Findable, Accessible, Interoperable, and Reusable. The index should become CGIAR´s north star.

CGIAR should research how the shortage or surplus of energy could affect food security

Cybersecurity will become a risk for the agriculture sector. CGIAR should do research on the link between the two. Signals of this change were recently seen in Mexico.

CGIAR should have an international ethics committee

What will be the future of CGIAR if AI will start to do research and be such a knowledgeable decisionmaker?

We foresee that CGIAR will soon encounter a dilemma: How can we sustain a business model that benefits small scale farmers if digital agriculture becomes so important?

We are the water

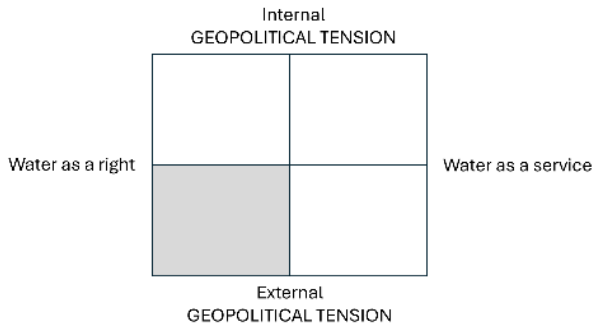


Figure 7: Scenario matrix of which ´We are the water´ is part of (External geopolitical tension, water as a right). Source: Veeger, M.

Scenario description

´We are the water´ is a future based on external geopolitical tension and water as a right (Figure 7). By 2040, nations across the Global South have created new political organizations around their main river basins. These alliances were first envisioned during the 2030 World Wide Water (WWW) Council, which emerged as a response to a series of extreme climatic events; such as unusually severe Niño phenomena, that caused peaks of drought across tropical regions and triggered multiple conflicts over the ownership and use of transboundary river basins. Coalitions such as the Amazon Union, La Plata Council, AsoMekong, and the Congo Committee were formed to manage water resources collectively. The WWW Council recognized access to water as both a universal human right and a shared responsibility, seeking to balance equitable access with regional sustainability.

The WWW Council also promoted the creation of a political and economic framework favoring decentralized and cooperative governance of water rights. This collaborative model has since been adopted in many regions around the world, standing in sharp contrast to traditional centralized systems. However, the implementation of this model led to significant disputes between organized communities and large corporations that long benefited from rivers, not only as sources of water but also as transportation routes or, in extreme cases, as waste disposal channels.

One of the Council's most innovative contributions has been its investment in scientific research on the intelligent use of water. For instance, it funded the development of biotechnological and genetically modified crops such as "Maizewheat," a hybrid combining the productivity of both maize and wheat into a single plant. This innovation reduces water consumption by at least 30% while increasing agricultural yields among participating member regions that co-financed the research.

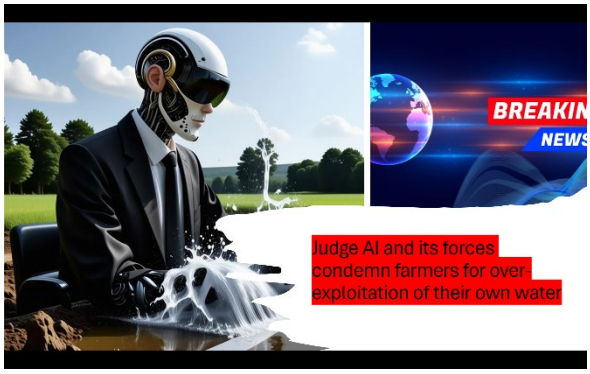


Figure 8. Scenario illustration of We are the Water. Credit: AI generated by workshop participants (Banana by Gemini)

Although the WWW Council and its collaborative approach have brought notable benefits to member regions, it has not been free of controversy. One major debate revolves around the introduction of AI judges, a software-based legal system designed to mediate complex transboundary disputes (Figure 8). The goal of this system is to harmonize the diverse water-related legislations of member regions under a neutral and shared legal framework. One high-profile case involved the use of icebergs to alleviate severe drought in sub-Saharan Africa. The Nile Association allocated resources to transport icebergs from the Antarctic to the affected areas. However, Greenland's authorities argued that the icebergs originated from their territorial waters and thus constituted national property. The AI judge ultimately ruled that the ice masses were captured in international waters and, since water is a human right, no nation could claim exclusive ownership.

The complex global context surrounding water governance has fueled extremist opposition to many of the water agreements. The “W Movement,” which ironically supports communal access to water, strongly opposes the use of AI in legal governance. Its members claim that collaboration should rely solely on human decision-making within national legal systems. One of their most extreme actions was a series of cyber and physical attacks on justice data centers, which disabled the Amazon Union’s systems for several weeks. Meanwhile, several corporations benefiting from water exploitation have invested significant resources in lobbying against the new taxes, boundaries, and regulations imposed by the WWW Council (Figure 9).

Despite such extremist actions and lobbying efforts, most council members remain satisfied with the agreements and are enjoying tangible, long-term benefits from their participation. Motivated by a strong focus on human-centered research, most member regions have significantly reduced hunger rates, even during periods of drought or flooding. Technological research supported by the Council has enabled the construction of long-distance aqueducts that collect and store water during flood seasons and redirect it to drought-affected areas within the network. In addition to these macro systems, the WWW Council also promotes community-managed irrigation systems, small modular networks powered by renewable energy that can easily integrate into larger water infrastructures.

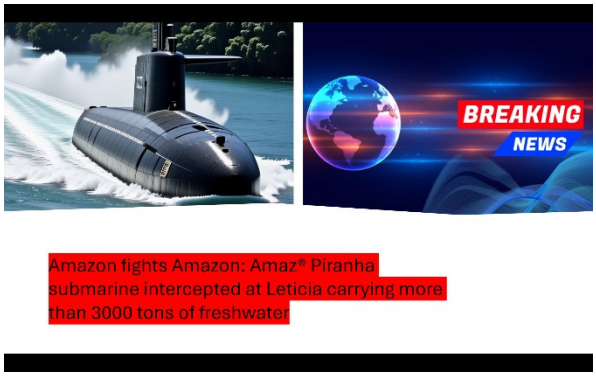


Figure 9. Scenario illustration of We are the Water. Credit: AI generated by workshop participants (Banana by Gemini)

Another area of innovation encouraged by the Council lies in the development of environmentally friendly chemicals. Advances in molecular technology have led to the creation of fertilizers and pesticides that fully dissolve after use, leaving no chemical traces in water streams. These compounds target specific pathogens, supporting biodiversity conservation and ecological balance. Further technological progress has been made in farming systems: the Council has approved the creation of an AI-based assistant for farmers that provides hands-on, science-based recommendations to improve both crop productivity and water efficiency.

Many traditional and hierarchical organizations are now closely observing the results of the WWW Council. This collective effort to safeguard a universal right has challenged long-standing paradigms of governance and collaboration. Several council governance structures have even inspired new approaches to private-sector organization. These emerging post-capitalist systems have raised deep questions about the meaning of ownership, property, and collective responsibility in a world defined by shared natural resources.

Personas

Farmer: Margaret Ospina, 59 (Figure 10). A widow and owner of a 1,000-hectare farm, Margaret has cultivated sugarcane her entire life, drawn by its guaranteed market access and stable prices. However, climate change and the growing perception among Gen Z and Alpha generations that sugarcane is a “drought crop”, due to its high water consumption and negative health associations, have placed her livelihood under scrutiny.

Margaret is an enthusiastic contributor and crowdfunder of the Freedom Crop Choice Foundation, which defends farmers’ rights to cultivate the crops of their choice while considering water, environmental, and social impacts alongside economic outcomes. She believes it is vital to protect the historical legacy of her family and their agricultural traditions. As she puts it, “At my age, I still dream of cultivating crops that nourish everyone and honour the land my family built.”

Policymaker: Dr. Andrea Ferreira - Age: 37 (Figure 10). Role: Minister of Water Governance and Food Sovereignty, Amazon Union. Dr. Ferreira is a seasoned policymaker and biotechnologist who leads the Amazon Union’s strategy on water governance and food sovereignty in a post-WWW agreement world. As geopolitical tensions escalate between Global South River unions and private corporations, Andrea defends the right to water as a common good. She promotes cooperative, basin-based governance models, supports low water hybrid crop breeding, and stabilizes food markets amidst cyberattacks and illegal extraction. Under her leadership, farmers got access to AI-powered exoskeletons to maintain productivity.

Rural Community: Rural communities are cooperative by nature and regard water as something almost sacred. Both digital and analogue tools are used communally, and circular economy practices have become the norm. Plant

by-products are revalorized and transformed into fertilizers or other essential materials. The amount of land used for food production has decreased thanks to the development of new lab-created species such as *Maizewheat*. Additionally, innovations like rotational vertical farming and sea-based cultivation have reduced the need for expanding agricultural land, allowing rural communities to act simultaneously as producers and conservationists.

CGIAR Researcher: Raja Beta X, 56 years old (Figure 10)**.** With a PhD in *Space Agrohydrology Economics*, Raja is dedicated to understanding and explaining the drivers of global water conflicts by reviving an old yet powerful principle: FAIR and open-source data. Due to strict water quotas, she has "0.5 children," a symbol of the deep societal adjustments brought by the era of water scarcity. Her professional life revolves around cooling systems — from the air conditioning in her office and the greenhouse experiments to the high-performance "supercalculator" embedded in her *iPhone 62X Max Pro Ultra Quantum* — and the quiet focus they allow her to think. Today, her performance is measured less by publications and more by the volume of freshwater recovered or saved through her research. Increasingly, she feels drawn to join the *WeFarmers Movement*, which advocates for a deeper reconnection between science, sustainability, and farming communities. *Quote:* "Big data, big dreams, big desert! But my machine learning models are still running perfectly;)"

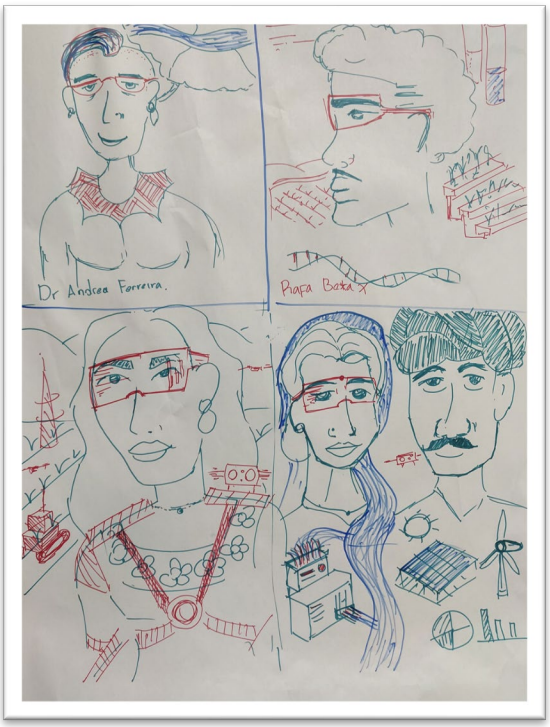


Figure 10. Illustrations of the personas from the scenario ´We are the water´. Credit: Juan Manuel Londono

The road to this future

In the early 2020s, climate change intensified water scarcity across continents, pushing nations into disputes over rivers, aquifers, and glaciers. By 2030, after a series of severe droughts, failed harvests, and rising water wars, the World Wide Water (WWW) Agreement was signed. This treaty declared water a global common good but left room for interpretation, creating tension between multinational corporations and sovereign states.

During the 2030s, countries in the Global South began to reorganize politically around river basins, realizing that water security depended on cooperation rather than national boundaries. They formed new federations—the Amazonian Union, La Plata Council, AsoMekong, Congo Committee, and others—that promoted decentralized governance and collective rights to water. These alliances embraced genetic crop innovation to breed low-water hybrids and reduce agricultural vulnerability, while also adopting AI, robotics, and exoskeletons to sustain an aging but longer-living farming population.

At the same time, corporations take advantage of water streams exploiting legal loopholes, claiming ownership of water rights purchased decades earlier. Backed by their satellite surveillance networks and dominance of space-based monitoring, they began asserting resource claims against the new unions. Parallel to this, digital judges—AI-assisted governance systems providing data-driven, real-time judgments and verdicts—were introduced to mediate disputes but soon became the target of terrorist attacks from extremist factions opposed to machine-led justice.

By the late 2030s, resource smuggling from non-unified northern regions accelerated, with the deployment of autonomous underwater robots to steal water and minerals. These escalating practices fractured global trust, polarizing the North and South into open confrontation.

By 2040, the world is at a tipping point: the Global South governs water as a shared human right, while corporations and Northern powers seek to enforce past contracts and control through technology. This clash of visions—commons versus ownership, cooperation versus domination—has turned water into the defining axis of global conflict.

Opportunities and risks of the scenario

Opportunities

1. Collective bargaining power
2. Decentralized governance innovation by introducing water councils
3. Water as a universal right (water as a living being)
4. New technological innovation
5. Emergency resource mechanisms
6. Water as a public good
7. New global governance framework
8. The emotional connection to water should be taken into account; “we feel better when we see water”

Risks

9. Corporate resistance & power struggles
10. Geopolitical polarization
11. Inequality (e.g., digital divide)
12. Extremism → Security threats & terrorism, for example cyber attacks on data centers that enable water governance
13. Dependence on fragile systems
14. Privatized resources
15. Migration challenges
16. Risk of having a “water market”

Recommendations

Recommendations for CGIAR policy, investments and research in the next 5 years, based on this scenario:

CGIAR centers should support and promote civil society initiatives that invest in human capital and empower local governance around natural resources

CGIAR should diversify beyond Official Development Assistance (ODA) funding

What we see in this scenario is that efficiency saved using AI in CGIAR is invested in human capital

Stronger collaboration is needed between CGIAR Centers and IWMI on water-related research, leveraging joint science programs and co-developed products.

Use the inter-governmental statement of CGIAR to leverage research and serve as a broker between governments about better water management.

“Working” with water (melted ice) from Antarctica to address water scarcity in other areas of the world, as has been suggested this year by countries with great military power, will affect the Global South since its ecosystems are linked to Antarctica primarily through the ocean's Antarctic Circumpolar Current (ACC). CGIAR must use its broker capacity to bring an end to these conversations.

The Global Commission on the Economics of Water (GCEW), of which IWMI is part of, recommends that rain-shed water should be considered in agreements.

Our waterbodies have a right – CGIAR should help establish this right.

We need digitalization to anticipate water management. We need infrastructure for this. CGIAR should come to an agreement with AI Tech companies to provide free access to their infrastructure, so CGIAR can do research about water cycles to address water security.

Research on water should be accompanied by research on energy: the two are now undeniably connected.

Diversification of renewable energy should be a CGIAR recommendation: The future of food systems and water management will rely on energy since many of the farming techniques will be digitalized.

Creating consciousness about the energy-water-ecosystem nexus is something IWMI does. This consciousness should be present in all of CGIAR

Open Source, Open Borders: How Farming Adapts in a Migrant World

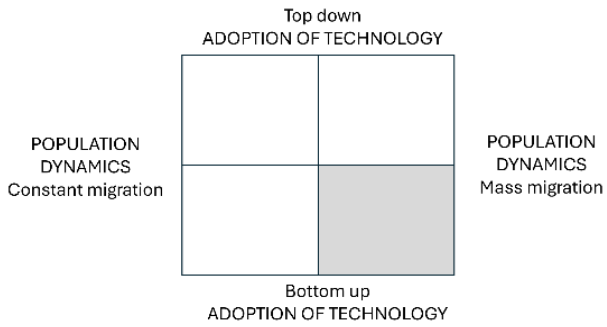


Figure 11: Scenario matrix of which ´Open Source, Open Borders´ is part of (Mass migration, Bottom-up adoption of technology). Source: Veeger, M.

Scenario description

In ´Open-Source Open Borders´ we imagine a future Global South with mass migration and the bottom-up adoption of technology (Figure 11). In the year 2040, the world grapples with unprecedented resource challenges exacerbated by climate change. Desertification has ravaged the Amazon, extreme weather events batter the Andean basins, and wet bulb temperatures render vast regions uninhabitable for months at a time. These forces have triggered massive migrations, displacing millions in search of viable livelihoods and straining global food systems (Figure 12). Social unrest simmers as refugee camps overflow, and rural communities face acute labor shortages. Yet, amid this turmoil, a beacon of hope emerges advanced, democratized technology empowers local startups to scale solutions globally, transforming migration from a crisis into a catalyst for innovation.

Figure 12. Scenario illustration of Open Source Open Borders. Credit: AI generated by workshop participants (Gemini)

At the forefront stands CGIAR, the global research partnership that pioneered innovations that secured the foundations of life on Earth for the coming decades. Their advances in sustainable food systems, equitable access to land and water, and climate-resilient technologies reshaped how humanity responds to resource scarcity and environmental change. These breakthroughs not only curbed the drivers of mass migration and conflict but also fostered new pathways for global cooperation. Recognized worldwide, their work anchored in next-generation seeds, climate-smart agriculture, and advanced digital tools—was honored with the World Food Prize for transforming the future of food and planetary security. Local startups, fueled by bottom-up tech evolution, rivaled corporate giants—leading to antitrust breakups of Big Tech and a plummeting of blue-chip stocks as farmers turned to grassroots alternatives. An open-source renaissance followed, with social platforms shifting from monetizing user data to paying for it, providing steady income for mobile youth.

Migration, once seen as brain drain, now drives brain circulation. Remittances and diaspora networks fund community-led ventures, while returning migrants infuse rural areas with global ideas. Predictive demand management via AI minimizes food waste, delivering resources directly to transient populations. Central to this

transformation is Linder, the "Tinder for agriculture"—a blockchain-certified app that matches farmers with workers, optimizing labor allocation across borders (Figure 13). Unified by Open ID standards, Linder iterations connect sharecroppers, enable flash collaborations, and ensure efficient resource distribution. Agri-tech coops share drones, robots, and sensors, while smart solar micro-grids (SSMGs) slash desalination costs to near-zero. Localized Ag-Coins with negative interest rates circulate wealth, bolstering community savings.

Figure 13. Scenario illustration of Open Source Open Borders. Credit: AI generated by workshop participants (Gemini)

95% of farmers leverage digital technologies for better food distribution. Agriculture is 50% more profitable than other sectors, thanks to tailored tools. A coalition of 30 countries has waived visas for blockchain-certified farmers, facilitating seamless movement. While risks like uneven access persist—particularly for communities without strong diaspora ties—this scenario turns migration into a resource, fostering resilient, inclusive food systems.

In terms of data quality, there is uncertainty about the effects of proliferation of local startups on data quality. However, the use of global data standards could have a positive effect.

When it comes to food habits and food production, diets will be increasingly homogenous around the world given mass migration and high information exchange. However, local diets might be more diverse given the higher exposure to food from different world regions. Thanks to LINDER, food will be produced more efficiently where it is needed.

In terms of geopolitical tension, water crisis, and conflicts, we will see an increasing frequency of conflicts due to the competing use of land, including land grabbing. This is reduced in regions where migrants and farms use LINDER.

Personas

CGIAR RESEARCHER: ¨By 2040, our work has secured life's foundations amid resource scarcity. We pioneered sustainable food systems, equitable land and water access, and climate-resilient tech—like next-generation seeds that thrive in extreme weather and digital tools for precision farming. Honored with the World Food Prize, we've curbed migration drivers and fostered cooperation. In open-source ecosystems, we collaborate with local universities on biotech and AI models via digital commons. Blockchain certifies data quality, letting community labs rival corporations. Startups proliferate positively, iterating site-specific solutions rapidly. We've democratized advancement: 95% of farmers now use our digital tech for better distribution, thanks to long-term community ties building trust. Agri-tech coops share drones, robots, and sensors; predictive AI minimizes waste for transient populations. This addresses geopolitical tensions and ecosystem health through efficient allocation. Challenges? Uneven access persists for remote areas, and scaling innovations risks overwhelming local capacities. But our bottom-up approach, anchored in decades of collaboration, turns migration into a catalyst. Returning migrants bring global ideas, infusing rural labs with fresh perspectives. We're not just researching—we're reshaping humanity's response to change".

FARMER: Rosa Martínez, a 42-year-old cassava and maize farmer in Caquetá, Colombia (Figure 14). "Back in the 2020s, when climate change hit hard—droughts ruining crops, floods washing away soil—I watched my two children migrate to Bogotá and Italy for work. I thought, "This is the end for our farm." Labor shortages left fields idle, and I could barely feed my family. But then, things changed. Remittances from my kids funded our local innovation hub, where young people tinker with open-source machinery and irrigation kits. Now, I use Linder—that app like Tinder for agriculture—to swipe and match with migrant workers across borders. Blockchain verifies their skills, and Open ID makes it seamless. No more waiting for help; workers arrive just in time for harvest. We've got shared drones from agri-tech coops scanning soil health, and smart solar micro-grids powering cheap desalination for water. My yields are up 30%, and agriculture here is more profitable than city jobs – 50% more than other sectors, they say. Predictive AI even tells me where to send excess produce to refugee camps, cutting waste. Sure, the poorest families without diaspora ties still struggle to access these tools, but for me, migration isn't loss – it's brain circulation. My son sends ideas from Italy, like new climate-resilient seeds from CGIAR. We're building resilient farms, one swipe at a time" .

Figure 14. . Illustration of the persona ´Rosa Martinez´. Scenario Open Source Open Borders. Credit: AI generated by workshop participants (Gemini)

RURAL COMMUNITY (Figure 15): "It's harvest season in Caquetá, Colombia, but things are different now. When the climate drove so many away, we feared our fields would be abandoned. My neighbors and I watched our children leave for Bogotá, for Spain, for anywhere with hope. But instead of decline, something unexpected happened.

Figure 15. Illustration of the persona ´Rural Community´. Scenario Open Source Open Borders. Credit: AI generated by workshop participants (Gemini)

Remittances started flowing in—not just money, but ideas. With support from our diaspora and the new Linder app, we set up a small innovation hub. Youth returning from the cities brought open-source farm apps and solar dryers for our cassava. We connect with workers from other regions through Linder, matching idle land with eager hands. Our cooperative shares drones and sensors, making precision farming affordable.

We're part of a network now—farmers, migrants, and researchers working together. The government's new visa-free policy for certified digital farmers means labor moves where it's needed. Our community issues Ag-Coins, keeping wealth circulating locally. We're more resilient, but not everyone benefits equally. Some neighbors without migrant relatives still struggle.

Still, we're proud. Migration didn't hollow out our village—, it brought us new life. We farm with new tools, share knowledge, and build a future together. The world changed, and so did we."

POLICY MAKER: Condor Traore, 64 years old, chief of a local water commission in West Africa. "I have applied the directives of the Minister of Natural Resources distributing water based on needs of local population. However, I have seen immigration increasing substantially over the last 14 years. I first urged local community leaders to resist giving away land and water to the newcomers. Many conflicts and tension have arisen due to land and water scarcity. I have been thinking to retire and migrate elsewhere in search of a quite place to spend my retirement.

After several months of interaction with local leaders and representatives of immigrants, both parties agreed to find out a mutually beneficial solution to share the benefits. Local population did not have workforce for agricultural activities, while immigrants did not have land and a job. However, there was little information on the characteristics of local population and their willingness to give away land and, on the other hand, on the immigrants' characteristics and their willingness to accept sharecropping agreements and at which conditions. Local small tech businesses were also grappling with the issue, and proposed a new approach based on information sharing. So, they worked

together in developing LINDER that made information known to each party in an equitable way, and the water add-on module was the solution to share the water flows based on respective needs and priorities. The water module also suggested a specific split of water harvesting burden among household members based on individual characteristics, something that was previously demanded out of young women only .

Opportunities and risks of the scenario

Opportunities:

17. Economic Transformation: Migration drives "brain circulation," with remittances funding innovation hubs and sustainable tech, making agriculture 50% more profitable than other sectors and attracting talent back to rural areas.
18. Technological Empowerment: Democratized tools like Linder, SSMGs, and Ag-Coins enable efficient resource allocation, reduce food waste via AI, and slash costs (e.g., near-zero desalination), empowering local startups to rival Big Tech and foster an open-source renaissance.
19. Global Cooperation and Stability: Coalitions of 30 countries waive visas for certified farmers, curbing conflict drivers, enhancing geopolitical stability, and promoting equitable food systems through CGIAR-led innovations.
20. Resilience and Inclusivity: 95% of farmers leverage digital tech for better distribution, turning migration into a resource that builds cultural resilience and mitigates social unrest through inclusive cooperatives.

Risks:

21. Uneven Access and Inequality: Communities without strong diaspora ties or infrastructure may lack access to tools like Linder or Ag-Coins, leaving the poorest behind and exacerbating divides.
22. Implementation Challenges: Rapid tech adoption risks overwhelming local capacities, with potential for land grabbing if oversight is weak, or uneven benefits sparking new social unrest.
23. Geopolitical and Environmental Tensions: While innovations curb migration drivers, persistent climate extremes (e.g., uninhabitable regions) could strain global cooperation of tech scales unevenly.
24. Trust and dependency on Tech: Overreliance on blockchain, AI, and digital platforms could create vulnerabilities, such as data privacy issues or system failures in unstable areas.

Recommendations

Recommendations for CGIAR policy, investments and research in the next 5 years, based on this scenario:

Conduct research on possible migration patterns: This scenario works with mass migration and digital tec as a solution to labor shortage. It would therefore be useful to study in what direction migration could go. Could there be futures in which certain countries stay without people and therefore without workforce?

Understanding demand is the biggest value addition the CGIAR could bring in this scenario: Understanding, for example, what kind of farms a certain region has (big or small farms), what they produce, what demands they have, what labor demands they have.

Anticipate data privacy issues and avoid the unethical use of data: CGIAR should take good care in anticipating data privacy issues for farmers. Individual but also collective farmer data (big data) could be used against them in certain geopolitical contexts; for example, to move migration in a certain direction, or to disadvantage population in certain regions. Considering the competitive advantages of CGIAR, where and how can CGIAR avoid the unethical use of data by third parties?

Research ethical issues with products supported by algorithms: In this scenario an algorithm links labor workers to farms that need workers. Migrants and farm holders will be competing for land and workers. What makes the decisions made by the algorithms such as Linder ethical? With AI on our doorstep, CGIAR needs to research the ethical consequences of tools, products and services it will offer.

Data as a business model: CGIAR should invest in business models, not in products. Given the current trend of declining public funding, perhaps it should reconsider giving data as a public good. An alternative business model could be that CGIAR gets paid for the data, or that certain private partners pay for data, whereas small scale farmers get access for free.

Cross cutting recommendations derived from the scenarios exercise

The worlds explored in this foresight exercise show us a wide spectrum of possible FLW systems in the Global South, each of them with different socio-economic, political, and environmental implications. Nevertheless, a few insights and recommendations retrieved from the process were insistent across most scenarios, and highlighted the need to:

- Invest in inclusive digital innovation, by addressing structural barriers faced by women, youth, and marginalized groups, such as access to land, finance, connectivity, and digital skills; so that they are not left behind in the digital transformation of FLW systems
- Engage with emerging technology and energy actors whose decisions increasingly shape digital infrastructure and sustainability outcomes, building partnerships that promote responsible innovation.
- Anticipate and study ethical risks associated with digital tools and algorithm-supported innovations, including issues of bias, transparency, and accountability.
- Strengthen cross-sectoral collaboration to address systemic challenges like water scarcity and climate change, and energy transitions
- Build adaptive research agendas that can respond to uncertainty and rapid technological evolution, embedding flexibility and scenario thinking into program design and investment planning.
- Position CGIAR as a global broker for responsible digital transformation, a neutral science intermediary that connects evidence with policy and innovation, facilitating collective intelligence, open knowledge, and decentralized partnerships aligned with global sustainability goals

Researchers work on the scenario ´We are the Water´. Photo credit: Veeger,M.

Next steps

The Future Scenarios Workshop laid the foundation for a shared vision of how digital transformation could shape the future of food, land, and water systems. The next phase will focus on translating these insights into action, helping CGIAR strengthen its foresight capabilities and inform strategic planning across programs and regions.

The lessons emerging from this process will:

- Guide the Digital Transformation Accelerator (DTA) and CGIAR's broader digital strategy over the coming years, ensuring coherence between foresight, innovation, and investment priorities.
- Support the definition of a long-term vision for AI and digital transformation within CGIAR, clarifying how these technologies can enhance research, innovation, and delivery of services to partners and stakeholders.
- Strengthen the integration between qualitative and quantitative foresight, linking exploratory scenario development with modeling to assess the potential costs, trade-offs, and implications of different futures across regions.
- Support a series of probes around the anticipation of futures enabled by digital technologies; including but not limited to Artificial Intelligence to experiment with the development of possible tools and products to better equip partners to manage food, land and water systems in ways that are equitable and sustainable.
- Continue to foster futures and foresight capacity across CGIAR and its partners, applying a human-centered lens that anchors digital technologies in the lived realities of farmers, policymakers, communities, extension agents, and researchers in Latin America and beyond.
- Foster an iterative foresight process that enables CGIAR and its partners to co-create and refine scenarios guiding decisions, partnerships, and stress-testing innovation planning in the years ahead.
- Expand multi-stakeholder participation in future foresight exercises, engaging farmers, community leaders, extension agents, policymakers, private sector innovators, and energy-sector actors to ensure that diverse perspectives ground scenario development in lived realities and real-world contexts.
- Develop communication and knowledge products that make foresight insights accessible and actionable across CGIAR and with partners.

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Annexes

Annex 1: Signals of change

What signals show us how digital technologies might impact food, land and water systems in the Global South in the future? These signals of change were collected, shared and clustered by participants on a Miro board in the weeks prior to the workshop.

AI is draining water from areas that need it most

META built a data center next door. The neighbors´ water taps went dry

Artificial Intelligence is Using a Ton of Water. Here's How to Be More Resourceful

Water consumption of African data centers in the age of AI

Unleashing the power of digital twins: Transforming water infrastructure in the GCC

How UAE is Leading Digital Twins in Urban Development

From bytes to bushels: How gen AI can shape the future of agriculture
Digital public infrastructure and network (India)
India's farmers are on the cusp of an Agritech revolution | World Economic Forum
VISTAAR: an open, interoperable, and federated public network dedicated to agricultural information and advisory services
Customized agricultural advice at scale: How digital extension helps Indian farmers grow more and lose less
Transforming smart farming for sustainability through agri-tech Innovations: Insights from the Australian agricultural landscape
How agtech is poised to transform India into a farming powerhouse?
Leveraging automation and digitalization for precision agriculture: Evidence from the case studies
Sustainable AI-based production agriculture: Exploring AI applications and implications in agricultural practices

Investing in AI & digital innovation for India's farming future

Digital Degrowth Symposium

ChatGPT May Be Eroding Critical Thinking Skills, According to a New MIT Study

Your Brain on ChatGPT: Accumulation of Cognitive Debt when Using an AI Assistant for Essay Writing Task△

Is the right going wrong? Analyzing digital platformization, data extractivism and surveillance practices in smallholder farming in Ghana

Digital agriculture will perpetuate injustice unless led from the grassroots

Working for a Trustworthy Digital Future

How emerging tech could mitigate emerging human crises

Collapse of critical Atlantic current is no longer low-likelihood

Language Models Represent Space and Time

My reflection of my current read: The coming wave (by Mustafa Suleyman).

The Generative Agronomist. One signal of change he points to is how AI systems have rapidly become cheaper and more accessible, spreading cutting-edge capabilities globally. In the future Agronomic and Extension advice from multimodal models will be so cheap, extension work has been disrupted. Automation for smallholder farmers is coming. Mustafa uses the example of AI powered tractors however: https://interestingengineering.com/ces-2025/unitree-shows-off-affordable-humanoid-dog-robots. Automation for small holder farmers will require different kind of robotics compared to the previous wave of precision agriculture. Imagine rent a robotic dog, from your local farmers cooperative for a few dollars to scan your potato or cassava field for diseases.

Global Yield Gap Atlas

AI and machine learning could accelerate and mainstream the culture meat revolution

3D printed food: the future of personalized nutrition

Bezos Earth Funds Opens Third Alt-Protein Hub in Singapore

Satellite embedding V1

New RS datasets that are only machine readable and interpretable will make detection of changes in land use and such, crop detection much easier in the future.

AI-powered pixels: Introducing Google's Satellite Embedding dataset

AlphaEarth Foundations helps map our planet in unprecedented detail

Nybl aims to transform palm tree agriculture with AI algorithms for early pest detection, soil condition optimization, and real-time data analytics for irrigation management.

Food System Innovations and Digital Technologies to Foster Productivity Growth and Rural Transformation

The Climate Tasting Menu Exhibit

Bacteria Cloud of Clouds (NUBE DE BACTERIAS DE LAS NUBES): Instalación y visualización de biodatos – [2025]

Corpus Corax: Speculative Human-Raven Translator

AI for Future Cities: Water

How AI can revolutionize water research and management in Africa

El impacto de la Inteligencia Artificial en la agricultura: Potencial y oportunidades (II)

Can Drones Solve India's Labor Crisis in Agriculture?

The Impact of Digital Technology on Agriculture: Opportunities and Challenges

Apollo Agriculture

Delivering regenerative agriculture through digitalization and AI

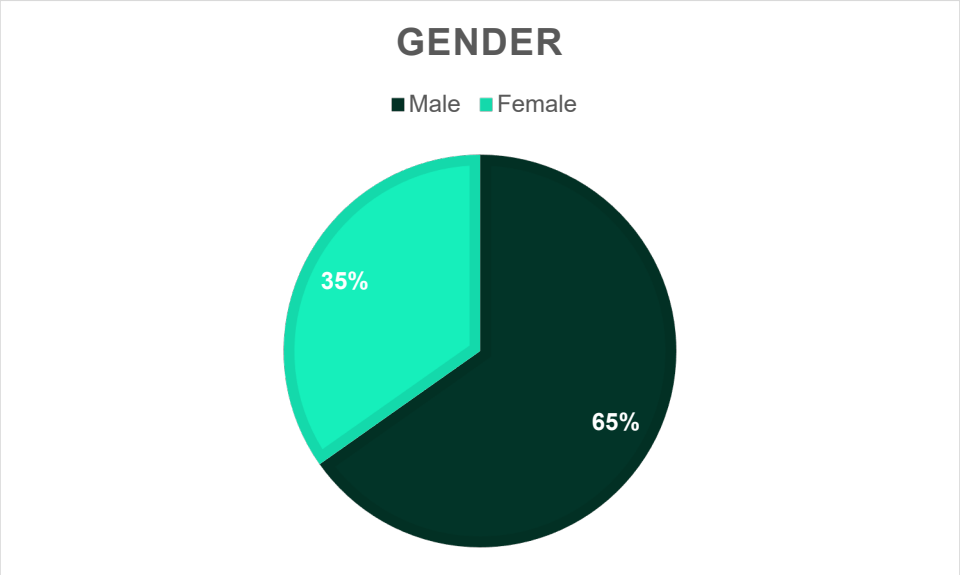
PRISE Pest Risk Information Service: Helping to improve the livelihoods of smallholder farmers by reducing crop losses

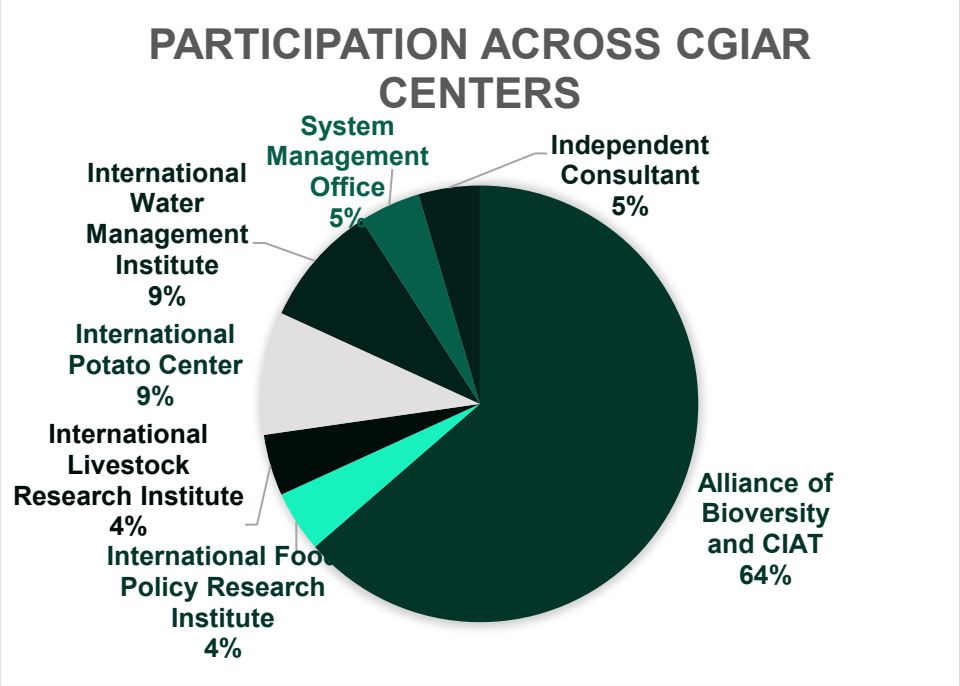
Examining the factors influencing the digital transformation of new agricultural operating entities: insights from Zhejiang, China

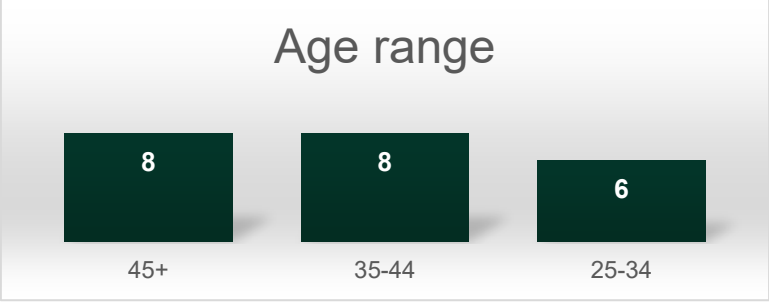
AI strawberries and blockchain chicken: how digital agriculture could rescue global food security
The EuroStack Project
Building Europe’s Digital Sovereignty Layer by Layer

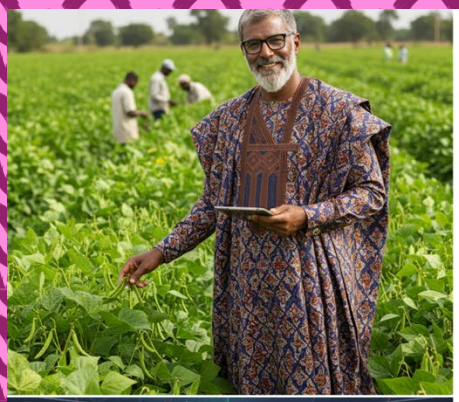
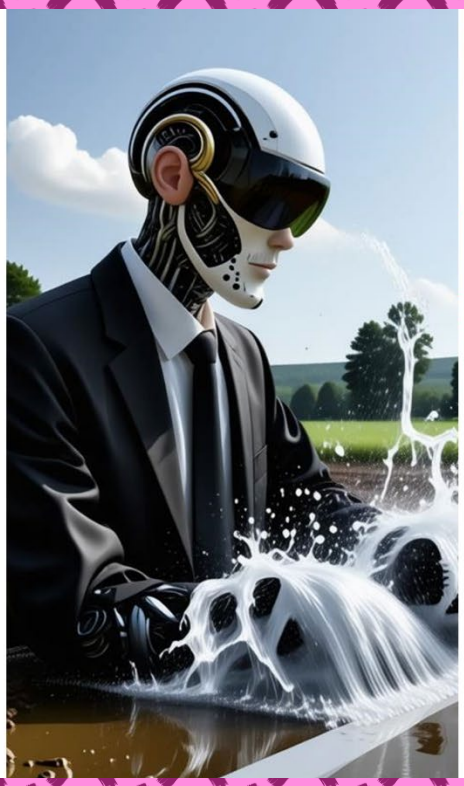
Annex 2: Participants

A total of 22 researchers participated in the face-to-face workshop in Palmira, Colombia from Sept 9th to 11th 2025, of which 35% were women and 65% were men, four CGIAR Centers were represented, and a balanced representation of all age groups.








CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to transforming food, land, and water systems in a climate crisis. Its research is carried out by 13 CGIAR Centres/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organisations, academia, development organisations and the private sector. www.cgiar.org

To learn more about this Science Program, please visit:
www.cgiar.org/cgiar-research-portfolio-2025-2030/digital-transformation

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