Harnessing Digital Technologies for Timely Decision-Making across Food, Land, and Water Systems

Initiative Lead and Co-Lead	Primary CGIAR Action Area	Estimated 2022 - 2024 Budget
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Challenge

Our food system is unsustainable. Threatened by climate change, biodiversity loss and persisting inequalities, urgent actions are required to transform food-land-water systems. The COVID-19 pandemic has demonstrated the importance of digital infrastructure and skills for resilient food systems [http://bit.ly/gfpr2021]. This Initiative addresses three information-related challenges in the food-land-water systems using digital technologies.
First, small-scale producers in the Global South are underserved by appropriate digital technologies. Less than 40% of small farms are covered by 3/4G mobile coverage [https://bit.ly/3gfHFxA], and only 13% of them in sub-Saharan Africa have ever accessed a digital service [https://bit.ly/3spUms7]. Enabling policies and investments are urgently needed, yet policymakers and investors do not always agree on priorities. Research is needed to assess the intersectoral values and develop business cases of investing in digital infrastructure, innovation ecosystems, and their catalytic impact for sustainable development. Second, food-land-water systems stakeholders lack timely and equitable access to data and information for identifying risks and manage them to promote resilient food systems and governance. More than 300 million small-scale producers do not have access to digital climate advisory services [https://bit.ly/3azwv3p]. Unmanaged risks hinder producers' adoption of technologies. Existing information may not be enough to manage emerging food systems risks from climate, pests, and markets [https://bit.ly/3sUYhh3]. Promising pilots exist, yet research is needed to benchmark solutions and develop strategies to localize and scale inclusively. Third, extension and digital advisory services need the technical capacity to utilize data and interpret research findings to synthesize actionable information. Existing knowledge is often outdated and difficult to apply in practice. The levels of digital literacy and skills across the Global South remain low [https://bit.ly/3t0j9Do], and technology access is gender-divided [https://bit.ly/2OUiJk9]. Research and capacity-strengthening support are needed to tailor advisory content and serve food-land-water systems stakeholders inclusively for their informed, effective risk management decisions.

Objective

This Initiative aims to support inclusive agricultural transformation and sustainable food-land-water management by improving information systems and strengthening digital innovation ecosystems. Target areas will be selected where capacity and demand for digital innovations coincide with food-land-water system challenges. Target stakeholders include producers, digital extension, agribusiness, environment and conservation organizations, investors, and policymakers.
In year 1, multi-stakeholder engagement and analyses on the digital technology landscape, information demand, prototype designing and evaluation, and gender inclusion will be undertaken in target areas. Initial use-cases will support local government agencies, crop and livestock insurance providers, and digital extension services to leverage cross-sectoral real-time data, ensuring gender inclusion and empowerment. In year 2, food-land-water system monitoring and modeling services will be co-developed in target areas and deployed to generate timely, actionable information for managing risks and natural resources. Architecture and policies for ensuring the inclusive collection and responsible management of data will be established. In year 3, information services will be jointly operated with local partners, with associated capacity strengthening programs on its use and maintenance.
New information will be used as a basis for policies, business decisions, and advisory content. Stakeholders' technical capacity and digital literacy will strengthen, connected with regional and global innovators. Scaling partners will synthesize actionable information from research findings, supported by CGIAR scientists and automation tools. Leveraging economies of scale, their content will potentially reach ten times more gender-balanced stakeholders and nudge them to adopt sustainable and climate-smart practices, verifiable using the Geospatial Impact Evaluation approach [https://bit.ly/2OZOPLq]. At least ten datasets, services, and knowledge products will be publicly released annually.

Theory of Change

This Initiative aims to contribute to accelerating the inclusive agricultural transformation and sustainable natural resource management by addressing systemic constraints in information flows across food-land-water systems. This Initiative will strengthen information systems and digital innovation ecosystems in target areas. Policymakers will be supported to enhance the efficiency of food-land-water systems by assessing trade-offs of investment and management options. Food systems stakeholders benefit from the localized food-land-water monitoring and modeling systems to detect risks early and adapt their businesses. Digital extension services will be strengthened to synthesize actionable advisory content and disseminate it equitably. Small-scale producers will receive tailored, timely information to inform day-to-day decision-making, manage climate and market risks, and contribute to the sustainability of society, environment, and biodiversity. Research-for-development communities will gain real-time insights on food-land-water systems dynamics, identifying opportunities for improvement. The latest technologies in artificial intelligence, remote sensing, and system dynamics modeling will be mobilized, aided by CGIAR's expertise in research, capacity building, inclusive user-centered design, and network of South-South public-private digital innovators. CGIAR will engage with more last-mile service delivery partners, who will benefit from high-quality research and the latest digital technologies while enabling CGIAR to amplify impact. CGIAR will safeguard stakeholder data privacy. Co-developed innovations will be institutionalized in in-country partner agencies for long-term sustainability and impact. Strengthened digital innovation ecosystems will contribute to spurring more innovations by local stakeholders, raising digital skills, exploring novel technologies for solving complex problems in food-land-water systems, and developing new business opportunities. These outcomes will collectively contribute to the digital transformation of food-land-water systems, where timely, actionable information is openly available to all stakeholders.
In-region activities will coordinate with the Regionally Integrated Initiatives of "Securing the Asian Mega-Deltas against Sea-level Rise, Flooding, Salinization and Water Insecurity," "Transforming Agri-Food Systems in South Asia (TAFSSA)," "Ukama Ustawi (U2) Water Secure and Climate Resilient Agricultural Livelihoods in East and Southern Africa," "From Fragility to Resilience in Central and West Asia and North Africa (F2R-CWANA) : Transforming responses to drought and climate variability," "Resilient and Sustainable LAC Agri-food Systems: Driving Global Food Security, Inclusive Growth, and Reduced Out-migration," and "Market-driven, Resilient and Nutritious Agri-food Systems in the Humid zones of West and Central Africa (WCA)" to identify their existing digital technology capabilities in the region, leverage public-private partnerships, and co-design effective solutions to region-specific food-land-water systems challenges. This Initiative will also coordinate digital technology-related components of the Thematic Initiatives of "ClimBeR: Building Systemic Resilience against Climate Variability and Extremes," "Excellence in Agronomy – Solutions for Agricultural Transformation (EiA)," "NEXUS Gains: Realizing Multiple Benefits Across Water-Energy-Food-Forest-Biodiversity Systems," "National Policies and Strategies for Food, Land and Water Systems Transformation," "Foresight and Metrics to Accelerate Inclusive and Sustainable Agri-Food System Transformation," "HER+: Harnessing equality for resilience in the agri-food system," "Market Intelligence for More Equitable and Impactful Genetic Innovation," "Rethinking Food Markets and Value Chains for Inclusion and Sustainability," "ASPIRE – Building Integrated Agri-Silvo-Pastoral Food Systems Resilient to Climate Change and Other Crises," and "SeEdQUAL Delivering Genetic Gains in Farmers' Fields." Specifically, the modeling analyses' underlying data, scenarios, and assumptions will be compatible with the "Foresight and metrics to accelerate inclusive and sustainable agri-food system transformation" Initiative when the extents of spatial and temporal scales overlap.

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Highlights

The Global South is poised to harness digital technologies to help achieve sustainable and inclusive development. This Initiative will facilitate a South-South digital innovation network by convening local innovators, CGIAR, regional food and agriculture Innovation Hubs, and global communities of practice with public-private partners to exchange knowledge and build capacity for information systems, governance, architecture, and interoperability.

Managing risks in food-land-water systems can be cost-effective using digital technologies, but this potential is unrealized in much of the Global South. This Initiative will strengthen the capability and utility of local information systems for stakeholders in target areas to early-detect food system risks and better manage them to promote the adoption of climate-smart practices and aim for a circular economy.

Concerns about the digital divide exist in food systems, between urban and rural, large and small enterprises, and male and female actors. The new Digital Inclusion and Empowerment Index in Food Systems will provide guiding principles, evaluative criteria, and case studies for digital farming service providers in both public and private sectors to adopt and promote inclusive and equitable food system outcomes.

Ground-truth data ensures the quality and relevance of machine learning-aided insights. Existing datasets fail to capture emerging risks of food-land-water systems under changing climate and landscapes. This Initiative will identify critical data gaps in target areas and equip collaborative networks to collect, share, and analyze data, maximizing efficiencies through improved interoperability and sampling frames.

Food producers need support to use the information to make informed decisions. This Initiative will strengthen digital farming services by connecting them with CGIAR scientists (or retirees [https://bit.ly/3t1gUjc]) and other experts to share knowledge and interpret research findings, user-centered designers to synthesize content, and communication channels (both digital and trusted agents) to ensure equitable dissemination and voice feedback.

Work Packages

	Scope of Work	3-year Outcomes
Digital Innovation and Policy	Conducting participatory, user-centered analyses on the technology landscape, benchmarking of existing solutions, and priority-setting of policies and investment options to support policymakers and stakeholders to develop digital strategies to empower innovation ecosystems and accelerate inclusive transformation. Strategies will reflect multi-stakeholder development priorities and the local political economy. The Initiative will accompany strategy implementation and support evaluating impacts.	Policymakers governing target areas make inclusive policy and investments to support digital ecosystems, based on the Initiative-supported assessment showing the food systems-wide benefits of digital infrastructure and information systems. Small-scale producers will benefit from localized digital advisory services that meet their specific needs. Agribusinesses will benefit from new capabilities and market opportunities from digital innovations.
Digital Inclusion and Empowerment	Developing a suite of tools, guidelines, and indices to track digital inclusion and intersectional inequalities and present options for changes in the empowerment of women and other target groups to ensure that gender and intersectional inclusion underlie program development and implementation. The Index will be promoted to food systems stakeholders and other Initiatives to assess their digital inclusion outcomes and use them as adaptive management tools.	Digital innovators targeting food systems (e.g., digital extension, financing, and e-commerce providers) will design inclusive products, utilizing the Initiative-developed Digital Inclusion and Empowerment Index, and reach more users with customized services. Policymakers will assess the status of digital inclusion in the target area and strategize to address digital divides. Small-scale producers will benefit from tailored digital advisory services that meet their needs.
Food-Land-Water System Dynamics Modeling	Conducting simulation analysis of short-term food-land-water system dynamics in each target area, predicting changes in food production, land-use allocation, and water productivity, based on seasonal climate forecasts. Additional what-if scenarios of management and policy options will be simulated to assess their trade-offs that affect the market, livelihoods, sustainability, biodiversity, risk, and inclusion outcomes.	Partner agencies will institutionalize the co-developed modeling system and strengthen their analytical capacity to support food systems decision-makers to assess impacts and trade-offs from what-if scenarios concerning changes in climate, policy, and market conditions and use the information to manage risks, develop strategies, and formulate policy for inclusive investments and innovations.
Real-time Monitoring of Food-Land-Water System Risks	Developing food-land-water systems monitoring and intelligence services in each target area to provide timely and reliable information to stakeholders, based on satellite remote sensing and ground-truth data from multiple sources. Types of data, information products, and delivery methods will be defined in consultation with demand partners. Tools and services to support ground-truth data collection, responsible management, and sharing will be developed.	Partner agencies will utilize the co-developed food-land-water monitoring system to early-detect emerging food-land-water system risks and generate timely, localized information products and release through digital channels. Government agencies will improve efficiency through the digitalized workflow. Policymakers will assess their decision impacts faster, enabling them to implement targeted policies that promote sustainable and inclusive outcomes.
Empowering Extension and Digital Advisory Services	Providing technical support for extension, digital farming, and value-chain service providers to interpret research findings and synthesize actionable advisory content. Scaling partners' capacities for data analysis, visualization, and storytelling will be strengthened. Information delivery will be improved to reach food system stakeholders in a targeted and equitable way through extension, CGIAR experts, social networks, and digital channels.	Extension and digital advisory services will provide more timely, locally relevant, and inclusively designed content to food-land-water systems stakeholders. Early warning of potential disruptions (e.g., drought and flood forecasts) and advisory content will help producers prepare and manage the risks, invest in adopting climate-smart practices, leading to more productive and profitable farming and sustainably managed natural resources.

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Impact Area Contributions

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Nutrition, health & food security	Timely, high-frequency monitoring of food-land-water systems and socioeconomic indicators, combined with multi-purpose ground-truth data and actionable advisory information, will enable food systems stakeholders to early-detect risks, make targeted interventions, and monitor the effects in real-time to ensure the continued supply of nutritious food and safe water for WASH and One Health.
Poverty reduction, livelihoods & jobs	Strengthened digital ecosystems with timely, reliable food-land-water systems information will allow food systems stakeholders to manage risks, optimize business decisions, create market opportunities, increase income and profitability, and improve livelihoods. Digital extension services will strengthen to provide targeted, inclusive advisory information and scale to reach ten times more subscribers, creating more youth employment opportunities.
Gender equality, youth & social inclusion	The Digital Inclusion and Empowerment Index will support digital innovators to design accessible tools and inclusive services that promote gender equality and social inclusion across food-land-water systems. Availability of open access ground-truth data will support local technology education programs to develop their own machine learning applications. Digital tools empower marginalized groups to voice concerns and influence governance.
Climate adaptation & greenhouse gas reduction	Food-land-water system stakeholders will access short-term (sub-seasonal-to-seasonal) climate forecasts to better manage the risks, adopt climate-smart technologies and management practices, and improve their climate adaptive capacity. Policymakers will use intersectoral data and food-land-water systems status indicators to negotiate global climate agreements on the adaptation and mitigation planning.
Environmental health & biodiversity	Timely information on the state of food-land-water systems and embedded biodiversity will help stakeholders assess their environmental impacts, such as infrastructure development (natural and built) impacts on surface water availability and deforestation, accounting for environmental costs. Publicizing this information will incentivize food system actors to adopt practices promoting environmental health and biodiversity.

Impact on SDGs

Regions

Central and West Asia and North Africa (CWANA), East and Southern Africa (ESA),
Latin America and the Caribbean (LAC), South Asia (SA), South East Asia and the Pacific (SEA),
West and Central Africa (WCA)

Countries
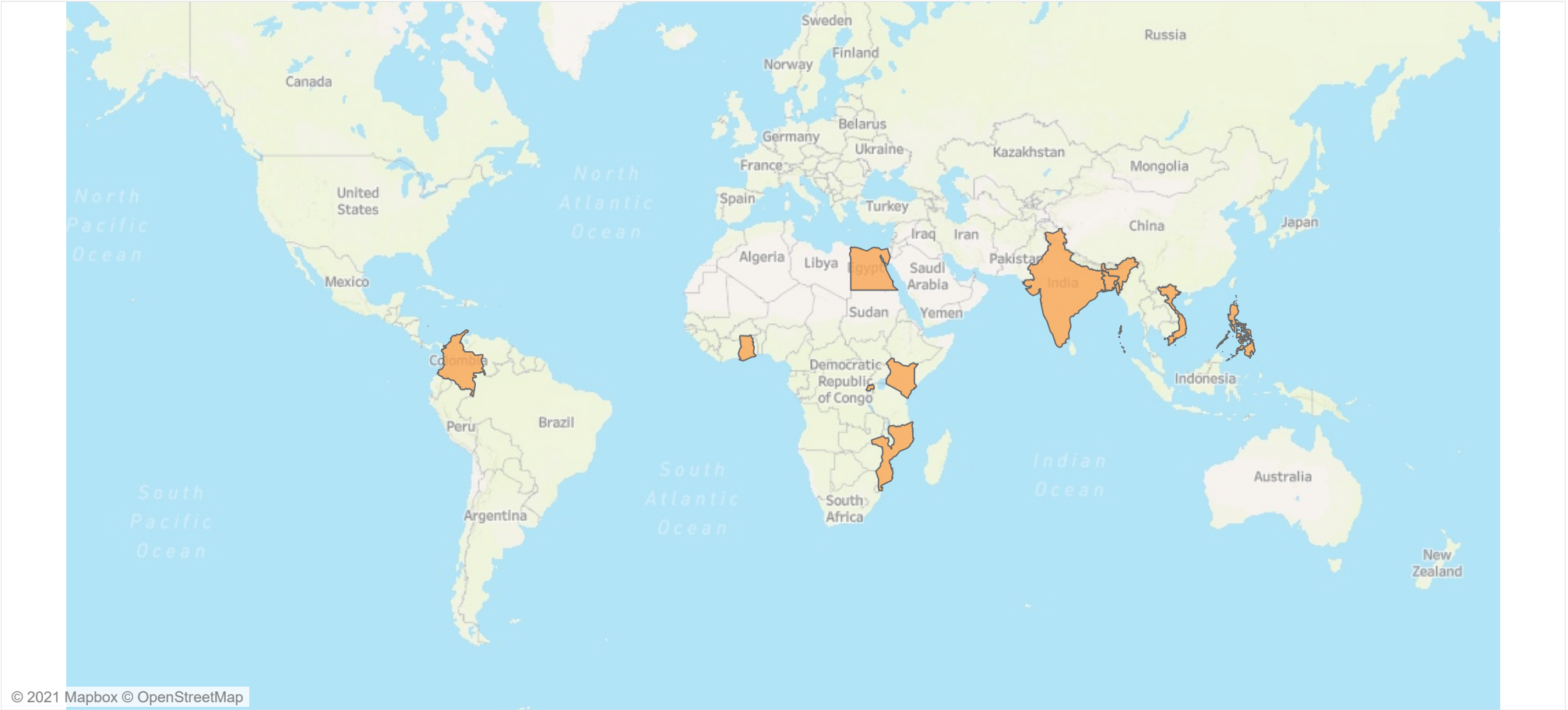
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Innovations

Digital Inclusion and Empowerment Index in Food Systems for policymakers, public and private digital service providers, and natural resource managers in target areas to assess the digital inclusivity of their policy and services across food-land-water systems and help develop empowerment strategies grounded in equitable access to technology and use, social inclusion, and user-centered design for digital services.

Monitoring and Modeling of Food-Land-Water Systems that estimate the production of livestock and crops, including fruit and vegetables, in target areas, complemented with information on market, processing, and consumption collected from crowdsourcing, digital transactions, and environmental sensing, verified using ground-truth data. System dynamics modeling allows users to simulate what-if scenarios of policy and management options.

Multi-purpose Ground-truth Data Collection and Sharing System that enables timely analytics and validations, including best-practice guidelines for data collection, sampling frames, interoperable metadata standards, and example codebase for building local technical capacity on machine learning while protecting privacy using a self-sovereign identity solution implemented on a secure, centralized repository.

Digital Advisory Content System for public and private digital extension services to (semi)automatically produce advisory content, supported by CGIAR's expertise to interpret real-time data and research findings, applied to respond to emerging food systems risks. Digital tools enable translations to local languages and real-time communications with users. Capacities raised for inclusive product design, data storytelling, and targeted delivery.

Digital Agrifood Solutions Benchmark that annually evaluates the scalability, productivity, profitability, environmental sustainability, and gender inclusion of food-land-water system digital advisory services, prominent in target areas. The benchmarking framework will accommodate different types of services and business models. Seals of Excellence will be awarded to the highest-performing solutions within each category.

Key Partners

Demand	Academic, Training and Research	National Agricultural Research and Extension System (NARES), The Regional Network of Agricultural Policy Research Institutes (ReNAPRI)
	Foundation	The Bill and Melinda Gates Foundation, Radiant Earth Foundation
	Government	United States Agency for International Development (USAID), The United Kingdom Foreign, Commonwealth and Development Office (FCDO), Swiss Agency for Development and Cooperation (SDC)
	Local Government	Ministries of Agriculture, Finance, Information and Communication Technology, and Planning
	Multilateral	The World Bank, Food and Agriculture Organization (FAO)
Innovation	Academic, Training and Research	Wageningen University and Research, University of Twente/ITC, University of Florida, University of Maryland, Stanford University, The College of William and Mary, Cornell University, University of California - Davis, International Institute for Applied Systems Analysis (IIASA), National Agricultural Research and Extension System (NARES), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Centre of Insect Physiology and Ecology (ICIPE), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Griffith University - Australian Rivers Institute
	Multilateral	UN Women, Food and Agriculture Organization (FAO), International Telecommunications Union (ITU), World Food Programme (WFP), International Fund for Agricultural Development (IFAD), The World Bank
	Other	GSM Association (GSMA), World Economic Forum, Ag Gateway, Digital Impact Alliance (DIAL), Global Forum for Rural Advisory Services (GFRAS), Digital Agriculture Knowledge Hub, Climate and food security early warning services
	Private Sector	Google X - The Moonshot Company, Open Farm and Field Data Exchange (ODX), The Syngenta Group, Facebook, 60 Decibel, aWhere, Hewlett Packard Enterprise, Planet, Esri
	Private Sector in Aid Recipient Country	Digital farming and advisory service providers, Digital finance service providers, Crop and livestock insurance providers
Scaling	Academic, Training and Research	National Agricultural Research and Extension System (NARES)
	International NGO	One Acre Fund, Digital Green, Mercy Corps/AgriFin, Farm Radio International, Grow Asia, Alliance for a Green Revolution in Africa (AGRA)
	Local Government	Ministries of Agriculture, Finance, Information and Communication Technology, and Planning
	Other	National and international food security and climate early warning service providers
	Private Sector in Aid Recipient Country	Digital farming and advisory service providers, Digital finance service providers, Crop and livestock insurance providers

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Implementation with Regional Initiatives:
- *Asian Mega-Deltas*
- *South Asia (TAFSSA)*
- *East and Southern Africa*
- *LAC Agri-food systems*
- *From Fragility to Resilience in CWANA*
- *West and Central Africa (WCA)*

Challenge

- **Small-scale producers** are underserved by appropriate, inclusive digital technologies. Enabling policies, investments, research, and advocacy are needed.
- **Food-land-water system stakeholders** lack timely & equitable access to data and actionable information for decision-making.
- **Extension and digital advisory services** lack sufficient capacity/skills for data analysis, interpretation, and timely delivery.
- **Lack of contextualized, user-centered, inclusive** data collection and analysis further exacerbates the digital, gender, and data divides.

Demand partners

- **PRIVATE** Digital Farming, Digital Finance
- **MULTILATERAL** WB, FAO
- **LOCAL GOV'T** Min. Ag, Finance, ICT
- **GOVERNMENT** USAID, FCDO, SDC
- **RESEARCH** NARES, ReNAPRI

Work Packages

1. **Digital Innovation & Policy** Digital strategy development for innovation ecosystems & inclusive transformation
2. **Digital Inclusion & Empowerment** Suite of tools, guidelines, & indices for digital and intersectional inclusion
3. **Food-Land-Water System Dynamics Modeling** Demand-led simulation, what-if scenario analyses
4. **Real-time Monitoring of Food-Land-Water System** Monitoring & intelligence services to provide timely, reliable, information
5. **Empowering Extension & Digital Advisory Services** Capacity building for data interpretation, visualization, & synthesis

Innovation partners

- **PRIVATE** Google X, ODX, Syngenta, Facebook, 60 dB, aWhere, HPE
- **MULTILATERAL** WB, FAO, UN Women, ITU, WFP, IFAD
- **RESEARCH** WUR, ITC, WM, IIASA, CSIRO, NARES, ICRISAT
- **OTHER** GSMA, WEF, DIAL, GFRAS, AgGateway, Radiant Earth

Outputs

1. **Digital Agrifood Solutions Benchmark** with evaluation of digital advisory services, incl. diversity of services and business models
2. **Digital Inclusion & Empowerment in Food Systems Index** to assess digital inclusivity in policy and services
3. **Monitoring & Modeling of Food-Land-Water Systems** that estimates production, integrated with variety of data sources for simulations.
4. **Ground-truth Data Collection and Sharing System** that enables timely analytics and validations
5. **Digital Advisory Content System** to rapidly synthesize advisory content to leverage existing CGIAR expertise

Scaling partners

- **PRIVATE** Digital Farming, Digital Finance
- **NGO** One Acre Fund, Digital Green, Mercy Corps/AgriFin, Farm Radio Int'l, Grow Asia, AGRA, Local NGOs
- **OTHER** Climate, food security early warning services

Outcomes

1. **Inclusive policy & investments** for enabling digital innovation ecosystems
2. **Inclusive products and datasets** for accessible, equitable digital products and increased business opportunities
3. **Strengthened analytical capacity** of partners to assess impacts and trade-offs of investment options
4. **Timely, localized, publicly-available information** for targeted decision-making, early detection of risks, adoption of climate-smart practices
5. **Actionable advisory content** for productive, profitable farming & sustainably managed natural resources.

Demand partners

- **PRIVATE** Digital Farming, Digital Finance
- **MULTILATERAL** WB, FAO
- **LOCAL GOV'T** Min. Ag, Finance, ICT
- **GOVERNMENT** USAID, FCDO, SDC
- **RESEARCH** NARES, ReNAPRI

Impact areas

NUTRITION, HEALTH, FOOD SECURITY enhanced by timely, actionable information, risk mgt., ensured supply of nutritious food and safe water

POVERTY REDUCTION, LIVELIHOODS, JOBS improved by strengthened digital innovation ecosystems, new market opportunity, digital advisory services reaching 10X subscribers

GENDER EQUALITY, YOUTH, SOCIAL INCLUSION improved by accessible tools & inclusive services, STEM education, communication channels

CLIMATE ADAPTATION, MITIGATION increased by sub-seasonal climate forecasts, risk management, adopting climate-smart technologies, resilient food-land-water systems

ENVIRONMENTAL HEALTH, BIODIVERSITY improved by monitoring food-land-water systems, allowing to assess environmental impacts and costs of development

2022   **2024**   **2030**

sphere of control

sphere of influence

sphere of interest

In Collaboration with the following CGIAR Thematic Initiatives:
- *ClimBeR*
- *Excellence in Agronomy*
- *NEXUS Gains*
- *National Policies & Strategies*
- *Foresight & metrics*
- *HER+*
- *Market intelligence*
- *Rethinking Food Markets*
- *ASPIRE*
- *SeEdQUAL*

Concentric Circle Diagram

Outermost Ring (Orange): DATA SOURCES/TYPES OF DATA
- Weather and climate
- Call detail records
- Socio-economic data
- Artificial intelligence
- Crop management
- Digital transaction data
- System dynamics modeling
- Data standards & interoperability
- Internet of Things
- Gender/intersectional data
- Machine learning
- Decision science
- Water resource data
- Satellite and UAV remote sensing
- Ground-truth data, area sampling frames
- Market, food flow

Second Ring: DATA ANALYSIS AND INTERPRETATION
- Data storytelling, visualizations, dashboards
- Data privacy and security
- Digital literacy and capacity
- Inclusive national policies and regulations
- Gender inclusion
- Mobile broadband infrastructure & connectivity
- Locally relevant content
- South-South, public-private partnerships
- User-centered design
- Timely data management systems

Inner Rings
ENABLERS (Blue)
ENABLING ENVIRONMENT (Purple)

ACTORS (Center)
- Producers, resource managers, traders, processors, consumers
- Policy-makers & investors
- Research and development, CGIAR

COLLABORATING WITH OTHER INITIATIVES AND ACTION AREAS
- Genetic Innovation Initiatives
- Systems Transformation Initiatives
- Regional Initiatives
- Resilient Agrifood Systems Initiatives

IMPACT PATHWAYS
- Capacity development
- Innovations
- Policy