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INITIATIVE ON
Plant Health

CGIAR Research Initiative on **Plant Health**

Annual Technical Report 2023

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Acronyms

AA	Action Area
ABC	Alliance Bioversity and CIAT
AfRGM	African Rice Gall Midge
AI	Artificial intelligence
APAARI	Asia-Pacific Association of Agricultural Research Institutions
ARDIT	Aflasafe Research, Development, Incubation, and Training
AVR	Avirulence
BBTD	Banana bunchy top disease
BLB	Bacterial Leaf Blight
BMGF	Bill and Melinda Gates Foundation
CABI	Centre for Agriculture and Bioscience International
CARDI	Cambodian Agricultural Research and Development Institute
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIP	International Potato Center
CWANA	Central and West Asia and North Africa
DEWAS	Disease Early Warning Advisory System
DL	Deep learning
DR Congo	Democratic Republic of the Congo
EMBRAPA	Brazilian Agricultural Research Corporation
EOI	End of Initiative
EOIO	End of Initiative Outcome
ESA	Eastern and Southern Africa
EASA	European Space Agency
FAO	Food and Agriculture Organization
FAW	Fall armyworm
FHB	Fusarium head blight
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HH-DST	Handheld-Decision Support Tool
IA	Impact Area
IAR	Institute of Agricultural Research (Nigeria)
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
icipe	International Centre of Insect Physiology and Ecology
IDM	Integrated Disease Management
IER	Institut d'Economie Rurale (Mali)
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
IL-CETC	Innovation Lab on Current and Emerging Threats to Crops
ILCYM	Insect life cycle modeling
ILRI	International Livestock Research Institute
IMM	Integrated Mycotoxin Management
INERA	Institut de l'Environnement et de Recherches Agricoles (Burkina Faso)
INRA	Institut National de la Recherche Agronomique (France)
INRAN	Institut National de la Recherche Agronomique du Niger
IPDM	Integrated Pest and Disease Management
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
KALRO	Kenya Agricultural and Livestock Research Organization
KEPHIS	Kenya Plant Health Inspectorate Service
LAC	Latin-America and the Caribbean
LMICs	Low- and middle-income countries
M&D	Manufacturing and distribution
MLN	Maize Lethal Necrosis
NARES	National Agricultural Research and Extension System
NBPGR	National Bureau of Plant Genetic Resources (India)
NGO	Non-governmental organization
NPPO	National Plant Protection Organization
OC	Outcome
ODK	Open Data Kit
OP	Output
P&Ds	Pests and diseases
PACA	Partnership for Aflatoxin Control in Africa
PCR	Polymerase Chain Reaction
PFSR	Post-flowering stalk rot
PH	Plant health
PHI	Plant Health Initiative
PORB	Plan of Results and Budget
PPP	Public-Private Partnership
PPRI	Plant Protection Research Institute (Vietnam)
PPT	Push-pull technology
R4D	Research for Development
RAFS	Resilient Agrifood Systems
RCT	Randomized controlled trial
RYMV	Rice Yellow Mottle Virus
SDGs	Sustainable Development Goals
TBRI	Taiwan Biodiversity Research Institute
TIDIS	Timely Disease Identification Point-of-Care System
TOC	Theory of Change
TR4	Tropical Race 4 (Fusarium Wilt of Banana)
UAV	Unmanned Aerial Vehicle
UPF	University of Passo Fundo
USAID	United States Agency for International Development
USDA-FAS	United States Department of Agriculture – Foreign Agricultural Service
WCA	West and Central Africa
WFP	World Food Programme
WP	Work Package
YMV	Yam Mosaic Virus
YRRMN	Yellow Rust Resistance Monitoring Network

Table of contents

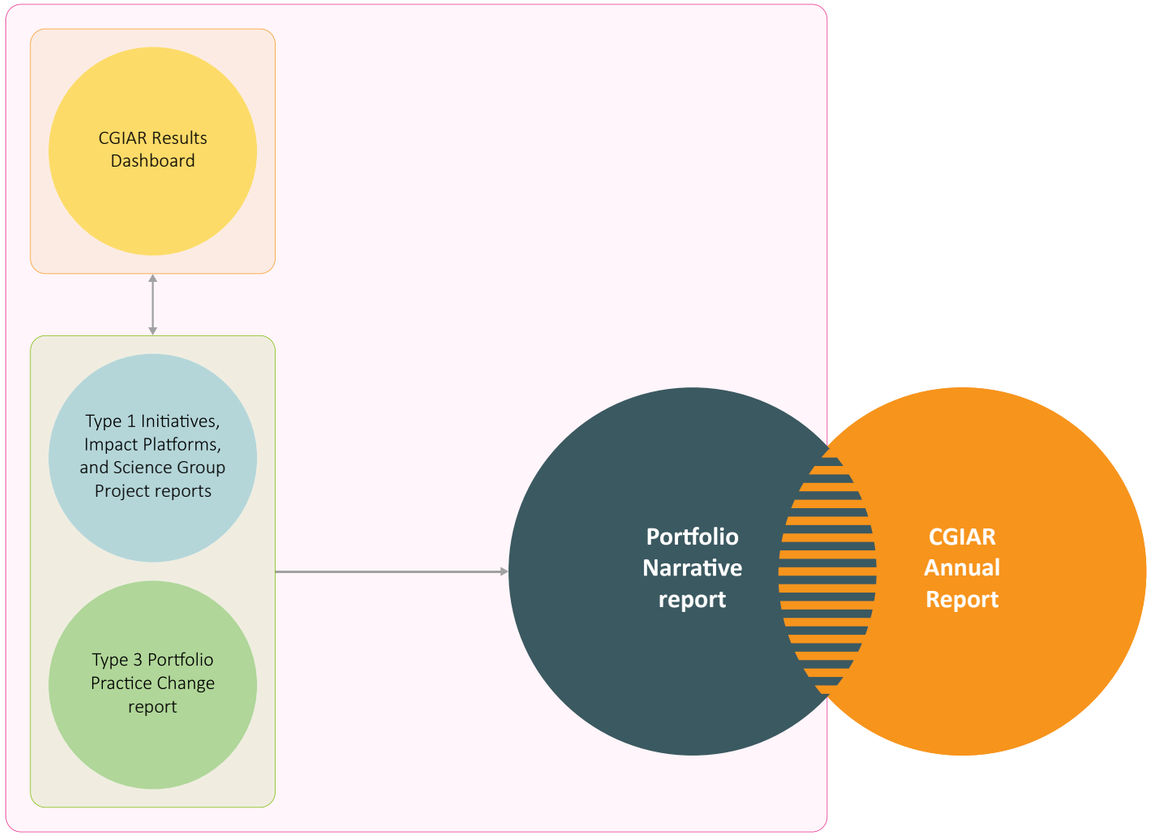
CGIAR Technical Reporting 2023

CGIAR Technical Reporting has been developed in alignment with the CGIAR Technical Reporting Arrangement. This Initiative report ("Type 1" report) constitutes part of the broader CGIAR Technical Report. Each CGIAR Research Initiative submits an annual "Type 1" report, which provides assurance on Initiative-level progress towards End of Initiative outcomes.

The CGIAR Technical Report comprises:

- Type 1 Initiative, Impact Platform, and Science Group Project (SGP) reports, with quality assured results reported by Initiatives, Platforms and SGPs available on the CGIAR Results Dashboard.
- The Type 3 Portfolio Performance and Project Coordination Practice Change report, which focuses on internal practice change.
- The Portfolio Narrative, which draws on the Type 1 and Type 3 reports, and the CGIAR Results Dashboard, to provide a broader view on Portfolio coherence, including results, partnerships, country and regional engagement, and synergies among the Portfolio's constituent parts.

The CGIAR Annual Report is a comprehensive overview of CGIAR's collective achievements, impact and strategic outlook, which draws significantly from the Technical Report products above. For 2023, the Annual Report and Technical Report will be presented online as an integrated product.



Section 1: **Fact sheet and budget**

Initiative name	Plant Health and Rapid Response to Protect Food Security and Livelihoods
Initiative short name	Plant Health
Initiative Lead	Prasanna Boddupalli (b.m.prasanna@cgiar.org)
Initiative Co-lead	Monica Carvajal Yepes (m.carvajal@cgiar.org)
Science Group	Resilient Agrifood Systems
Start – end date	01/01/2022 – 31/12/2024
Geographic scope	**Regions targeted in the proposal** Central and West Asia and North Africa · East and Southern Africa · Latin America and the Caribbean · South Asia · Southeast Asia and the Pacific · West and Central Africa **Countries targeted in the proposal** Bangladesh · Benin · Bolivia (Plurinational State of) · Burkina Faso · Burundi · Colombia · Côte d'Ivoire · Ecuador · Egypt · Ethiopia · Ghana · India · Kenya · Lebanon · Malawi · Mali · Mexico · Morocco · Mozambique · Niger · Nigeria · Peru · Philippines · Rwanda · Senegal · Tanzania, United Republic of · Democratic Republic of the Congo · Sudan · Viet Nam · Tunisia · Uganda · Zambia
OECD DAC Climate marker adaptation score[1]	**Score 1: Significant** The activity contributes in a significant way to any of the three CGIAR climate-related strategy objectives — namely, climate mitigation, climate adaptation and climate policy — even though it is not the principal focus of the activity.
OECD DAC Climate marker mitigation score[1]	**Score 0: Not targeted** The activity does not target the climate mitigation, adaptation and climate policy objectives of CGIAR as put forward in its strategy.
OECD DAC Gender equity marker score[2]	**Score 1B: Gender responsive** On top of the minimum requirements for 1A, the Initiative/project includes at least one explicit gender equality outcome and the Initiative/project team has resident gender expertise or capacity. The Initiative/project includes indicators and monitors participation and differential benefits of diverse men and women.
Website link	https://www.cgiar.org/initiative/13-plant-health-and-rapid-response-to-protect-food-and-livelihood-security/

[1] The Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) markers refer to the OECD DAC Rio Markers for Climate and the gender equality policy marker. For climate adaptation and mitigation, scores are: 0 = Not targeted; 1 = Significant; and 2 = Principal.

[2] The CGIAR Gender Impact Platform has adapted the OECD gender marker, splitting the 1 score into 1A and 1B. For gender equality, scores are: 0 = Not targeted; 1A = Gender accommodative/aware; 1B = Gender responsive; and 2 = Principal.

These scores are derived from Initiative proposals, and refer to the score given to the Initiative overall based on their proposal.

EXECUTIVE SUMMARY

The CGIAR Research Initiative on Plant Health (PHI) is organized around **five Work Packages (WP1–WP5)**, which collectively contribute to the Initiative's aim and objectives. **PHI-WP1** team developed a context-based capacity development plan for strengthening diagnostics and surveillance efforts of crop pests and diseases (P&D). Capacity building activities in 2023 fostered a sense of community within each region and facilitated exchange of knowledge locally and globally as part of the Global Plant Diagnostic & Surveillance Network. Sustained efforts and investment are essential for maintaining this network. Over 20 molecular and image-based artificial intelligence (AI) tools for detection, characterization, monitoring, and surveillance of P&D were developed/improved/validated in collaboration with 9 innovation partners; these tools/methods are being used by at least 20 national partners in 8 targeted countries.

PHI-WP2 focuses on equitable access and optimization of P&D data systems, improving risk assessment and communication on emerging threats globally. Key achievements include predicting pest emergence, monitoring virulence variations, and enhancing data management platforms. Notable developments include refined models like EPIRICE aiming at understanding climate impacts on P&Ds, integration of genomic surveillance modules, and deployment of remote sensing and image-recognition AI for real-time surveillance of wheat and banana diseases. These efforts enable precise surveillance, anticipation of threats, and effective management strategies. Additionally, surveillance and modeling results support advocation efforts for engaging policy makers for proactive management of P&Ds.

PHI-WP3 team continued to make significant progress in developing/validating eco-friendly integrated pest and disease management (IPDM) technologies and innovations against targeted P&D in cereals, food legumes, roots, tubers, banana, and vegetables, including biological control, biopesticides, ecological engineering, etc.

Relevant technologies/innovations were integrated, and evaluated/validated, through participatory engagement of farming communities and extension personnel, through the Plant Health Innovation Platforms. Capacity strengthening of national partners, extension workers, and farmers on IPDM was undertaken in over 20 target countries. In 2023, ecofriendly plant health innovations or IPDM packages were adopted by an estimated 461,698 smallholders in 20 low- and middle-income countries (LMICs) (Africa-11; Asia-5; LAC-2; CWANA-2).

PHI-WP4 continued making significant progress in integrated mycotoxin management (IMM), including aflatoxins, fumonisins, and deoxynivalenol. The efforts are grounded in field-based effectiveness, ensuring practical solutions for use in LMICs. Smart hermetic storage devices that reduce mycotoxins and postharvest losses in cereals were tested. Biocontrol testing, targeting Aflasafe registration for future expansion in Mexico, Niger, Burundi, Uganda, Rwanda, and Mali continued. The team made intensive capacity building efforts for key stakeholders through training programs, workshops, and field visits. Collaboration among stakeholders along the value chain drove success, highlighting inclusivity and tailored approaches. Ongoing engagement with farmers associations, governments, private sector, and NGOs is critical to control mycotoxins in the staples.

PHI-WP5 team developed gender-responsive assessment tools to identify men and women's plant health management needs, constraints, and interests. In 2023, results from six countries (Kenya, Peru, Uganda, Rwanda, Benin, Côte d'Ivoire) informed CGIAR and national partners to improve technology and innovation design and/or scaling approaches. In addition, based on six scoping studies in 2022, the PHI-WP5 team undertook two randomized controlled trials (RCTs) in 2023 to investigate adoption and impacts of aflatoxin biocontrol Aflasafe in Nigeria, and push-pull technology against fall armyworm (FAW) in Uganda. Results from these two RCTs will provide evidence-based recommendations on suitable scaling approaches for IMM and IPDM.

	2022	**2023**	2024
PROPOSAL BUDGET	$11.00M	**$13.00M**	$16.00M
APPROVED BUDGET [1]	$9.33M	**$8.49M** [2]	$9.03M [3]

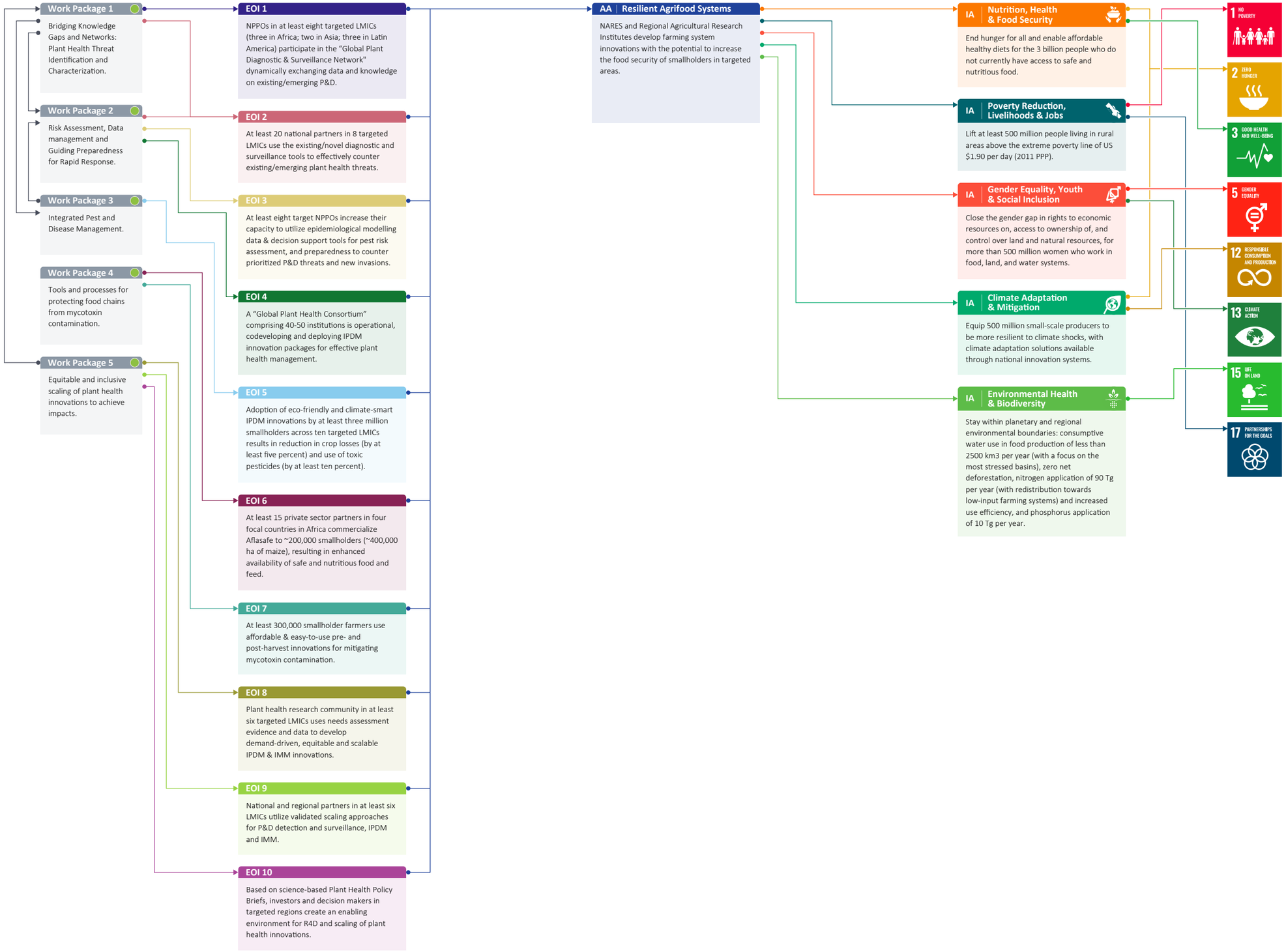
[1] The approved budget amounts correspond to the figures available for public access through the Financing dashboard.
[2] This amount includes carry-over and commitments.
[3] This amount is an estimation of the 2024 annual budget allocation, as of the end of March 2024.

Plant-based biopesticide prepared by extension agents for cowpea pest management.
Credit: Sarah Sallau (IITA)

Section 2: **Progress on science and towards End of Initiative outcomes**

Initiative-level theory of change diagram

This is a simple, linear, and static representation of a complex, non-linear, and dynamic reality. Feedback loops and connections between this Initiative and other Initiatives' theories of change are excluded for clarity.



EOI	End of Initiative outcome
AA	Action Area
IA	Impact Area
SDG	Sustainable Development Goal

Note: A summary of Work Package progress ratings is provided in Section 3.

"Partners visit an Aflasafe manufacturing facility built by a Nigeria private sector company HarvestField Industries Limited, in Ogun State, Nigeria. Credit: Mamadou Mboup (IITA)

Summary of progress against the theory of change

In 2023, PHI teams at the CGIAR Centers, together with 180 research/innovation and scaling partners globally, made significant progress in achieving the outputs and outcomes across the five Work Packages.

PHI-WP1 (bridging knowledge gaps and networks on plant health threat identification and characterization) is implemented by seven CGIAR Centers (AfricaRice, Alliance Bioversity International and CIAT, CIP, CIMMYT, IITA, IRRI and ILRI) in collaboration with 65 partner organizations, which are playing a key role in the regional diagnostics and surveillance networks. The strategic locations of the CGIAR Centers in the global South, coupled with the expertise in P&D identification and characterization, facilitated partnerships with national plant protection organizations (NPPOs), national agricultural research and extension systems (NARES), and ministries of agriculture spanning 34 countries across 4 regions (18 in Africa, 6 in Asia, 6 in Latin America and the Caribbean [LAC], and 4 in Central and West Asia and North Africa [CWANA]). Building upon insights gained in 2022 through a global online survey of knowledge and capacity gaps in diagnostics and surveillance of P&Ds, the team planned context-based capacity strengthening and conducted 13 training sessions to improve NPPOs' detection and surveillance capabilities in 10 targeted LMICs. Also, WP1 focused on developing and improving detection tools/innovations for characterization, monitoring, and surveillance and supported surveillance activities in 21 LMICs for more than 20 P&Ds on 8 crops (banana, cassava, enset, forages, maize, potato, rice, wheat). WP1 also ensured that at least 25 national partners in 10 targeted LMICs use novel diagnostic/surveillance tools.

PHI-WP2 made significant progress on developing standard procedures for ensuring equitable access and optimizing use of P&D data management systems across various regions, thereby enhancing risk assessment, modeling, and communication regarding several emerging P&Ds. Noteworthy achievements include pest emergence prediction and understanding of virulence variation related to post-flowering stalk rot in South Asia; identification of novel strains of Rice Blast and rice yellow mottle virus in Uganda and Côte d'Ivoire; legume viruses in Ethiopia and Lebanon, etc. The team is also monitoring virulence variations of wheat rust pathogens, Fusarium head blight in wheat, yam mosaic virus, bakanae disease of rice, potato psyllid, etc., using sentinel plots in different countries across Africa, Asia, and LAC. Pest risk models for African armyworm and FAW, and predisposing factors of Maize Lethal Necrosis (MLN) spread in East and Southern Africa, were analyzed. Significant enhancements were made to plant health data management platforms, facilitating information access for modelling, risk predictions, and data-driven decision-support tools for P&D control in LMICs. Remote sensing, drones and AI models were used to monitor crops and media reports on major P&D occurrence for early warning. The data generated by the team is instrumental in advocacy and engaging policy makers regarding P&D containment strategies.

In 2023, **PHI-WP3** (integrated pest and disease management/IPDM) team across six CGIAR Centers worked closely with 68 partners to develop/validate/deploy eco-friendly and climate-smart IPDM innovations and to validate these through Plant Health Innovation Platforms. Multiinstitutional and multidisciplinary collaborative efforts resulted in development/validation of diverse technologies, including botanicals, biological control, biopesticides, and ecological engineering for integrated management of major diseases (e.g., banana bunchy top disease (BBTD), banana Fusarium wilt TR4, chickpea and lentil viruses and their vectors, wheat blast, etc.), insect pests (e.g., African rice gall midge, cowpea pests, aphids and pod borers of food legumes, cassava whitefly, fruit fly, etc.), and parasitic weeds of Faba bean. Decision-support tools have been developed to enable MLN-free commercial seed production and potato late blight management. Capacity building events were organized in several countries, including Ethiopia, Lebanon, Kenya, Zambia, Nigeria, Mali, Mexico, Ecuador, Bangladesh, etc.

PHI-WP4 (integrated mycotoxin management) team has continued fostering nurturing relationships with private sector, local and international NGOs, including in Asian countries, for reducing mycotoxin contamination in staple crops. The team implemented activities for effectively transferring mycotoxin control technologies in maize, groundnut, rice, and sorghum in targeted regions, including extension of shelf-life of dry spores sent to Aflasafe manufacturers and optimizing formulations. Biocontrol testing in maize, groundnut, and sorghum generated effectiveness data to register products in Mali, Rwanda, DR Congo, Uganda, Burundi, and Sudan. Aflasafe manufacturers and distributors in 10 African countries received technical support, besides new manufacturers in Mozambique, DR Congo, and Burundi. PHI also worked closely with local communities, extension workers, and other stakeholders to raise awareness and to improve knowledge/skills on mycotoxin prevention and management.

PHI-WP5 focuses on gender equality, social inclusion, and impact assessment, in close interface with other Work Packages. In 2023, the WP5 team addressed gender and social inclusion in plant health management by developing interdisciplinary research tools/methods collectively through the Global Research Network on Gender and Plant Health. Insights from the studies undertaken collaboratively by seven CGIAR Centers (AfricaRice, Alliance of Bioversity International and CIAT, CIP, CIMMYT, IRRI, and IITA) in 2023 enabled improvement of the design of digital decision-support tools, such as Tumaini App (an AI-powered application for detecting pests and diseases), and a potato late blight handheld-decision-support tool, and recommendations toward training methods that are responsible to women's needs. On the impact assessment front, 2121 households were surveyed in a RCT aiming to examine adoption and impacts of Aflasafe among small-scale farmers in Nigeria. Baseline data from 1200 households were collected and analyzed in another RCT investigating adoption and impacts of Push-Pull Technology (PPT) among maize producers in Uganda. A phone survey of 398 farmers in 57 communities in Kenya was organized to assess the current levels of FAW and MLN, farmers' awareness and practice of control options, and the use of extension and mobile phones for accessing relevant information. All the three impact assessment studies have significant gender components.

Progress by End of Initiative outcome

EOIO 1: NPPOs in at least 8 targeted LMICs participate in the "Global Plant Diagnostic & Surveillance Network", dynamically exchanging data and knowledge on existing/emerging P&D.

The PHI team successfully mapped relevant stakeholders and identified key knowledge and capacity gaps in diagnostics, characterization, and surveillance of emerging P&Ds in 2022. This informed the development of a context-based capacity plan and a series of training sessions in 2023. The capacity building activities fostered a sense of community within each region and facilitated exchange of knowledge locally, regionally, and globally as part of the Global Plant Diagnostic & Surveillance Network. Sustained efforts and investment are essential for maintaining this collaborative network.

EOIO 2: At least 20 national partners in 8 targeted LMICs use the existing/novel diagnostic and surveillance tools to effectively counter existing/emerging plant health threats.

During 2022–2023, over 20 molecular and image-based AI tools for detection, characterization, monitoring, and surveillance of an array of P&Ds were developed/improved or validated in collaboration with 9 research and innovation partners. These tools/methods are being used by more than 20 national partners, including NPPOs, NARES, and extension staff in 8 targeted countries. The PHI team has also significantly advanced equitable access and utilization of P&D data management systems, improving global risk assessment and communication about emerging P&Ds (WP2-OC1). Data-driven decision-support tools are aiding advocacy and engagement of policy makers for effective P&D preparedness and management decisions.

EOIO 3: At least eight target NPPOs increase their capacity to use epidemiological modelling data & decision-support tools for pest risk assessment and preparedness to counter prioritized P&D threats and new invasions.

Efforts by the WP2 team enhanced knowledge on emerging P&Ds and aided in developing risk prediction models for preparedness to counter pest threats (WP2-OC2). This includes using data science to predict FAW outbreaks in Africa; combating BBTD in Nigeria, Uganda, and Tanzania; and creating risk prediction models for Fusarium head blight and wheat blast in Mexico, Bangladesh, and Zambia. Phytosanitary expert assessments determined predisposing factors of MLN in Africa, and potato psyllid in Central America. AI models were established to monitor global media reports on major P&D occurrences and detect banana Fusarium wilt in real-time using unmanned aerial vehicles.

EOIO 4: A "Global Plant Health Consortium" comprising 40–50 institutions is operational, co-developing and deploying IPDM innovation packages for effective plant health management.

In 2023, the PHI-WP3 team, in partnership with 68 non-CGIAR partners, including an array of research/innovation and scaling partners, is co-developing and deploying IPDM innovation packages against prioritized plant health threats. "Plant Health Innovation Platforms" in Kenya and Lebanon undertook work on integrating, co-developing and co-validating IPDM innovation packages of viruses and their vectors on faba bean and on FAW in maize through participatory engagement of researchers, extension personnel, and smallholder farmers.

EOIO 5: Adoption of eco-friendly and climate-smart IPDM innovations by at least three million smallholders across ten targeted LMICs results in reduction in crop losses and use of toxic pesticides.

In 2023, eco-friendly plant health innovations or IPDM packages were adopted by an estimated 461,698 smallholders in 20 targeted LMICs (Africa-11; Asia-5; LAC-2; CWANA-2) in the global South. Capacity building of national partners, extension personnel, and farming communities was also intensively undertaken in over 20 countries on various aspects of IPDM for effective management of various plant health threats affecting cereals, food legumes, roots, tubers, banana, and tomato.

EOIO 6: At least 10 private sector partners in targeted countries use aflatoxin biocontrol as part of integrated mycotoxin management, resulting in enhanced availability of safe & nutritious food & feed.

The PHI-WP4 team conducted experiments to extend the shelf life of dry spores sent to five private-sector Aflasafe manufacturers, improved field performance, and optimized formulations. The team generated effectiveness data to register products in Mali, Rwanda, DR Congo, Uganda, Burundi, Sudan, and Mexico. WP4 continued supporting 5 private-sector manufacturers and 11 distributors of Aflasafe in 10 African countries; and developed and nurtured relationships with local and international NGOs demanding aflatoxin-reduced crops. Commercialization strategies defining the best ways to scale Aflasafe were produced for Uganda and Burundi. Technical support on the design of Aflasafe manufacturing facilities and the installation and fine-tuning of appropriate equipment was provided to manufacturers in Mozambique, DR Congo, and Burundi.

EOIO 7: National partners and farming communities in targeted LMICs use affordable & easy-to-use pre- and post-harvest integrated mycotoxin management innovations for mitigating mycotoxin contamination of food crops.

The WP4 team engaged with farmers, private-sector entities, researchers, and development partners to foster collaboration in co-developing and adopting mycotoxin management tools. The team provided training and technical assistance to 10 extension agencies and 20 private-sector actors involved in crop value chains to enable them to effectively implement IMM strategies. PHI also raised awareness among consumers about the importance of mycotoxin management and initiated pilot projects to demonstrate the feasibility and effectiveness of IMM in reducing mycotoxin contamination along value chains.

EOIO 8: The plant health research community in at least six targeted LMICs uses needs assessment evidence and data to develop demand-driven, equitable and scalable IPDM & IMM innovations.

Gender-responsive assessment tools to identify men's and women's plant health management needs, constraints, and interests are co-developed by interdisciplinary teams. In 2023, results from six countries (Kenya, Peru, Uganda, Rwanda, Benin, and Côte d'Ivoire) have informed PHI's technology developers and national partners to improve innovation/technology design and/or scaling approaches.

EOIO 9: National and regional partners in at least six LMICs use validated scaling approaches for P&D detection and surveillance, IPDM and IMM.

Built on six scoping studies and needs assessment evidence in 2022, the PHI team made significant progress through two RCTs in 2023 to investigate adoption and impacts of Aflasafe in Nigeria and push-pull technology against FAW in Uganda.

EOIO 10: Based on science-based Plant Health Policy Briefs, investors and decision-makers in targeted regions create an enabling environment for R4D and scaling plant health innovations.

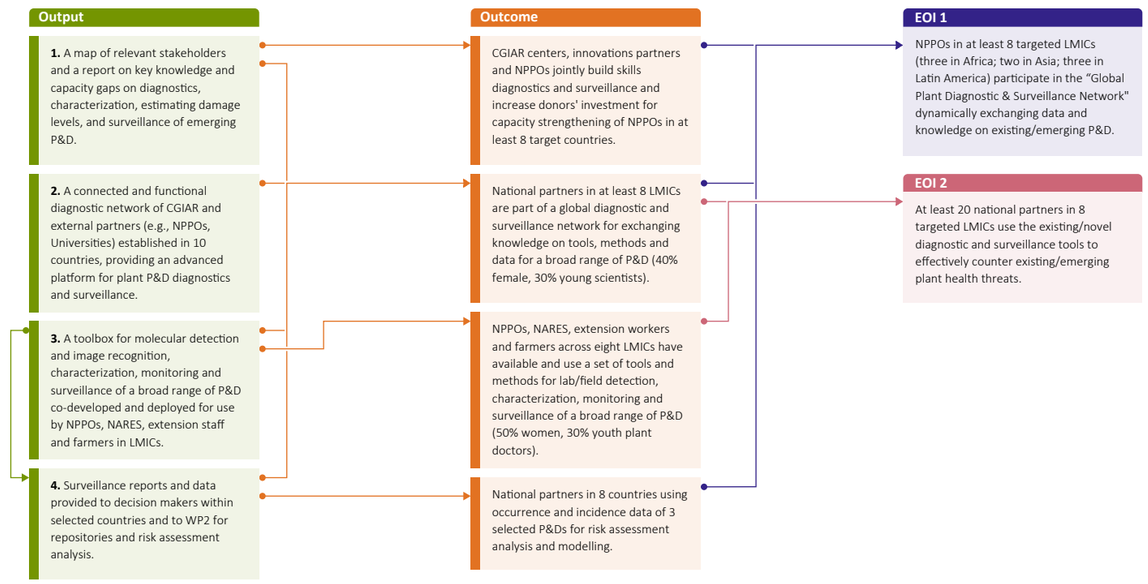
Results from the two RCTs the PHI team implemented in 2023 will provide evidence-based plant health policy recommendations in 2024 on suitable scaling approaches for innovations contributing to IMM, and integrated pest management (IPM) of FAW in Africa. This, in turn, will contribute to the creation of an enabling environment for research for development (R4D) on IMM and IPM in countries in sub-Saharan Africa, especially Nigeria and Kenya, and scaling gender-appropriate plant health innovations.

Rice farmers in the Prey Veng province, Cambodia visit the rice-mungbean-watermelon fields to learn about biodiversity and plant health management. Credit: Nurmi Pangesti (IRRI)

Section 3: **Work Package progress**

WP1: Bridging Knowledge Gaps and Networks: Plant Health Threat Characterization

On track

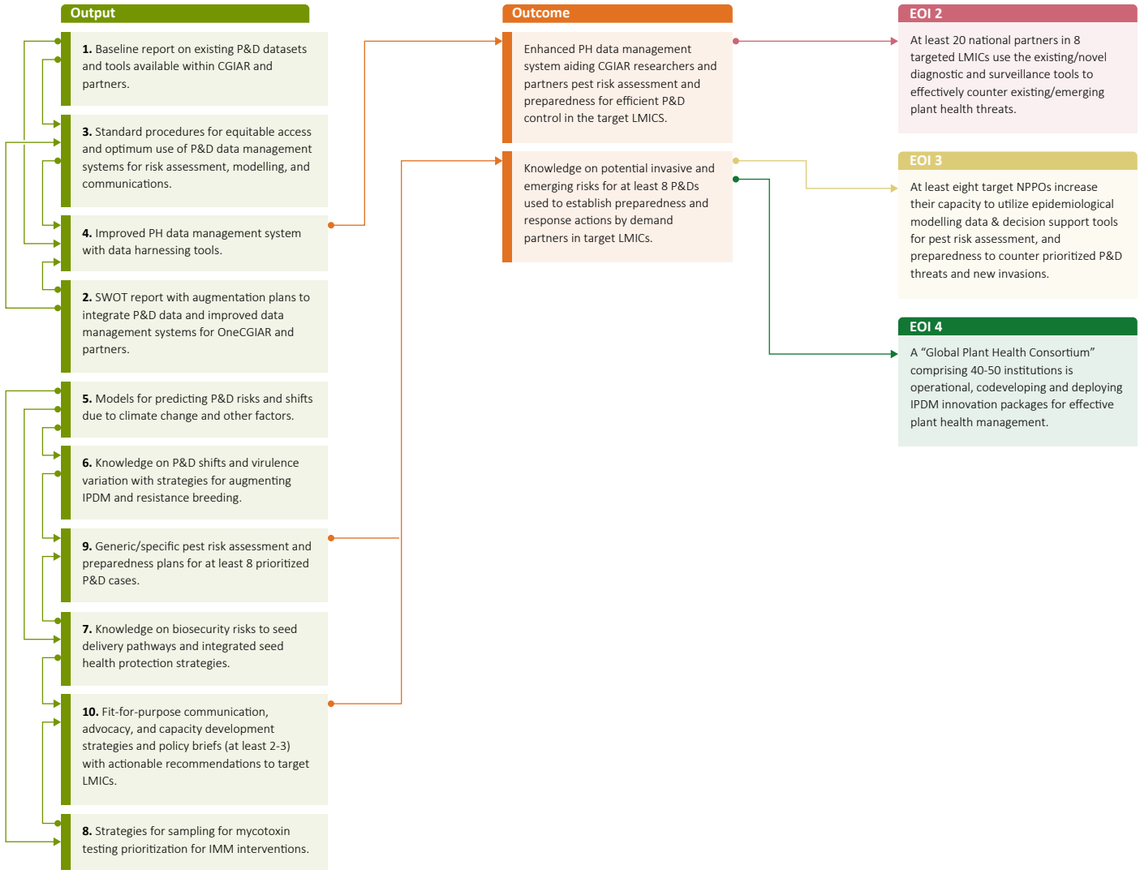


Work Package 1 progress against the theory of change

During 2023, WP1 continued working on bridging networks and knowledge gaps on plant health threat identification and characterization across 34 countries, in collaboration with 65 organizations, mostly NPPOs. The interinstitutional collaborations aimed at developing and implementing context-based capacity strengthening plans with NPPOs within each region, building on insights gained in 2022 (**WP1-OP1/OP2**). Based on consultations and prioritization, 13 in-person training sessions were organized. The goal was to strengthen regional diagnostic and surveillance capacity. Over 20 molecular and image-based AI tools for detection, characterization, monitoring, and surveillance were developed/improved or validated in collaboration with 9 innovation partners (**WP1-OP3**). Leveraging some of these tools, WP1 supported national institutions surveillance efforts for various crops, including banana (7 countries, Africa/Asia/LAC, for Fusarium wilt TR4 and banana bunchy top disease); cassava (5 countries, Africa/Asia, for viruses and whitefly); enset (Ethiopia for Paraputo ensete and Xanthomonas wilt); forages (Ethiopia for Alfalfa mosaic virus and southern bean mosaic virus); maize (6 countries in Africa for Fall armyworm and Maize lethal necrosis); potato (6 countries, Africa/LAC, for potato purple top disease and Late blight); rice (3 countries, Africa/Asia, for Southern rice black-streaked dwarf virus, rice blast); and wheat (4 countries, Africa/CWANA/LAC, for wheat blast, Fusarium head blight, wheat rust, yellow rust/stem rust) (**WP1-OP4**). The progress made in 2023 across the four outputs of WP1 have contributed to achieving the proposed End of Initiative outcomes, namely: (i) enhancing NPPOs' detection and surveillance capabilities in at least 8 targeted LMICs while participating in a plant diagnostic and surveillance network, and (ii) at least 20 national partners in these LMICs use modern diagnostic and surveillance tools to effectively counter plant health threats.

WP2: Guiding Preparedness and Rapid Response: Data Management and Risk Assessment

On track



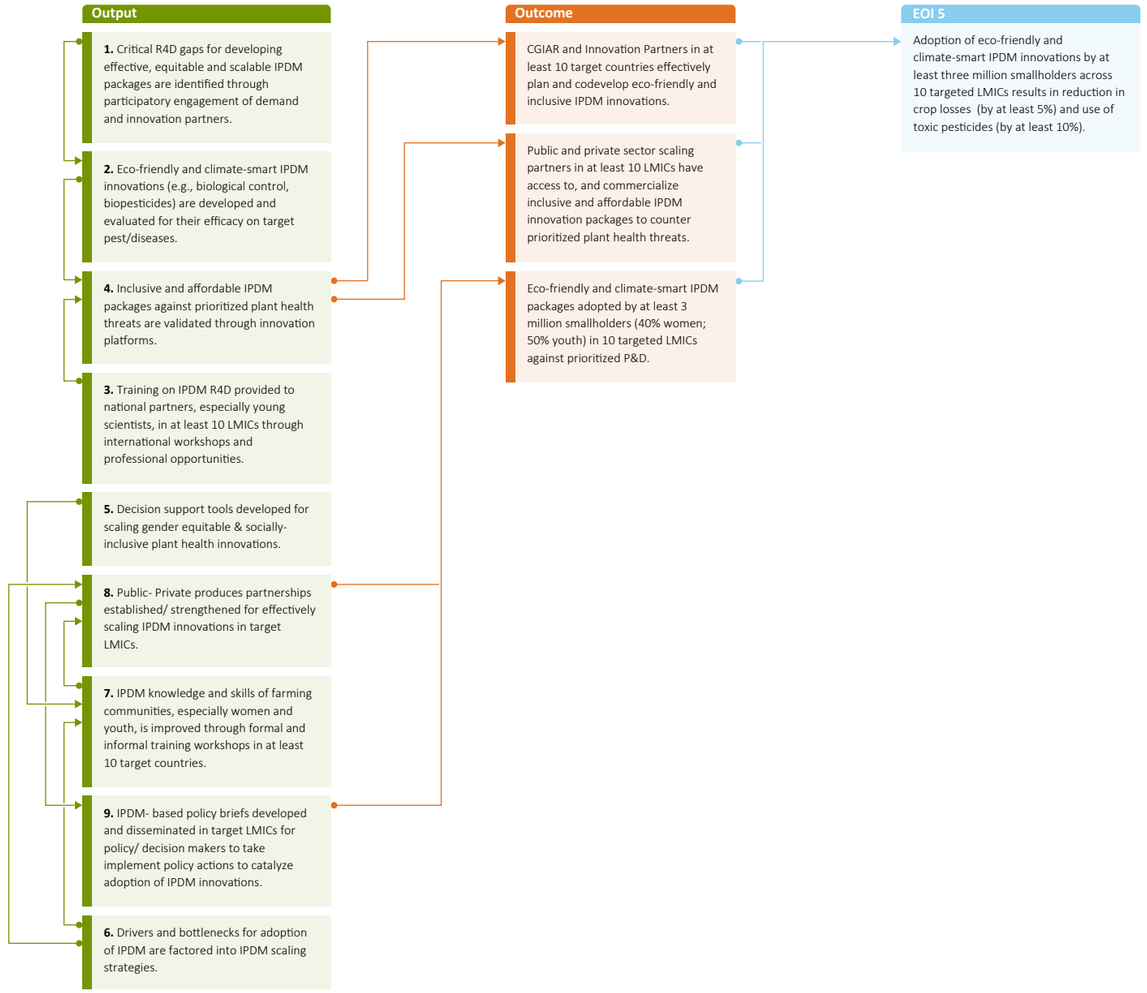
Work Package 2 progress against the theory of change

In 2023, the PHI-WP2 team has significantly advanced standard procedures for ensuring equitable access and optimizing the utilization of P&D data management systems across various regions, thereby enhancing partners’ capabilities for risk assessment, modelling, and communication regarding several emerging P&Ds (**WP2-OC1**). Noteworthy achievements include pest emergence prediction (**WP2-05**) and virulence variation (**WP2-06**) related to post-flowering stalk rot in South Asia; novel strains of Rice Blast and Yellow Mottle Virus in Uganda and Cote d’Ivoire; legume viruses in Ethiopia and Lebanon; monitoring virulence variations using sentinel plots of wheat rust pathogens in Ethiopia, Kenya, India and Pakistan; Fusarium head blight in India, Bangladesh, Pakistan, and Nepal; identification of new phylogenetic groups of yam mosaic virus in Nigeria; emergence of Bakane disease of rice in West Africa; potato psyllid in Peru; risk models for African armyworm and FAW; and predisposing factors of MLN spread in East and Southern Africa.

Furthermore, significant enhancements were made to plant health data management platforms (**WP2-04**), facilitating information access for modelling (**WP2-03**), risk predictions, and data-driven decision-support tools for P&D control in LMICs (**WP2-OC2**). This includes development of an updated web platform for Insect Life Cycle Modeling (ILCYM) to determine pest outbreaks; a refined EPIRICE model to forecast rice blast and brown spot dynamics; integration of the NextStrain module for genomic surveillance of cassava geminiviruses in Southeast Asia and potexviruses in LAC; wheat rust and blast early warning system in Bangladesh and Zambia; a Sentinel-2-based cropland map for improving wheat rust detection and forecasting models; deployment of remote sensing and AI models for mapping BBTD in Nigeria; enhancement of the Tumaini AI platform for real-time surveillance of banana diseases; and AI models to monitor media reports on major P&D occurrence for early warning.

WP3: Integrated Disease and Pest Management Solutions for Threat Mitigation

On track

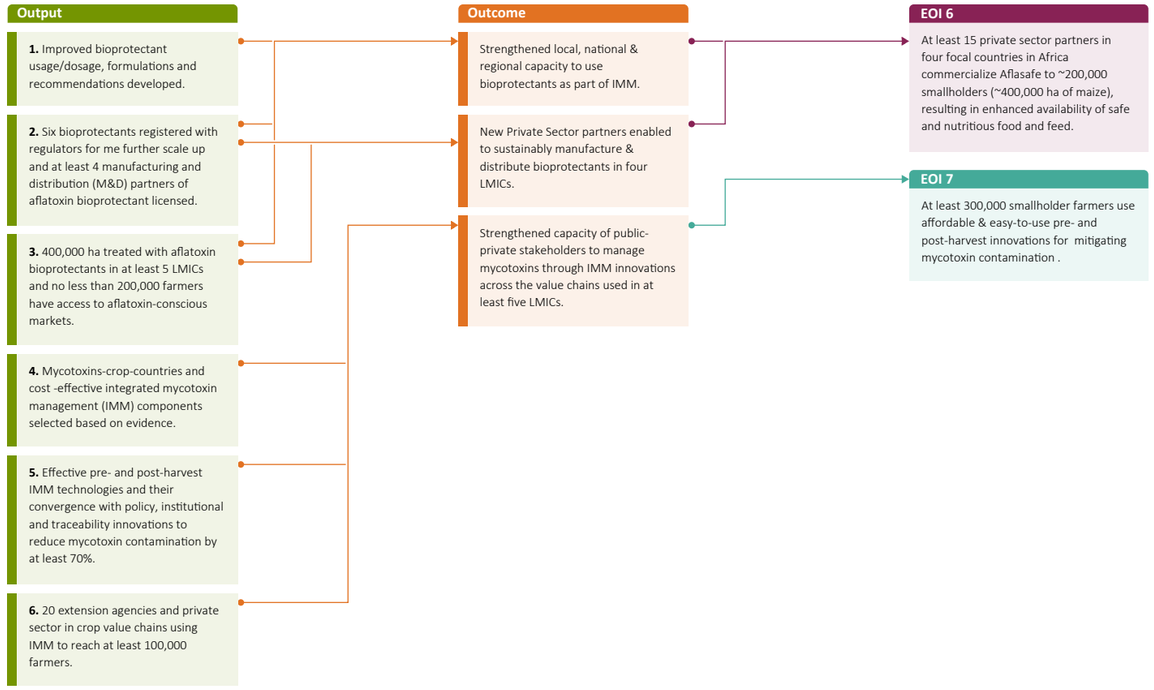


Work Package 3 progress against the theory of change

During 2023, the PHI-WP3 team made significant progress on several fronts; for example, a) the WP3 team, including partners, developed/ validated an array of innovations, including biological control (e.g., banana Fusarium wilt; root knot and burrowing nematodes of vegetables); biorationals and biopesticides (e.g., African rice gall midge and rice stem borers, aphids and pod borers of food legumes; aphid vector of BBTV; FAW on maize; cassava whitefly, fruit fly, etc.); ecological engineering (e.g., rice pests), etc. (**WP3-OP2**); b) capacity building of 527 national partners (44 percent women), including post-graduate students, scientists, and extension personnel, and over 1350 farmers (45 percent women) in over 20 countries, including Ethiopia, Lebanon, Kenya, Zambia, Nigeria, Mali, Mexico, Ecuador, and Bangladesh, to strengthen knowledge/skills on various aspects of IPDM in 9 crops; the topics included production and exchange of pathogen-free clean seed/planting materials, integrating host plant resistance with biological control, community-based biopesticide production, gender and social inclusion in plant health management, etc. (**WP3-OP3 & OP7**); c) Plant Health Innovation Platform at Qos Elias, Lebanon, enabled demonstration of various IPM-based innovations for managing viruses and their vectors on faba bean and FAW in maize (**WP3-OP4**); d) decision-support tools for MLN virus-free clean commercial seed production in maize and for potato late blight management were developed (**WP3-OP5**); and f) strong linkages established with complementary projects on plant health management (e.g., Plant Health efforts of the UN Food and Agriculture Organization (FAO), etc.) toward operationalizing a “Global Plant Health Consortium” (**WP3-OC1**).

WP4: Tools and Processes for Protecting Food Chains from Mycotoxin Contamination

On track



Work Package 4 progress against the theory of change

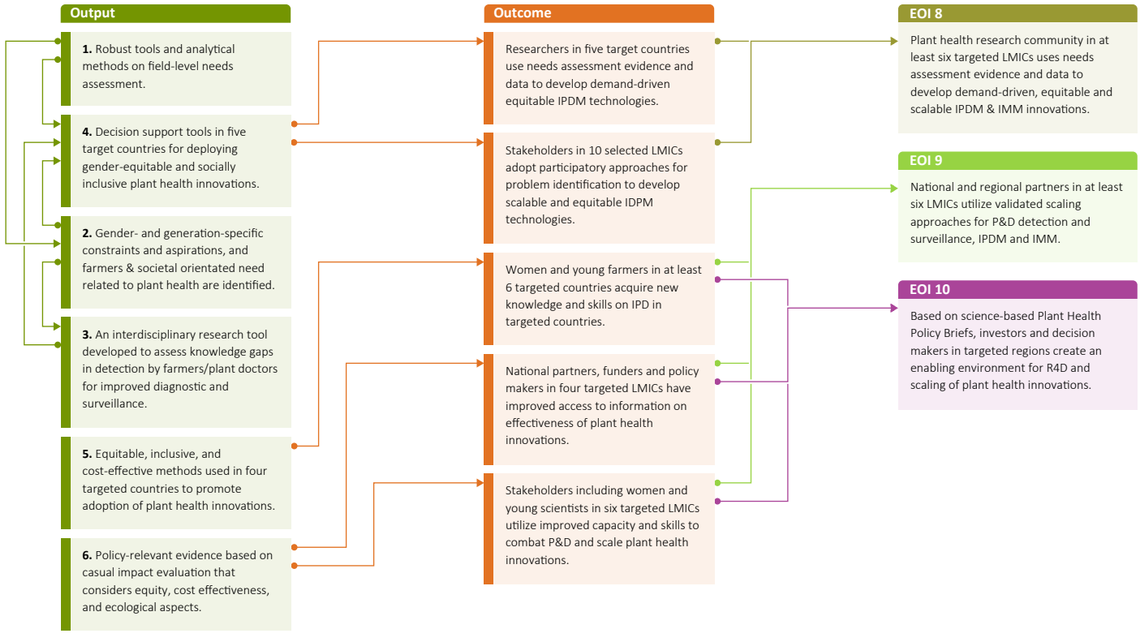
PHI-WP4 (integrated mycotoxin management) works toward validating (e.g., smart storage) and strengthening scaling diverse preharvest (e.g., biocontrol) and postharvest (e.g., nixtamalization) mycotoxin control interventions to reduce consumer exposure to mycotoxins and for smallholder farmers to obtain access to premium markets. In 2023, the team achieved several outputs including: a) publications based on research to understand multiple-year application on carry-over of biocontrol in small- and large-scale agricultural fields; b) continuation of effectiveness trials in Niger, Rwanda, DR Congo, Burundi, Uganda and Mexico to gather data to prepare and submit registration dossiers for aflatoxin biocontrol products (**WP4-OP1**); c) obtained provisional registration of biocontrol products for use in Rwanda and Uganda (WP4-OP2); d) developed an Aflasafe commercialization strategy for Uganda; e) renewed technology transfer and licensing agreements with private-sector manufacturing partners in Nigeria and Senegal (WP4-OC2); f) extended partnerships with NARES (e.g., KALRO), advanced research institutes in the US, extension agencies, NGOs (e.g., Sasakawa Africa Association, World Food Programme, FAO) and private-sector partners (e.g., Delish and Nutri) in 12 countries (e.g., Cameroon, Kenya) to reach the targeted number of farmers (**WP4-OC1**); g) protecting crops of more than 57,000 farmers in 9 countries in sub-Saharan Africa (Nigeria, Kenya, Tanzania, Mozambique, Senegal and The Gambia, Burkina Faso, Ghana, and Mali) with aflatoxin management strategies (**WP4-OP3**); and h) organized and gave presentations in high-level meetings (e.g., fair for BMGF, African Union Commission-PACA, International Organization of Biological Control and International Plant Pathology Congress meetings). In addition, WP4 members attended workshops in target countries (e.g., Azerbaijan) and regions (e.g., APAARI countries) which requested assistance from PHI based on its impactful mycotoxin control strategies, supported by empirical evidence and field-based effectiveness. WP4 also reorganized its objectives and activities in Sudan as a result of its ongoing devastating internal conflict.

1 Burkina Faso: 5,703; Tanzania: 2,108; Nigeria: 16,217; Ghana: 365; Kenya: 7,830; Senegal and The Gambia: 23,368; Mozambique: 1,572; Mali: 500. Total: 57,663

Wheat stem rust race characterization in a greenhouse at KALRO-Njoro.
Credit: Sridhar Bhavani (CIMMYT)

WP5: Methods for Inclusive and Equitable Scaling for Achieving Impacts

On track



Work Package 5 progress against the theory of change

PHI-WP5 focuses on gender equality, social inclusion, and impact assessment, in close interface with other Work Packages. In 2023, WP5 addressed gender and social inclusion by developing interdisciplinary research tools and methods collectively through a Global Research Network on Gender and Plant Health (**WP5-OP1 & OP3**). Seven CGIAR Centers have conducted studies to identify gender gaps and gender-based constraints in the following three themes: 1) pest and disease identification; 2) adoption of digital tools; and 3) extension and training approaches (**WP5-OP2**). The insights from these studies helped technology developers to improve the design of digital decision-support tools, such as Tumaini and potato late blight handheld decision-support tool (**WP5-OP4**), and provided recommendations toward gender-responsive training methods for women.

Regarding impact assessment, during 2023, a) 2121 households were surveyed in an RCT to analyze adoption of Aflasafe among small-scale farmers in Nigeria; b) baseline data from 1200 households were collected and analyzed in an RCT investigating gender-responsive adoption of Push-Pull Technology (PPT) among maize producers in Uganda for Fall Armyworm (FAW) management. With the results from the two RCTs to be used to provide evidence-based policy recommendations on equitable scaling of PHI innovations and the impacts of scaling (**WP5-OP5 & OP6**); and c) a phone survey of 398 farmers in 57 communities in Kenya was organized to assess the current levels of FAW and MLN, farmers' awareness and practice of control options, and use of extension and mobile phones for accessing information. This study provides needs assessments by gender and the baseline P&D situation of plant health innovations in Kenya and contributes to equitable scaling and impact assessment (**WP5-OP5 & OP6**).

Work Package progress rating summary

WORK PACKAGE	PROGRESS RATING & RATIONALE
1	**Progress rating** The provided text outlines the progress and achievements of WP1 during 2023, highlighting its focus on bridging knowledge gaps and establishing networks for plant health threat identification across multiple countries, as well as collaboration with various organizations. Significant progress was made across the three major outputs (OP2, OP3, and OP4). However, budget reductions since the initiation of the Initiative necessitated scaling back certain activities, particularly those related to surveillance and the organization of additional training sessions. As a result, adjustments were made to the total number of target countries and institutions in the initially defined End of Initiative outcomes 1 and 2.
2	**Progress rating** The PHI-WP2 team has managed to fulfill its commitments for 2023 despite a reduction in funding mid-year. The team focused on innovation development, which involved creating, improving, and validating tools and models to predict shifts in P&D. The different data-driven decision-support tools for preparedness tracked several emerging P&Ds in LMICs across Africa, Asia, and LAC. This included BBTD, FAW and MLN in Africa, potato psyllid in LAC, and southern rice black-streak dwarf virus and wheat pathogens (rust and blast) in Asia and Africa. The team anticipates continuing the momentum in 2024 to promote the use of tools and enhance partners' capacity to adopt decision-support tools.
3	**Progress rating** WP3 progress is well aligned with CGIAR's 2023 Plan of Results and Budget (PORB) and theory of change (TOC), with several key achievements, including: a) co-creation of eco-friendly and climate-smart IPDM innovations against targeted plant health threats in various crops, including rice, maize, wheat, food legumes, potato, sweet potato, banana, cassava, tomato, etc.; b) integrating and identifying/validating the most effective, affordable, and scalable IPDM packages through the Plant Health Innovation Platforms in Kenya and Lebanon; c) training of more than 5,000 partners, including researchers, extension personnel, and farmers on IPDM for effective scaling; d) 461,698 farmers in 20 LMICs are estimated to have adopted IPDM through PHI in 2023; and e) establishing strong linkages with complementary initiatives/projects led by non-CGIAR institutions for coordinated implementation of plant health management, especially in the global South.
4	**Progress rating** Despite challenges, scaling of aflatoxin biocontrol continues. WP4 has been successful in generating effectiveness data for product registration in multiple countries. Commercialization strategies and investor involvement in Uganda, Zambia, and Burundi highlight proactive scaling efforts. Technical support to manufacturers, infrastructure growth, and multistakeholder engagement continues. The bundling of mycotoxin management tools is undergoing validation in target countries, highlighting a comprehensive approach to addressing mycotoxin contamination.
4	**Progress rating** WP5 progress is in line with both the 2023 PORB and TOC. WP5 has addressed gender and social inclusion by developing interdisciplinary research tools and methods collectively through the Global Research Network on Gender and Plant Health. This team has made significant progress in two RCTs for impact evaluation case studies in Nigeria and Uganda.

Definitions

On track

- Annual progress largely aligns with Plan of Results and Budget and Work Package theory of change.
- Can include small deviations/issues/delays/risks that do not jeopardize success of Work Package.

Delayed

- Annual progress slightly falls behind Plan of Results and Budget and Work Package theory of change in key areas.
- Deviations/issues/delays/risks could jeopardize success of Work Package if not managed appropriately.

Off track

- Annual progress clearly falls behind Plan of Results and Budget and Work Package theory of change in most/all areas.
- Deviations/issues/delays/risks do jeopardize success of Work Package.

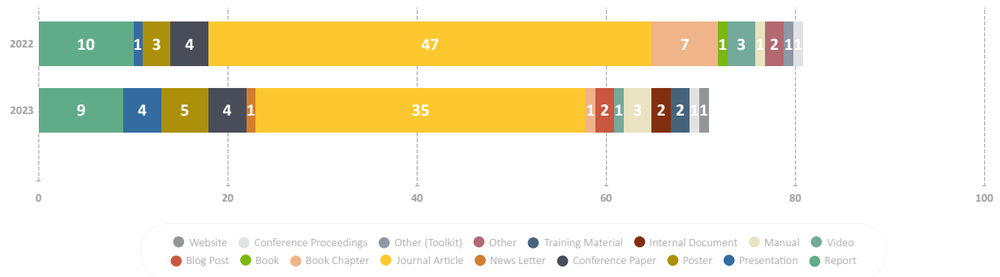
Section 4: **Key results**

This section provides an overview of results reported by the CGIAR Research Initiative on Plant Health in 2023. These results align with the CGIAR Results Framework and Plant Health's theory of change. Source: *Data extracted from the* CGIAR Results Dashboard *on 29 March 2024*.

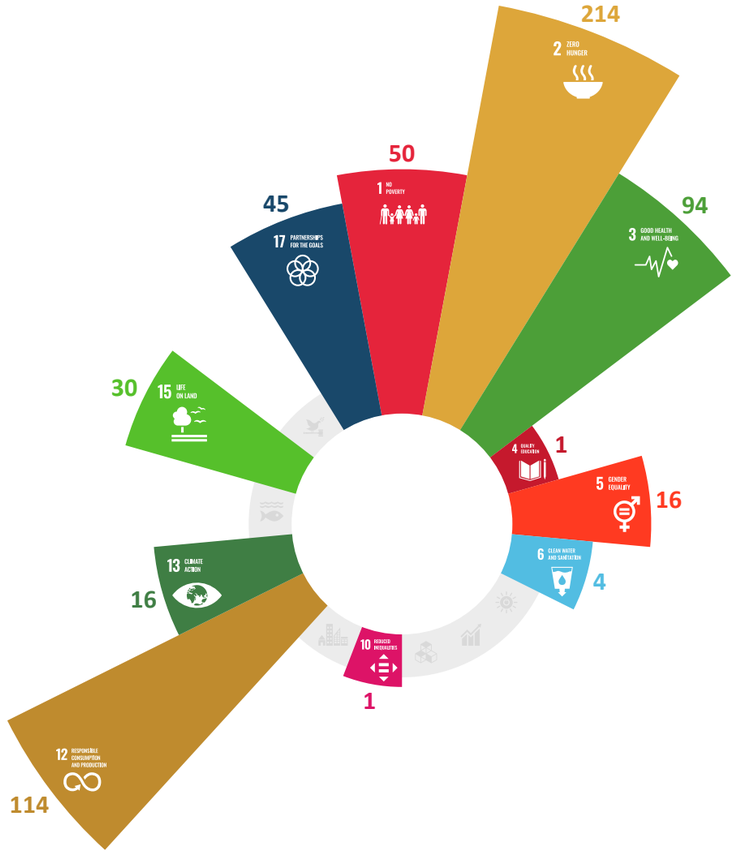
Overview of reported results

Percentage of reported results tagged to CGIAR Impact Areas

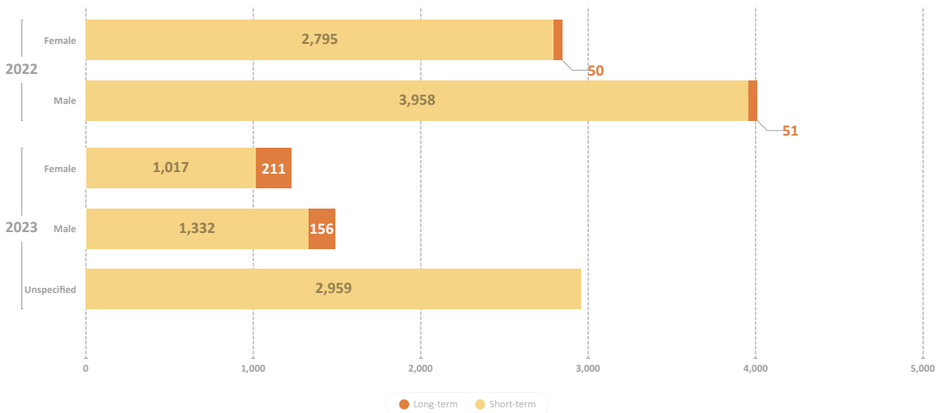
Number of knowledge products by type



Contributions to the UN Sustainable Development Goals



Number of individuals trained by the Initiative

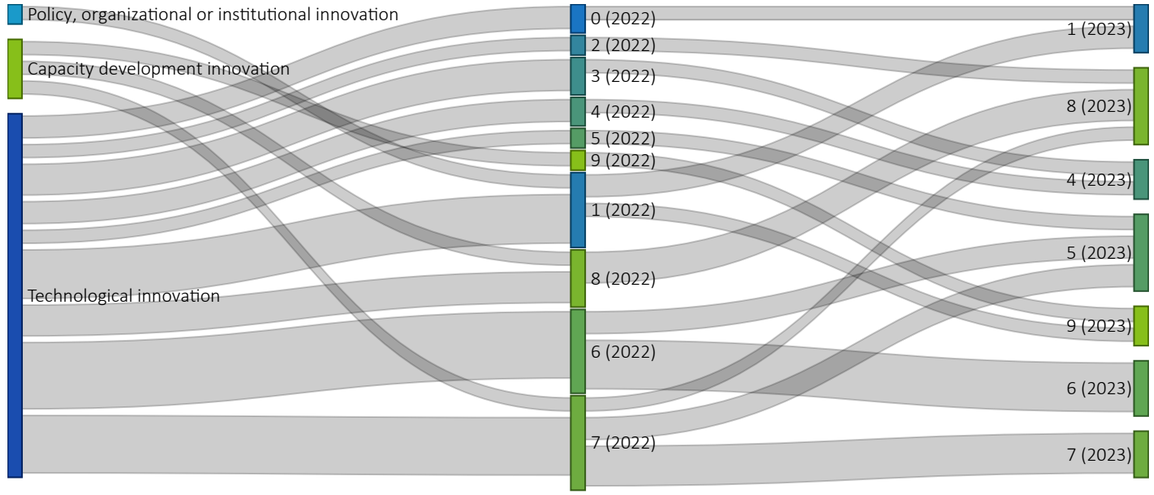


Innovations by readiness level

Pipeline overview
# of innovations

9	**Proven Innovation** The innovation is validated for its ability to achieve a specific impact under uncontrolled conditions	9
8	**Uncontrolled Testing** The innovation is being tested for its ability to achieve a specific impact under uncontrolled conditions	12
7	**Prototype** The innovation is validated for its ability to achieve a specific impact under semi-controlled conditions	8
6	**Semi-Controlled Testing** The innovation is being tested for its ability to achieve a specific impact under semi-controlled conditions	13
5	**Model/Early Prototype** The innovation is validated for its ability to achieve a specific impact under fully-controlled conditions	12
4	**Controlled Testing** The innovation is being tested for its ability to achieve a specific impact under fully-controlled conditions	15
3	**Proof of Concept** The innovation's key concepts have been validated for their ability to achieve a specific impact	8
2	**Formulation** The innovation's key concepts are being formulated or designed	4
1	**Basic Research** The innovation's basic principles are being researched for their ability to achieve a specific impact	4
0	**Idea** The innovation is at idea stage	2

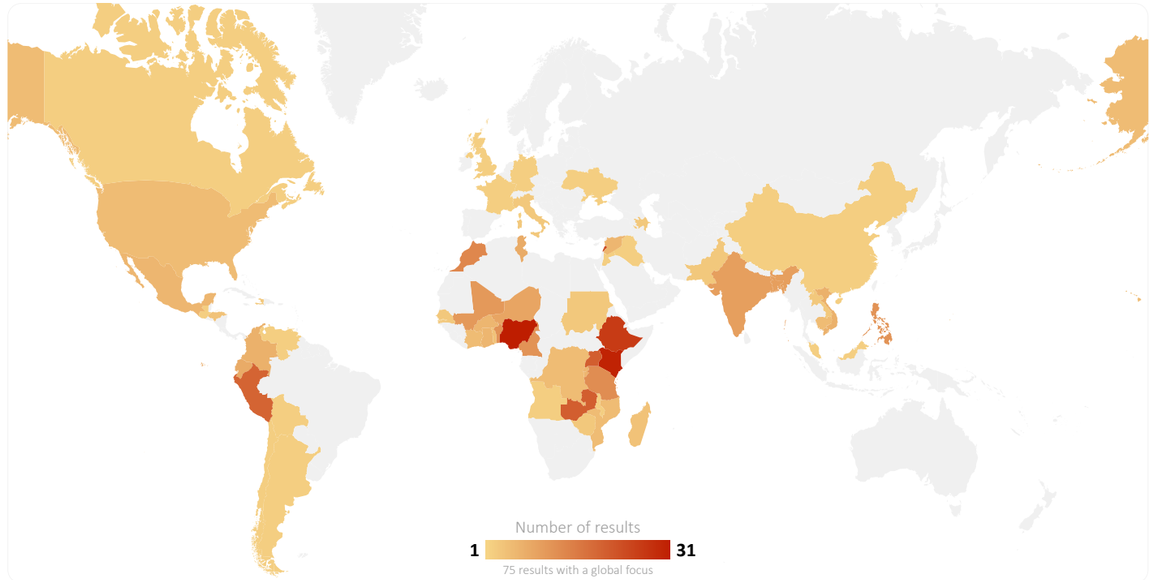
Progress in scaling readiness level for reported innovations



Innovation type	Discontinued	Decreased	Increased	Same	Total
Technological	**7**	**4**	**5**	**14**	**30**
Policy, organizational or institutional	**-**	**-**	**-**	**1**	**1**
Capacity development	**1**	**-**	**-**	**2**	**3**
Total	**8**	**5**	**4**	**17**	**34**

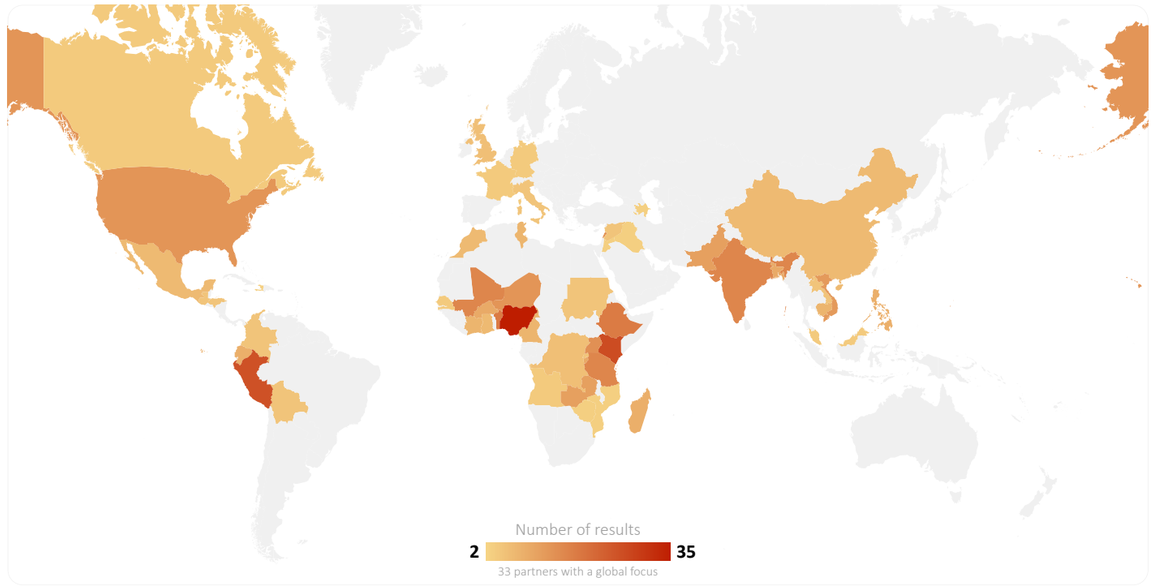
Number of results by country

Data here represents an overview of reported results in 2022 and 2023. One result can impact multiple countries and can therefore be represented multiple times.



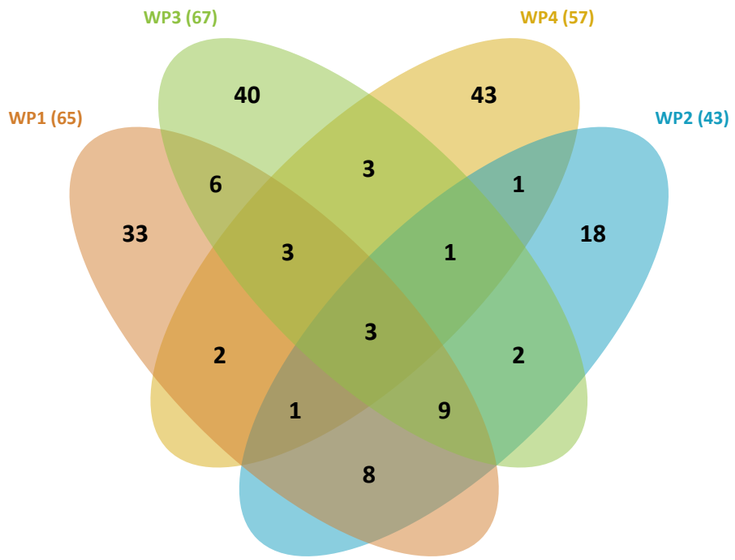
Section 5: **Partnerships**

External partners contributing to results, per country



Colors represent the number of different partners which collaborated on results achieved in a specific country. One result can impact different countries and therefore the same partner can be associated with more than one country.

Source: Data extracted from the Results Dashboard on 29 March 2024.



Partnerships and Plant Health's impact pathways

In 2023, the PHI team collaborated with a total of 180 non-CGIAR partners across 58 countries, including international agricultural research centers (e.g., CABI, icipe, World Vegetable Center), NARES institutions, NPPOs, universities, governmental organizations, private companies, and NGOs, among others. All these partners contributed to the implementation of various activities under the PHI Work Packages.

Out of 180 non-CGIAR partners, 90 organizations were demand partners from 45 countries, 108 were innovation partners from 47 countries, and 82 were scaling partners. Some partners played more than one role. Some partners are involved in ongoing efforts through bilateral projects, which PHI is leveraging to extend, adopt, and scale plant health innovations in the global South.

Sixty-five partners contributed to **WP1**, primarily focusing on the development and validation of molecular and image-based AI detection tools for characterizing, monitoring and surveilling targeted P&Ds and operating the regional diagnostic and surveillance network. In **WP2**, 43 partners contributed, mainly by developing models for predicting P&D risks and shifts due to climate change and other factors and advancing knowledge on P&D shifts and virulence variation, including strategies for enhancing IPDM and resistance breeding. Sixty-eight partners were involved in **WP3**, focusing on developing and evaluating eco-friendly and climate-smart IPDM innovations, creating inclusive and affordable IPDM packages for prioritized plant health threats, validation through innovation platforms, and training on IPDM R4D. **WP4** partnered with 57 organizations, supporting public-private stakeholders in managing mycotoxins through IMM innovations, registration and licensing of aflatoxin bioprotectants, protection of aflatoxin-susceptible crops, and scaling mycotoxin management through extension agencies and the private sector. Additionally, 10 partners contributed to **WP5** on gender and socially inclusive plant health management.

In 2023, PHI disbursed sub-grants totaling US$ 726,129 to 39 non-CGIAR partners, including NARES, universities, NPPOs, government organizations, International agricultural research institutions, advanced research institutions, NGOs, and the private sector (ESA-15; WCA-1; CWANA-4; South Asia-6; SE Asia-7; LAC-4; Europe-2), for implementing specific work plans with deliverables that complement the work done by CGIAR Centers.

Farmers' field day in Peruvian Central highlands (Jauja, Junín, Perú) on potato disease management. Credit: Willmer Perez (CIP)

Section 6: **CGIAR Portfolio linkages**

Portfolio linkages and Plant Health's impact pathways

During 2023, PHI worked closely with several CGIAR Initiatives from the three science areas. Linkages and joint outputs were reported in collaboration with two Initiatives under Genetic Innovations, four under Resilient Agrifood Systems, and one under Systems Transformation (Gender Platform). Some examples are: (i) **Accelerated Breeding** Initiative contributed to breeding and deployment of improved varieties with host plant resistance (disease-/parasitic weed-/insect-pest resistance), against various plant health threats, including resistance to wheat blast and Fusarium head blight, MLN, FAW, and Striga in maize, bacterial leaf blight in rice, etc. (**WP3**); (ii) the Genebanks Initiative supported the development/improvement/validation of diagnostic tools/protocols and the socialization of regional diagnostic hubs with NPPOs (**WP1**); (iii) Resilient Agrifood Systems Initiatives contributed to the TOCs of WP3, WP4 and WP5, including interactions with the **Fragility to Resilience in Central and West Asia and North Africa** Initiative to strengthen the capacities of national scientists/technicians for managing different plant health threats (**WP3**); (iv) the **Excellence in Agronomy** Initiative helped to gain understanding of gender-based roles in rice-based systems and diversification of cropping systems for pest management; and (v) the **Asian Mega-Deltas Deltas** Initiative co-developed research designs with PHI and implemented surveys to understand men and women farmers' responses to rice pests and diseases in a changing climate; this information is critical to mainstream gender for more equitable and inclusive plant health management and impacts in Southeast Asia (**WP5**); (vi) and the **Rethinking Food Markets Initiative** helped to evaluate the impacts of solar driers on vegetables in Nigeria (**WP4** & **WP5**). These linkages have supported progress towards the End of Initiative outcomes OC1, OC2, OC3, OC5, OC8 and OC10.

Bilateral projects are playing a crucial role in complementing the work of PHI. Indeed, the progress obtained to date would not have been possible without diverse funding sources. A few examples from 2023 are given below:

- GIZ-supported the Alert4 Project (Alliance of Bioversity International and CIAT) for the improvement of the Tumaini Banana Disease Surveillance Dashboard, a new innovation for Musaceae protection (PHI-WP1).
- Projects were funded by USAID/USDA/FAS (Foreign Agricultural Service) on delimitation surveys for mapping a banana bunchy top virus (BBTV) outbreak in East Africa and improving preparedness to counter the emerging invasion. These efforts also benefited from supplementary funding from the USAID Innovation Lab on Current and Emerging Threats to Crops (USAID-IL-CETC). Another example is an EASA-funded Sentinel for Wheat Rust Disease project, with partners from Université catholique de Louvain and the University of Cambridge (PHI-WP2).
- A PHI-CIP team received complementary funding from USAID-IL-CETC for potato pest and disease management in Honduras, Guatemala, and Kenya, and from CABANAnet (Capacity Building for Bioinformatics in Latin America), funded by the Chan Zuckerberg Institute, for plant pathogen identification and population analysis in potato and sweet potato.
- Projects funded by the French Development Agency for implementation in Sudan, the Royal Government of Norway for implementation in Mali and Niger, the Agricultural Business Initiative (aBi) for implementation in Uganda, the World Bank for implementation in DR Congo and Burundi, GRUMA for implementation in Mexico, and USDA-FAS for implementation in Mali have been pivotal in complementing PHI-WP4 activities and expanding the reach and impact of mycotoxin management efforts.

A PHI-WP5 team in CIP, AfricaRice, and Bioversity received complementary funding support (US$ ~50K) from the CGIAR Gender Impact Platform in 2023 to implement case studies and a regional workshop in Africa.

Section 7: **Adaptive management**

RECOMMENDATION	SUPPORTING RATIONALE
Focus on a set of prioritized, high-impact objectives under each Work Package, especially: (i) innovations already in the pipeline (stages 1 to 4) to advance product development along the Scaling Readiness pathway (stages 5 to 7), (ii) scale-up validated innovations to increase adoption by the farmers; and (iii) generate more useful "knowledge products" relevant for different types of stakeholders (researchers, farmers, policy makers).	In the final year of this Phase 1 of the Initiatives, we should prioritize further development and scaling of innovations already reported in prior years to ensure maximum impact of the investments in these. We should also focus on the development of knowledge products that are highly relevant and applicable to diverse stakeholders.
Promote more integration among scientists working on different crops and different CGIAR Centers and partner institutions to work together for effective plant health management with a landscape/ agroecology perspective.	Smallholders normally grow different crops with different phytosanitary problems that require integrated solutions. We may need to change the way Initiatives are funded and allocate mandatory budgets for multi-Center, multi-Initiative activities to promote dynamic interactions among the CGIAR Centers and partners to develop/validate/deploy multiinstitutional and transdisciplinary innovations.
Improve cohesion among diverse practitioners across institutions globally working on P&D data management and risk modelling for cross-learning and development of integrated tools useful for multiple P&Ds and regions.	The PHI-WP2 team across CGIAR Centers have been working independently on different P&D cases using different models for P&D risk prediction. Strengthening the community of practice on P&D data management and risk modelling will help improve cohesion, cross-learning, and adoption of standard approaches for P&D risk prediction and management.
Develop risk mitigation and contingency plans for newly emerging P&Ds identified based on risk models developed under the Plant Health Initiative.	The PHI-WP2 team has developed tools and models to identify predisposing factors and to predict P&D emergence. These will be handy in preparing P&D outbreak mitigation and contingency plans for newly emerging threats to guide control measures in the targeted LMICs in the global South.
PHI may further prioritize research areas to align with the budget and identify opportunities to leverage bilateral projects. Budget allocation for CGIAR and non-CGIAR partners would need to be revisited if the trend of budget reduction for PHI continues. Our artners require additional budget allocations, but it is not possible to meet their needs unless the Initiative budget grows.	Continuous budget cuts since the start of PHI in January 2022 have forced us to cut several important activities demanded by our stakeholders. Also, due to the financial calendar of the Initiative, subgrant funds to non-CGIAR partners are typically distributed only in the second quarter of the year, which does not align well with the crop calendars in many regions. And because there will be a reorganization of the CGIAR Research Portfolio to 2025, with the Initiatives (in their present form) closing by 31 December 2024, all the subgrant activities must be closed by this year end. These two facts mean that there is a shorter implementation period for the subgrantees than in the previous two years, and that fewer subgrantees will be able to deliver in the given period due to local crop calendars.

Section 8: **Key result story**

Data-driven smart tools for countering emerging crop pests and diseases in Africa, Asia, and Latin America

PHI employs data tools, AI, remote sensing, habitat data, and biology to predict and prevent pest and disease outbreaks in LMICs.

Demonstration of digital tools for banana disease surveillance to quarantine officers in Nigeria. Credit: Lava Kumar (IITA)

Primary Impact Area

Contributing Initiative

Plant Health

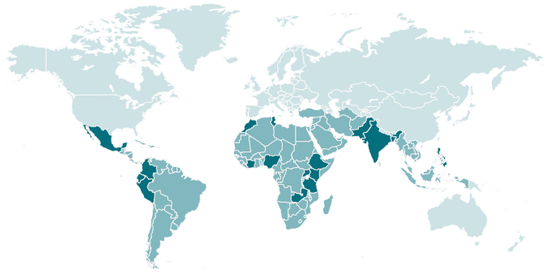
Contributing Center(s)

AfricaRice · Alliance of Bioversity International and CIAT · CIMMYT · CIP · ICARDA · IFPRI · IITA and IRRI

Contributing external partner(s)

Bangladesh Wheat and Maize Research Institute · Borlaug Institute for South Asia, India · Brazilian Agricultural Research Corporation (EMBRAPA) · Ethiopian Institute of Agricultural Research · icipe, Kenya · Indian Council of Agricultural Research, India · Institut National des Grandes Cultures, Tunisia · Institut National de la Recherche Agronomique, France · Instituto Nacional de Investigaciones Agropecuarias, Ecuador · Instituto Nacional de Investigaciones Forestales, Agricolas y Pecuarias, Mexico · Lebanese Agricultural Research Institute · Kenya Agricultural and Livestock Research Organization · National Crops Resources Research Institute, Uganda · National Root Crops Research Institute, Nigeria · Pakistan Agricultural Research Council · Punjab Agricultural University, India · University of Cambridge, UK · Université Catholique de Louvain, Belgium · Université Félix Houphouët-Boigny, Côte d'Ivoire · University of Passo Fundo, Brazil · University of Sheffield, UK · Zambia Agricultural Research Institute

Geographic scope



Regions:
Sub-Saharan Africa · Central and West Asia and North Africa (CWANA) · Southeast Asia · Latin America

Countries:
Bangladesh · Colombia · Cote d'Ivoire · Ecuador · Ethiopia · India · Kenya · Lebanon · Mexico · Morocco · Nigeria · Pakistan · Peru · Philippines · Tunisia · Tanzania · Uganda · Zambia.

In 2023, PHI's WP2 team honed data-driven tools to combat rapid-spreading P&Ds in both perennial and annual cropping systems. Utilizing cutting-edge data processing, remote sensing, machine learning, and AI, these efforts enable tools and procedures for early detection, mapping, and monitoring of crop infestations, averting large-scale outbreaks. The TUMAINI Banana Disease Dashboard, alongside advancements in wheat rust monitoring, climate modeling, and pathogen genomic surveillance strengthens plant health biosecurity policies against economically significant P&Ds in LMICs.

In 2023, the PHI WP2 team on "Risk Assessment, Data Management, and Guiding Preparedness for Rapid Response" enhanced data-driven decision-support tools to combat invasive pests and diseases (P&Ds) with potential to spread rapidly and significantly disrupt agricultural production and farmer livelihoods. The team successfully leveraged past advancements and integrated novel innovations to track P&Ds within both perennial and annual cropping systems. A few achievements are highlighted here.

Predictive tools for managing disease in banana farming: Addressing invasive diseases such as banana bunchy top disease (BBTD), fusarium wilt, and bacterial wilt, a collaborative effort by the Alliance of Bioversity International and CIAT, IITA, and their partners generated significant innovations. A TUMAINI Banana Disease Dashboard[1] leverages a decade's worth of surveillance data (50,000 GPS points catalogued across 15 countries) and data analytics to visualize and track patterns in the spread of banana P&D. Additionally, remote sensing and AI transformed banana-mapping[2] within African mixed farming systems. Utilizing data obtained from synthetic aperture radar, unmanned aerial vehicle imagery (45,000 images), and ground-truthing with GoPro cameras (150,000 images), the team developed AI models with an 80 percent accuracy rate in predicting banana areas, and enhancing disease risk modelling and surveillance decision-making. A custom-trained Yolo-v8 AI model was developed to conduct surveys of banana fields using unmanned aerial vehicles that distinguish healthy and infected plants[3]. Logistic regression techniques were employed to determine environmental conditions conducive to BBTD spread across the African landscape, bolstering landscape surveillance and decision support[4].

Innovations in monitoring P&Ds in an annual cropping system — the case of wheat: Collaborating with partners, the PHI team at CIMMYT utilized cutting-edge sensor technologies to map and monitor rust occurrences in wheat. Leveraging unmanned aerial vehicles and ultra-high-resolution satellite sensors, the team monitored wheat rust in on-station and on-farm experiments and identified 18 spectral features as predictors of rust diseases and yield impact[5]. Using Random Forest AI models and Sentinel-2 satellite data, high-resolution static and dynamic wheat distribution maps were generated, enhancing forecasting models for rust vulnerability in Ethiopia[6]. In tandem with remote surveillance efforts, Yellow Rust Resistance Monitoring Network sites were established for tracking the evolution of resistant-breaking strains and evaluating the performance of newly bred wheat varieties against existing strains. The data collected facilitate informed breeding decisions that support development of more resilient wheat cultivars[7].

Other advancements have fortified predictive modelling capabilities centered on harnessing biophysical data. These include release of an enhanced insect life cycle modelling web platform to elucidate climate change effects on insect pest outbreaks[8]. Additionally, an upgraded EPIRICE model has been devised to forecast the impacts of weather factors on rice blast and rice brown spot dynamics across Africa and Asia[9, 10]. Another module, integrated into the NextStrain web, facilitates tracking cassava geminiviruses in Southeast Asia and cassava potexviruses in LAC[11]. A simulation model blending African armyworm bioecology with AI algorithms was developed to predict and prepare for pest outbreaks[12]. In addition, with text mining and AI technologies, we created a global media analysis tool for tracking reports of P&D occurrences[13].

We also employed genomic surveillance to gauge the influence of pathogen genetic diversity on crop disease control. This work investigated viruses afflicting chickpea and lentil in Ethiopia, faba bean in Tunisia[14], yam mosaic virus in Nigeria[15], rice yellow mottle virus in Nigeria[16], toradovirus in potato associated with rugose symptoms in Peru[17], and post-flowering stalk rot pathogens in South Asia (9,265).

These innovations from the multidisciplinary approach of WP2 contribute to the country's preparedness to counter economically important P&Ds and augment plant health biosecurity policies.

Annexure 1: Additional Key Result Stories from PHI in 2023

NOTE: In addition to the Key Result Story reported above on "Data-driven smart tools for countering emerging crop pests and diseases in Africa, Asia, and Latin America" under PHI-WP2, the PHI team's efforts have led to four additional Key Result Stories emanating from the work done with partners globally in 2023 under WP1, WP3, WP4, and WP5. These can be accessed through the **hyperlinks** below.

PHI Work Package	Key Result Story
WP1	Tools for detection, monitoring, and surveillance of crop pests and diseases
WP3	Innovations for integrated management of major crop pests and diseases in the Global South
WP4	Fostering public-private collaboration for scaling mycotoxin mitigation tools in Africa and the Americas
WP5	Gender and Plant Health Global Research Network tackling gender barriers in technology development, adoption, and scaling

Front cover photo

A lead farmer explaining integrated virus and vector management on faba bean at the Plant Health Innovation Platform in Lebanon.
Credit: Safaa Kumari (ICARDA)

Back cover photo

Wheat yellow rust sample collection by KALRO Pathology Team.
Credit: Eric Githinji (KALRO)

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