



CABI Science Strategy 2022–2025

KNOWLEDGE FOR LIFE

CABI improves people's lives worldwide by providing information and applying scientific expertise to solve problems in agriculture and the environment



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Executive summary

CABI's mission is to 'improve people's lives worldwide by providing information and applying scientific expertise to solve problems in agriculture and the environment' in a changing climate. The majority of CABI's development work is thus in the application of scientific knowledge, rather than in pure research programmes. However, CABI's implementation projects are supported by a core programme of research into invertebrate pests, plant diseases and weeds, and the use of climate-smart pest management methods including nature-based plant protection inputs which can control them. To support farmers with the information they need, CABI will continue to design, validate and evaluate extension approaches and communication tools, to optimize reach and impact of public and private sector advisory services. The principal beneficiaries of CABI's scientific research programmes are farmers (women, men and youth) gaining access to sufficient safe and nutritious food, as well as improved livelihoods from better market access, through sustainable, climate resilient agriculture in healthy ecosystems.

This document outlines CABI's strategic objectives and Priority Research Areas through to 2025 to support the delivery of the current CABI Medium Term Strategy, 2020–2022 and to feed into the next CABI Medium Term Strategy, 2023–2025. It provides a medium-term context for shorter-term decisions and to guide programme and project development, planning and resource allocation.

Climate change and gender and social inclusion are two overarching drivers for this Science Strategy, which will be considered in all CABI's research. In order to achieve its strategic goals of the Medium Term Strategies, CABI will align its research programme with its development agenda by investing in the following Priority Research Areas within its overall programme:

- **Priority Research Area 1:** The impact of pests. Quantifying the impact of pests (invertebrate pests, plant diseases and weeds) on livelihoods, yield, biodiversity, and ecosystem functioning as affected by climate change
- **Priority Research Area 2:** Management of invasive alien species. Developing, validating and evaluating climate-smart ecosystem management approaches for invasive species to tackle emerging pests that threaten crops and livelihoods on the one hand and protect and restore biodiversity on the other
- **Priority Research Area 3:** Improved and safer food systems. Evaluating the advocacy of safe and effective biological control-based plant protection systems by advisory services, their use by farmers and its impact on production, quality and safety in plant health systems
- **Priority Research Area 4:** Advisory services and communications tools. Designing, validating and evaluating new extension approaches and communication tools to meet female and male farmers' needs

Complementing CABI's Priority Research Areas, we anticipate several cross-cutting research approaches which will underpin and add value to the Priority Research Areas: modelling and data science, molecular biology and microbiology, and monitoring and evaluation. The need for specific support areas is also recognized: access to genetic resources and benefit sharing, data management and data sharing, CABI's Ethical Review Board (ERB), and commercialization of selected research outputs.

The quality and quantity of CABI's research outputs and their contribution to achieving CABI's mission will be monitored and assessed within CABI's Medium Term Strategies and associated Key Performance Indicators (KPIs) and milestones. This Strategy also explains how CABI's research will be disseminated in line with our policy on open access publication¹, and how its external impact will be measured and monitored.

1. CABI's Knowledge Management Strategies, <http://www.cabi.org/about-cabi/business-policies-and-strategies/>

Introduction

CABI's mission is to 'improve people's lives worldwide by providing information and applying scientific expertise to solve problems in agriculture and the environment'. The principal beneficiaries of CABI's scientific research programmes are farmers (men, women and youth) gaining access to sufficient safe and higher quality food, as well as improved livelihoods from better market access through sustainable, climate resilient agriculture in healthy ecosystems. CABI's scientific research programmes are mainly externally funded by development agencies, national and state agencies, farmer associations, foundations, universities and the private sector.

CABI's strength has always been its objective, science-based approach² with a unique combination of hands-on research and high-quality publishing expertise. In recent decades this has been augmented by greater involvement in making a real difference worldwide by putting research into use through large scale development cooperation projects and programmes, implementing sustainable agricultural practices and raising the incomes of poor rural farmers. This is reflected in the growing importance of social and economic science in CABI's Science Strategy.

CABI is recognized as a world leader with a strong scientific reputation in invertebrate pests, plant diseases and weeds, and the use of climate-smart pest management methods including nature-based plant protection inputs which can control them. To support farmers with the information they need, CABI will continue to design, validate and evaluate extension approaches and communication tools, to optimize reach and impact of public and private sector advisory services. Working with CABI's Member Countries, the discovery, evaluation and use of biological control agents is a major activity contributing to the successful control of many pests, and a platform for the development and implementation of integrated pest management contributing to sustainable agricultural production around the world.

Innovation has been an essential aspect of CABI's research and publishing throughout its history of more than 100 years, keeping CABI relevant to its Member Countries. In recent years, the award-winning Plantwise programme, building on the plant clinic concept, has received widespread recognition for its contribution to strengthening national agricultural extension systems. CABI's Action on Invasives global programme focused on strengthening national and regional capacity to respond to emerging invasive pests. This included identifying and managing risks before invasion occurs, and improving coordinated responses to invasions through effective communication and deployment of sustainable agricultural technologies. Building on lessons learned from Plantwise and Action on Invasives over the past 10 years, CABI's newly launched global programme PlantwisePlus will support low and lower-middle income countries to predict, prepare themselves for, and prevent plant health threats in a changing climate – reducing crop losses and empowering farmers to increase income, food security and food safety by producing more and higher quality food.

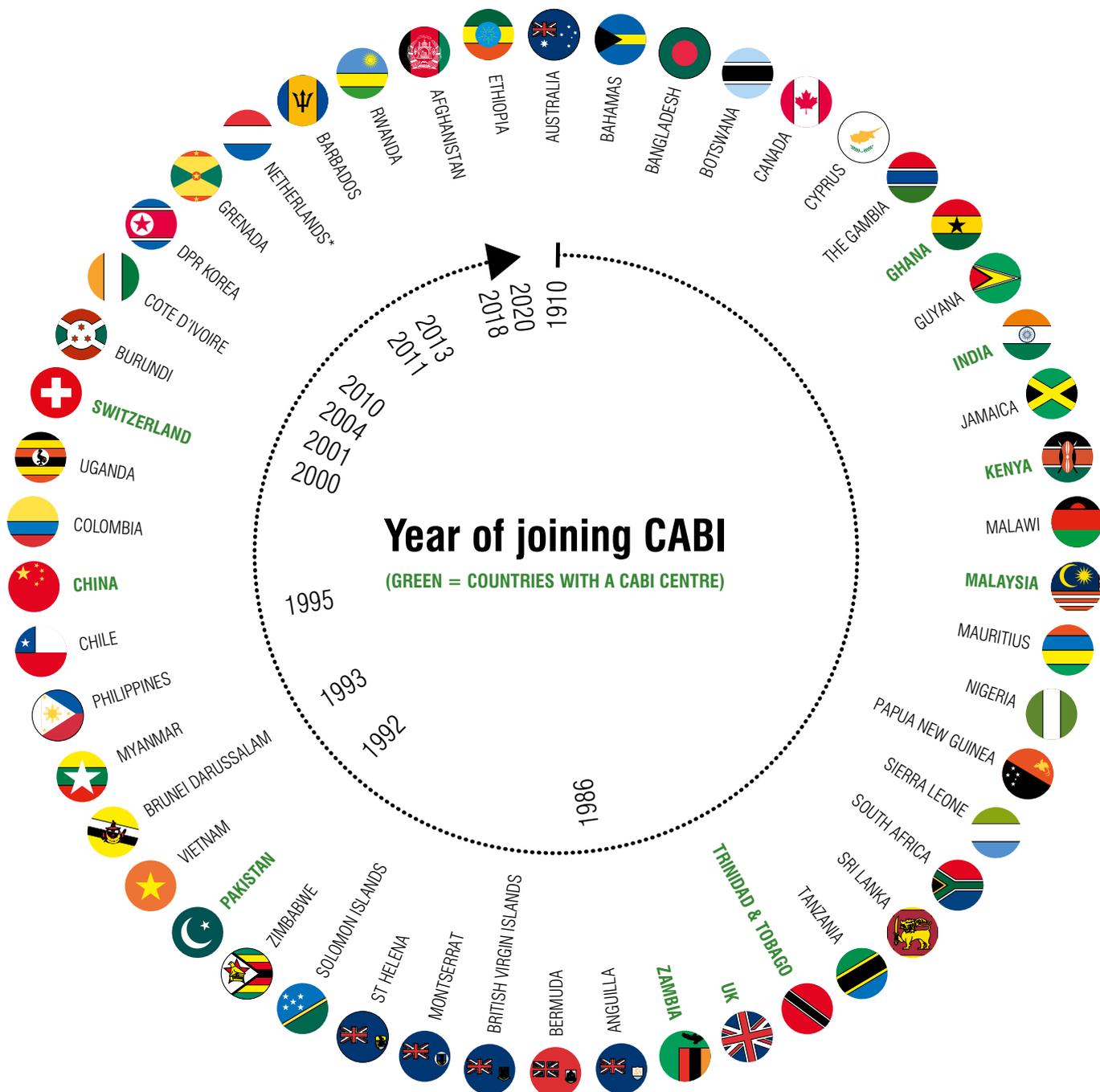
Crucially, all of CABI's scientific and development programmes have been enhanced by the added value provided by the publishing programme, either through the compilation and distribution of the CAB Abstracts database or through the direct publication of CABI's scientific knowledge. The Plantwise Knowledge Bank has been acknowledged as a key differentiator for the Plantwise programme, not only providing a platform for information dissemination, but also a system for data gathering and analysis. More recently, the CABI BioProtection Portal contributes to the awareness of registered bioprotection products at the advisory service provider and farm level which in turn will facilitate the uptake of these nature-based pest management products.

CABI depends on its strong international network of relationships that keep its finger on the pulse of what is important in the world and to its Member Countries. Its unique system of governance by its current 49 Member Countries (please refer to diagram on page 6) keeps it in touch with governmental priorities, while staff and partners working on projects around the world are experiencing daily concerns and challenges of farmers working on-the-ground. The PlantwisePlus programme keeps CABI in close contact with national agricultural systems in a number of countries; this collaboration, and data from the plant clinics and digital decision support tools, provides further insight to identify research gaps and needs, where CABI can assist national programmes. CABI's scientific research, therefore, is always led by human need and designed for practical application. There is a key role for an organization that combines scientific expertise with the ability to bridge the gap between science and development.

2. CABI Policy and Guidelines for Proper Scientific Conduct in Research <http://www.cabi.org/about-cabi/business-policies-and-strategies/>

Diagram showing when Member Countries joined CABI

(Countries with a CABI centre shown in green text)



AFRICAN
GREEN
REVOLUTION
FORUM 2019
3-6 SEPTEMBER
ACCRA, GHANA
www.agrf.org

GROW DIGITAL

Leveraging digital transformation to
drive sustainable food systems in Africa



Partnerships

Partnerships

Collaboration with national programmes, particularly those of Member Countries, is a long-standing feature of CABI's research; joint research and training programmes are important for building national programme science capacity. All four Priority Research Areas outlined in this document will be relevant to CABI's low- and lower-middle-income Member Countries, and two areas will be of particular relevance to our upper-middle- and high-income Member Countries. CABI's science will therefore make a difference in all Member Countries, taking into consideration local context including policy and institutional frameworks.

CABI will maintain its active programme of research, development and implementation, working closely with farmers, extension systems, national research institutes, non-governmental organizations and the private sector across a wide range of crops and ecosystems. Building meaningful public-private partnerships will underpin much of the future agenda in development.

CABI will continue to work and further strengthen its partnerships with other high-profile research entities (universities, national and international research organizations) in order to gain access to complementary scientific skills (and where appropriate develop its own skills base), to facilitate graduate student involvement and to access research-specific funds.

CABI is a recognized observer at the G20 Chief Scientists of the Ministries of Agriculture meetings, where we help present a perspective from lower-income countries to the global research agenda. This role provides opportunities to engage with G20 Chief Scientists and representatives including those from international agricultural organizations, such as the Food and Agriculture Organization of the United Nations (FAO), the Consortium of International Agricultural Research Centers (CGIAR) and other international agriculture research centres.

CABI has been actively working with the FAO through The Global Action for Fall Armyworm Control, participating in technical committee meetings, in particular regarding biological control and communication with farmers. This involvement has provided opportunities for involvement in research projects in the affected regions and we are exploring the scope for an institutional level partnership.

Our role as a partner in collaboration with CGIAR centres (particularly the International Institute of Tropical Agriculture (IITA), International Centre for Tropical Agriculture (CIAT), International Maize and Wheat Improvement Centre (CIMMYT) and International Rice Research Institute (IRRI)) will help put research into use more effectively. CABI will continue to be an active participant in the Association of International Research and Development Centers for Agriculture (AIRCA), increasing food security by supporting smallholder agriculture and rural enterprise as part of healthy, sustainable, climate-smart agricultural intensification at the landscape scale. From 2022, the EUPHRESKO network (EUPHRESKO = EU Plant Health RESearch COllaboration) and CABI have agreed to become reciprocal members for mutual access to our respective networks and can mutually reinforce the importance of plant health research across our complementary memberships.



Strategic objectives and Priority Research Areas

Strategic objectives and Priority Research Areas

The goal of the CABI Science Strategy 2022–2025 is to provide strategic objectives and define priority research areas to support the delivery of the CABI Medium Term Strategy, 2020–2022. It will inform the 2022 CABI Regional Consultations and feed into the CABI Medium Term Strategy for 2023–2025. The CABI Science Strategy will help define CABI's role and provide long-term context for shorter-term decisions and to guide programme development, planning and resource allocation.

Internal and external strategic alignment

The CABI Science Strategy has been developed taking into consideration the research achievements under the CABI Medium Term Strategy 2017-2019 as well as the recommendations of the external CABI Science Review 2020-2021, and the views of CABI's senior management and staff. The CABI Science Strategy is aligned with CABI's goals, desired outcomes and outputs as outlined in the CABI Medium Term Strategy 2020–2022. This ensures that CABI's research will contribute to delivery of the Sustainable Development Goals (SDGs), particularly SDGs 1, 2, 4, 12, 13, 15 and 17³.

This Science Strategy addresses the needs of Member Countries in helping them to respond to the challenges highlighted in the CABI Regional Consultations 2018–2019 such as climate change adaptation including invasive species management, safer plant health systems producing more and higher quality food, and ecosystem restoration. Finally, this Science Strategy will underpin the delivery of the flagship global programme, PlantwisePlus, which sets out an ambition to support smallholder farmers to transition to safe and sustainable climate-smart production systems.

Externally, this Strategy responds to the ultimate challenge of how the world will feed 10 billion people by 2050, in the face of climate change. It can support CABI Member Countries to achieve the Paris Agreement goals and help them to implement their respective national climate change policies and plans, including their Nationally Determined Contributions. The need for improved research and action in plant health systems to respond to the growing pressures of climate change is clear.

CABI considers a plant health system as consisting of all organizations, people and actions whose primary intent is to promote, restore or maintain plant health. A plant health system needs to recognize the interactions between biotic and abiotic stresses on crops, including the impacts of climate change driven shocks and slow-onset hazards. The components of, and actors within, the system include: extension, research, inputs, finance, policy and standards. While the components exist in some form in every country, the linkages between different elements are often weak and rarely operate as a coherent system. CABI will focus its research to address these bottlenecks, capacity weaknesses and technological deficits, in order to reduce crop losses and promote plant health.

Furthermore, CABI is well-positioned, through this Science Strategy and complementary policies, to support Member Countries in fulfilling relevant international obligations and following international guidelines, including:

- The Convention on Biological Diversity and Nagoya Protocol on Access & Benefit Sharing
- The World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures
- The International Plant Protection Convention
- The International Code of Conduct on Pesticide Management
- The Cartagena Protocol on Biosafety

3. <https://sustainabledevelopment.un.org/sdgs>: 1 – no poverty; 2 – zero hunger; 4 – quality education; 12 – responsible consumption and production; 13 – climate action; 15 – life on land; 17 – partnerships for the goals



Overarching research drivers

Overarching research drivers

The world is warming and weather patterns changing due to rising levels of greenhouse gases in the atmosphere. Species are variously shifting their ranges upward and poleward, adapting to the changes, and going locally and globally extinct. This applies to pests of agricultural production, which already cause substantial losses and costs, as well as invasive species in valuable natural ecosystems. In addition to ongoing challenges such as soil erosion, water, overuse of agro-inputs, land ownership, and access to credit, farming systems need to adapt to the changing climate and address new and changing pest problems. Equally, those involved in safeguarding our ecosystems will need support to address changing invasive species problems in targeted, safe and economic ways.

Mainstreaming gender in CABI's work will contribute to understanding how gender social relations and underlying power dynamics affect women, youth and excluded groups' participation in and benefit from development interventions.

Climate change

Scope

Climate change is impacting agriculture across the globe. Smallholder farmers are particularly vulnerable to the growing negative impacts of climate change, including shocks from extreme weather events – made more frequent and more severe by climate change – and slow-onset hazards including shifting seasons and higher temperatures, massively disrupting crop production. It is also changing the risks from pests, weeds, and diseases, with shifts both poleward and to higher altitudes, while simultaneously crops may become less resilient to attack.

CABI's approach

The Adaptation Research Alliance⁴ is a global collaborative effort to catalyse increased investment and capacity for action-oriented research that supports effective adaptation to climate change – primarily in low- and lower-middle-income countries. CABI is a member of the alliance, which is finalizing a set of principles for collaborative climate change research that will guide our work. Addressing climate change in CABI's scientific work is imperative to ensure other activities are not undermined, and that the impact of this critical variable is considered in all that we do. This includes consideration of:

- research to understand how to best build resilience to the impacts of climate change in agricultural systems and value chains
- research to identify adaptation techniques, technologies, and strategies to adapt to climate change impacts
- research to identify ways of reducing greenhouse gas intensity of crop production, and sequestering soil organic carbon through land management approaches

CABI has pioneered the climate-smart pest management concept emphasizing nature-based solutions, and this should guide the organization's approach to scientific work and research in this area. This means considering the complex relationships between biotic and abiotic factors in smallholder farming systems, short-term and long-term analyses of pest and disease risks under different climate scenarios, and the need for timely, accurate, and actionable information for smallholder farmers to minimize risks to their production and livelihoods.

Examples of research questions

The impacts of climate change will be pervasive across all areas of agricultural development and environmental management in the coming years and decades, which will necessitate its consideration across all CABI's Priority Research Areas for example:

- How does climate change affect the pest and disease risks in different areas?
- How can climate-smart pest management approaches enhance the resilience of smallholder agriculture to biotic and abiotic stresses?
- How great is the mitigation potential of biocontrol products and associated sustainable management approaches vs conventional products and approaches?

4. https://southsouthnorth.org/portfolio_page/adaptation-research-alliance/

- How does climate change affect the plant microbiome, and what are the opportunities for enhanced mitigation and adaptation technologies developed through microbiome research?
- What are the potential trade-offs and benefits of climate-positive income generation opportunities for smallholder farmers, such as including payments for ecosystem services, biodiversity protection, carbon credit schemes, and low-carbon production premiums?

Potential outcomes

While each of the different areas of science and research questions will have a range of specific outputs, overall, they should together contribute to the following outcomes:

- better understanding of climate change impacts on pest risk and pest-plant interactions
- quantification of mitigation impact/potential of the use of biological control and landscape restoration
- documenting the role of climate-smart pest management as a nature-based solution to climate change impacts on agriculture
- more informed farmers better equipped with scientifically backed approaches and technologies to cope with the impacts of climate change

Key areas of scientific skills which CABI will need to develop

Further effort through internal learning mechanisms and formal training is required to support staff across the organization to better understand the role that climate change is playing, and will play, in their areas of work and expertise. Moreover, CABI could benefit from working with a strategic roster of external experts to help implement scientific research work in both locations and in specific topics where it currently lacks internal capacity.

Gender and social inclusion

Scope

Mainstreaming gender in CABI's work is about understanding how gender social relations and underlying power dynamics affect women, youth and excluded groups' participation in and benefit from development interventions. It involves a twin track approach of applying a gender lens across projects and programmes and targeted actions to advance empowerment of women and girls. Gender needs to be integrated:

- to ensure women, youth and other socially excluded groups benefit equitably from development investments
- to ensure we do not perpetuate existing gender inequality in our development interventions
- to enhance the impact of development investment, to have better sector-specific outcomes.

CABI's approach

CABI follows a three-pronged approach on gender and social inclusion. We aim to mainstream gender internally in our organizational policies and practices and develop internal staff capacity on gender and social inclusion. This includes on-going gender training for staff, pro-active hiring and promotion of women social scientists within the organization.

Secondly, CABI aims to ensure that gender considerations are integral throughout its project and programme work from design to implementation and evaluation. When programmes are designed to address a specific issue or problem, we will include an analysis of the social context in which the problem exists. Hence, we aim to understand who is most affected by the problem and how the problem affects different categories of people based on gender and other social stratifications, such as, age, ability and social status. This understanding will inform the programme and project design and intervention.

Finally, CABI aims to generate evidence and facilitate learning on gender and social inclusion internally within the organization, and externally in sector platforms, based on lessons from its programmes and projects.

Examples of research questions

CABI will generate evidence on specific gender issues and problems within its work to inform the design and implementation of its approaches. Research questions may include:

- What are the existing gaps and good practices in provision of gender sensitive rural advisory services and how can CABI bridge these gaps and replicate good practices?

- What factors influence women's participation in and benefit from interventions to improve crop value chains and how can CABI's interventions empower women in the value chains?
- What are the drivers and barriers for uptake of improved invasive pest management technologies and practices by men and women farmers, and what role do existing gender relations play in facilitating or hindering uptake?
- What is the gender gap in access to knowledge through ICTs, and what approaches can help to bridge this gap?
- What factors influence women's access to and control of assets and resources, and how can CABI's interventions improve women's access and control?
- How do existing gender-based social norms influence or affect project implementation and what approaches can be used to shift social norms?

Potential outcomes

- Results of gender sensitive rural advisory services and value chain assessments used to tailor interventions to improve women's participation and benefits
- Assessments of drivers and barriers to technology uptake by women and marginalized groups guiding technology development, dissemination and promotion strategies
- Evidence about the causes and effects of gender gaps in the use of ICTs for agricultural information provision; testing of successful approaches to bridge the gap used to inform inclusive design and implementation of ICT approaches for communication of agricultural information
- Understanding of gender-based social norms in food systems is used to inform design of interventions that contribute to the empowerment of women

Key areas of scientific skills which CABI will need to develop

There has been progress in developing gender skills in recent years, through recruitment of a gender specialist, and capacity building in gender skills for CABI staff. However, the demand for gender skills has consequently increased, and there is a need to recruit additional staff with gender expertise.

A photograph of a man standing in a field of tall grass. He is wearing a white cap and a white polo shirt. He is looking down at the ground. The background shows a blurred landscape with trees and hills.

CABI's Priority Research Areas

CABI's Priority Research Areas

CABI's core scientific strength supports the required transition process to sustainable agriculture. This in turn improves climate resilience in sustainable food production, resulting in more, higher-quality and safer food, protecting biodiversity from the impacts of pests and emphasizing nature-based, safe and appropriate approaches and techniques. Applying our expertise in socio-economic and biological sciences, we will work with women and men farmers, national programmes and other players to minimize these negative impacts. Within this broad remit, we identify four Priority Research Areas as follows.

Priority Research Area 1: The impact of pests

Quantifying the impact of pests on livelihoods, yield, biodiversity, and ecosystem functioning as affected by climate change.



Scope

Invasive native and non-native pests, plant diseases and weeds (in the following referred to as 'pests') pose serious risks to biodiversity and to ecosystem services that are fundamental to human well-being. Climate change is altering the distribution and abundance of pests, which is likely to create novel or accelerate existing risks to livelihoods, crop production, food security and ecosystem resilience. Besides their impact on the agricultural sector, invasive species also contribute to human-caused global environmental change as they threaten biodiversity and ecosystems services, such as the availability of water and fodder, pollination, and the regulation of human and animal diseases. Establishing a thorough understanding of pest impacts in social-ecological systems is complex and requires well-planned and coordinated inter- and trans-disciplinary work. There is a paucity of high-quality evidence and data on impacts of invasive native and non-native pests, and much of the data that does exist is geographically biased towards high-income countries.

CABI's approach

CABI will use inter- and trans-disciplinary research collaborations to quantify the environmental, economic and social impacts of pests on social-ecological systems. We will follow the best practice principles of inclusive, collaborative, and demand-led action research. A holistic approach will be used to understand how these impacts interact with other drivers of global change, including climate change, land use and trade. In parallel, we will continue to analyse the impact of native and invasive non-native pests on selected socio-ecological systems, collate and curate relevant datasets to identify gaps, conduct surveys and other field work to fill data gaps, such as ground-truth earth observation data. Evidence synthesis approaches such as systematic reviews, systematic maps, and meta-analyses will identify patterns and trends. Research outputs will be used to prioritize invasion pathways and create awareness and preparedness of management options to reduce risks of the most damaging new invasive species introductions.

Potential research outputs, 2022-2025

- Rigorous timeseries estimates of the scale, causes and pattern of crop losses due to pests and the economic burdens that these cause
- Estimates of the environmental, social, and economic impacts of individual selected pests
- Predictions of the potential distributions of invasive species under climate change, and hence potential future invasions and invasion pathways
- National and regional protocols to create awareness and management options to reduce risks of the most damaging new invasive species introductions

Potential outcomes

Realistic assessments of the potential damage and crop losses due to pests will be used by national programmes to develop plans for surveillance systems and associated decision-making processes for managing invasive species. Research outputs will provide a basis for developing activities under Priority Research Area 3, which will address climate-smart pest management approaches. Baseline data will be available to assess the value of pest management interventions, and develop understanding of their resilience to global change and possibilities for adaptive management.

Key areas of scientific skills which CABI will need to develop

Interdisciplinary and transdisciplinary thinking and working will be encouraged to combine CABI's biological, environmental and social science skills in collaboration with key local partners. We will need to strengthen skills in non-linear modelling and complexity-systems oriented modelling to understand current and future impacts of pests and associated crop losses.

Priority Research Area 2: Management of Invasive Alien Species

Developing, validating and evaluating climate-smart ecosystem management approaches for invasive alien species to protect and restore biodiversity.



Scope

Invasive alien species (IAS) are a major cause of agricultural crop yield reductions and the loss of indigenous biodiversity. One of the most environmentally-friendly, sustainable and cost-effective methods for IAS management is biological control. Depending on the circumstances, this method may work on its own. However, more often, an integration of different methods is needed for successful management. In some cases, an integrated landscape management approach is required that also addresses the underlying reasons of invasion, such as altered disturbance regimes or climate change, human interventions and mis-management (eg overgrazing). The aim of IAS management depends on the specific environment invaded and stakeholder needs. Although an increasing number of studies exist, validating and evaluating the success of biological control and integrated ecosystem management of IAS are still not an integral part of all projects, and studies that do exist often only look at the direct effect on the IAS itself.

CABI's approach

One of CABI's main areas of expertise is the management of invasive invertebrates, diseases and weeds using classical biological control, often as part of an integrated management approach. To offer a sustainable, long-term solution for IAS management, CABI's expertise on biological control will need to be combined with effective restoration measures and landscape wide management and governance plans which also consider climate change. CABI will continue and/or initiate studies looking more broadly at community responses to IAS control, changes to the supply of ecosystem services, socio-economic aspects and their interactions. We will also quantify the benefit of successful IAS management in relation to climate change, both with regard to adaptation (eg increased ecosystem resilience) and mitigation (eg increased carbon sequestration). CABI will base its overall approach on best practice for inclusive and collaborative transdisciplinary research, including early and continuous stakeholder engagement.

Potential research outputs, 2022–2025

- New biological control agents for recalcitrant or emerging pests that threaten crops, livelihoods and the environment
- Quantified impact of successful IAS management on livelihoods, ecosystem service supply and climate resilience of restored landscapes

- Stakeholders' acceptance and their capacity to respond to IAS management strategies, considering potential trade-offs between socio-economic needs and conservation and/or restoration goals
- Integration of biological control with landscape management to reduce pest densities and crop losses
- Re-establishment of native biodiversity and ecosystem functions following the management of key invasive species

Potential outcomes

Classical biological control is accepted by stakeholders and used for the control of appropriate flagship IAS in partner countries, and in compliance with access and benefit sharing expectations under the Nagoya Protocol. The social and economic impact of successful classical biological control programmes are documented with stakeholders and communicated widely, including to the public. National plans and coordination mechanisms in place for the prevention, containment, management and mitigation of IAS.

Key areas of scientific skills which CABI will need to develop

CABI should increase its ability to work holistically. This includes aspects such as monitoring and evaluating climate-smart and gender sensitive pest management practices, climate resilience and IAS management, social science approaches to measuring adaptive capacity, and evaluating landscape restoration interventions. There is also a need to partner skills in bioeconomic modelling.

Priority Research Area 3: Improved and safer food systems

Evaluating the advocacy of safe and effective biological control-based plant protection systems by advisory services, their use by farmers and its impact on production, quality and safety in plant health systems.



Scope

Improved Integrated Pest Management (IPM) practices safe to humans, crops, animals and the environment are needed to better address key food production and safety issues. This is particularly important in the context of increasing global concerns relating to trade, emerging pests and climate change. CABI works to support the use of climate-smart IPM options within production systems to improve food and nutrition security and safety. As market forces increasingly influence on-farm production decisions, we will seek to understand how to improve uptake of IPM-based solutions, including biological control, and how improved uptake can add produce value through the supply chain from seed to market. Research will be carried out with consideration of the local socio-economic context, including gender and diversity implications. We will also investigate policy factors that affect registration and use of chemical pesticides and biological control products and agents.

CABI's approach

A variety of inter-disciplinary approaches, involving biological and social scientists will be used to develop

and test IPM solutions, and promote their uptake including classical biological control options developed under Priority Research Area 2. The effectiveness and safety of new IPM approaches at smallholder level, including the use of low-risk plant protection products and technologies will be tested. We will monitor and model the potential impacts of climate change on IPM and plant health systems. Studies will be carried out to understand the barriers (both at farm level and in the enabling environment) associated with adoption of less hazardous IPM options and biological control-based solutions, as well as the cost-effectiveness of such approaches. Problem-oriented research will be used to find out how interventions work in the field, including assessing the feasibility and sustainability of locally-run production units for known and newly identified biological control products and agents.

Potential research outputs, 2022–2025

- New climate-smart IPM approaches and products for recalcitrant or emerging pests and diseases identified and tested, addressing the need for registration and availability of low-risk plant production products
- Assessment of barriers preventing uptake of lower-risk IPM solutions
- Analysis of the needs, interests and motivations of advisory services, including agro-input dealers as regards developing capacity for uptake of lower-risk products including biopesticides
- Assessments of the feasibility and sustainability of community-based production of biological control products

Potential outcomes

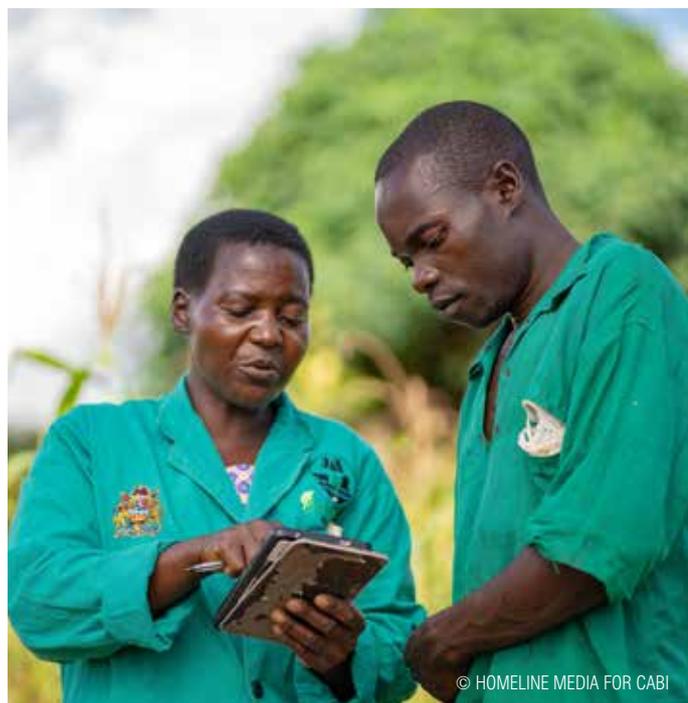
Policy enabling environment facilitates improved and appropriate registration of low risk plant protection products within existing legislation. Farmers and advisory services are more aware of low-risk plant protection products and IPM approaches, which is reflected in increased uptake in targeted crop systems. Local production has improved accessibility, availability and affordability of low-risk plant protection products at the community level, leading to higher quality and safer food production.

Key areas of scientific skills which CABI will need to develop

There is still a need to broaden our social science skills, including additional gender and climate expertise, agricultural economists who are able to undertake market analyses, cost-benefit analyses, value chain assessments etc. Additional statisticians are also required.

Priority Research Area 4: Advisory services and communication tools

Designing, validating and evaluating new extension approaches and communication tools to meet female and male farmers' needs.



Scope

There is a general consensus that lack of actionable information is one of the major constraints to farmer adoption of new technologies and practices. CABI is involved in developing and testing new advisory and communication approaches (including One health approaches), and exploring cost-effective ways to reach and engage with large numbers of farmers in knowledge exchange. Pluralistic approaches to delivering advisory services will be considered including private sector models embedded in agri-businesses. As digital solutions become more prominent, CABI will explore solutions that are adapted to context so that equity issues around access to services and information are not exacerbated. Research will inform the evolution of CABI interventions and provide evidence that can be used by others to plan services and scale-up activities. Change at farm level is often a result of change in the enabling environment. Research evidence to be used in advocacy approaches with a broad set of stakeholders beyond farmers including policy and decision makers, investors and farmer intermediaries (agro-input dealers, extension staff etc.) will be a key aspect of our work.

CABI's approach

In order to maximize the effectiveness of our work, we are engaged in an ongoing process of understanding: the enabling environment (including other players and partners in this space), systems in which we operate, and the impacts of our interventions. We will capitalize and build on successful interventions, experimental learning and partnerships. Research approaches include action research, analysis of digital tool analytics data, key informant interviews, focus group discussions and collection of household survey data using experimental and quasi-experimental design. We use these tools to generate evidence about what does and doesn't work, why, and in which

contexts to influence change at a policy level and to inform the work we do in project implementation. Activities to support the principles behind CABI's approach to advisory services and communication tools include:

- needs assessments and participatory approaches involving users and other stakeholders in co-creation of services and tools to ensure our work is demand-driven and that we address real needs and challenges
- gender analyses to ensure that we have a clear understanding of different stakeholders, their different needs and the way that they interpret information
- assessing and testing services and tools (including digital tools) for effectiveness, and accessibility by marginalized groups; recognizing that there is often a trade-off between reaching high numbers and reaching underserved communities
- impact evaluations that consider socio-economic and environmental constraints affecting adoption (eg market access, poor availability of inputs, insecure land tenure etc.)

Potential research outputs, 2022–2025

- Good practice guidelines for gender sensitive rural advisory services based on assessments of advisory and communication approaches and their impact on uptake of new practices and technologies by women farmers and farmers from other marginalized groups
- A comprehensive understanding of the role of digital dissemination and extension approaches, leading to tailored materials and delivery mechanisms that consider when, where and with whom digital approaches are appropriate and beneficial
- Recognition of the needs and requirements of different agri-business advisory service models; including a description of how different models can work and the outcomes of implementing models on reach, cost-effectiveness, relevance and sustainability
- Assessments of the effectiveness (trade-offs between reach and impact) of different advisory and communication approaches in delivering behavioural change at farmer and intermediary level
- Analysis of the commercial and development case for investing in agri-businesses that source produce from smallholders

Potential outcomes

A range of intermediaries are delivering high-quality advisory services sustainably as part of bundled service provision within agri-businesses. Digital solutions are embedded as part of service provision and communication at scale, where appropriate. Use of digital solutions recognizes the need for alternative approaches where infrastructure or farmer capacity presents a barrier. Investors are investing in small and medium enterprises that facilitate the equitable involvement of male and female smallholder farmers. Improved service delivery leads to better decision-making at farm level with higher incomes for farmers, safer food and a reduction in negative impacts on the environment.

Key areas of scientific skills which CABI will need to develop

CABI should continue to develop skills in human-centred design and action research across the organization. Increasing gender expertise will ensure the needs of different stakeholders are identified and met. As methods of training evolve, pedagogical skills should be developed. For projects requiring digital services and tools, CABI should strengthen capacity in user experience, product ownership and data analytics. Additional expertise in evaluation research and impact assessment will also be crucial for demonstrating progress in this area.



Cross-cutting research approaches

Cross-cutting research approaches

Complementing CABI's Priority Research Areas, we anticipate several cross-cutting research approaches which will provide significant inputs to the Priority Research Areas.

Modelling and data science

Scope

Modelling and data science underpin much of the work that CABI undertakes. Applying such approaches across the four Priority Research Areas will rely on the generation and availability of high-quality datasets, enabling robust application of numerical approaches to answer the questions and hypotheses raised. Modelling and analytical techniques can help to guide decision-making from farmer through to policy level and provide much needed guidance in the face of climate change.

CABI's approach

CABI's use of modelling has expanded significantly and there is a growing portfolio of diverse projects that have applied both mechanistic and correlative modelling in fields such as:

- estimation of economic, social and environmental impact of invasive species
- methods to assess yield loss due to different biotic and abiotic factors
- using earth observation data sources to drive early warning/decision support models
- development of species distribution models for pest risk analysis under current and future climate scenarios
- detection and identification of invasive species using remote-sensing

Examples of research questions

Modelling will contribute to the four Priority Research Areas to answer questions such as:

- How can species distribution modelling contribute to pest risk assessment, for example within season modelling to show geo spatial/temporal risk information?
- What best practice approaches can be used to quantify yield, potential yield and application of yield loss methods, to fill gaps for key geographical areas and crops which are data poor?
- Which areas and seasons will be optimal for future potential biocontrol releases, based on within season suitability maps and biological modelling?
- Can models make useful predictions regarding the ecosystem level effects of climate change in the context of management of species?

Potential outcomes

- Better information contributing to pest risk assessments under current and future climate scenarios
- Improved methods and data relating to crop yield losses
- Effective use of biological control agents (both classical and augmentative) through optimization of the timing and location of releases/application
- Improved data-driven information relating to pest monitoring, early warning and management

Key areas of scientific skills which CABI will need to develop

Across CABI, we will need to upgrade the modelling skills of existing staff, hire in new skills, and partner with consultants in growth areas. New approaches such as machine learning and artificial neural networks could be developed to answer more complex ecosystem level questions. Long term we will develop some of these key skills in-house. CABI will position itself as a bridge between highly technical project partners such as university researchers, applied science and extension.

Molecular biology and microbiology

Scope

Molecular biology and microbiology remain central to many areas of CABI science. Assessment of the impact of pests on livelihoods, yields, and biodiversity requires accurate sample characterization and component-organism identification. Molecular biology and microbiology are also valuable in the development of safer food systems, as DNA sequence analysis is used to measure beneficial impacts upon biodiversity. Microbial biological control agents can also be securely archived, through CABI's Genetic Resource Collection (GRC) and associated preservation services. They can also be quality controlled after manufacturing through either DNA sequencing or matrix-assisted laser-desorption and ionization time-of-flight (MALDI-TOF) mass spectroscopy.

CABI's approach

Microorganisms, insects, and plants are identified by conventional Sanger sequencing of 'barcode' DNA regions or by next-generation sequencing (NGS) and, in some cases, very rapidly by using MALDI-TOF mass spectroscopy. In addition to identification, microbial pest samples (including all associated metadata) can be safely archived for future reference – a service that the GRC has long provided and continues to provide for CABI Member Countries, and CABI's programmes, as well as external customers.

Biodiversity can be assessed at the molecular level by techniques including taxonomic-composition NGS (often referred to as 'metabarcoding'), where the various organisms present, before and after intervention for example, can be 'counted' using their barcode DNA sequences for characterization. This approach also enables an 'early warning system' for the detection of new and emerging pests and diseases when they are at very low numbers. Taking this a stage further, we can also investigate not only which organisms are present but also which genes they are actively expressing through so-called metatranscriptomic-NGS – giving a functional as well as compositional insight into biodiversity.

Examples of research questions

Key research questions related to pest impact and biodiversity include:

- Can we measure (beneficial) impacts on biodiversity?
- Can we characterize this at the taxonomic-composition level?
- Can we characterize this at the gene-expression level?
- Can we detect early signs / occurrences of pests?

Key research questions related to invasive-species management include:

- What is the source of an introduction or native range of a pest?
- What natural enemies (species and biotypes) have been collected?
- How can these be best matched to the target pest for optimal management through biological control?

Potential outcomes

- Better (and objective) understanding of biodiversity loss or improvement at the molecular level
- Improved understanding of ecosystems and their biodiversity, based on taxonomic composition and gene-expression
- Optimized discovery of effective biological control agents, including improved matching of biological control strains to target pest populations
- Safe and effective storage of microbial biological control agents

Key areas of scientific skills which CABI will need to develop

Key to the analysis of NGS datasets is state-of-the art skills in bioinformatics, and we need to increase our capacity in this area. In addition, expertise in gene-expression would add considerable value to biodiversity studies.

Monitoring and evaluation

Scope

Monitoring and evaluation is now recognized as a key part of project delivery within CABI, and we continue to integrate the approach within projects and programmes. Evaluation has a strong research element that addresses a broad range of issues, with its main purpose being to determine the effectiveness of a specific programme or intervention digging into causality and contribution. Assessments can include the appropriateness of the intervention design, consider the four 'E's of value for money (economy, efficiency, effectiveness, equity), look for unintended as well as intended outcomes and impacts, and be used to improve current and future interventions.

CABI's approach

Evaluation research will be embedded at project design, so that where appropriate, CABI's projects and programmes include experimental and quasi-experimental designs to identify appropriate control and treatment groups, and to test hypotheses using appropriate control and treatment groups. Evaluation methods will focus on measuring results, and examining causality and attribution. Context analysis will be used to assess how variations within or between countries and regions affect implementation. The choice of evaluation approach will be pragmatic and driven by what is suitable, feasible and affordable in the given situation. A range of evaluation procedures will continue to be used, from complex quantitative randomized control designs to rapid methods of data collection and analysis. The main approaches will be:

- baseline studies (existing statistics, needs assessment, situation analysis or field surveys) to identify priority interventions or areas and to provide a comparison of the situation after interventions
- high-quality studies, using both descriptive and inferential statistics, showing outcomes/impacts at scale
- in-depth impact studies using rigorous methods to demonstrate the impact of CABI's work against the pre-project situation
- qualitative approaches to dig deeper into causality and impact pathways

Examples of research questions

Evaluation research will cut across all CABI Priority Research Areas and work. Research questions include:

- Do farmers experience a reduction in crop losses and increase in income due to adoption of climate-smart plant health practices?
- Is local and regional trade and consumer demand for safer food increasing through the adoption of nature-based solutions?
- Has the introduction of improved IAS prevention and management practices reduced the socio-economic impacts for farmers and/or the effects on ecosystem services?
- Are digital advisory services effective in providing advice to farmers, and has their use contributed to additional demand for such services, especially by youth?
- Are agro-input dealers shifting to recommend and/or selling safer plant protection products?

Potential outcomes

- Results of robust hypothesis testing, including attribution and causality, used to guide project and programme design, learning and adjustments
- Assessments of the efficiency, effectiveness, equity and economy of CABI interventions, used to make choices based on value-for-money
- Evidence of whether CABI's interventions deliver the expected benefits, and/or unintended benefits and consequences, to support accountability to stakeholders and donors
- New approaches for impact assessment applied that contribute to the state of knowledge related to advisory service delivery, uptake of IPM, adoption of climate-smart plant health practices, etc

Key areas of scientific skills which CABI will need to develop

There is a strong demand for interdisciplinary teams of social and biological scientists across CABI's work. Therefore, there is a need to increase the number of staff with evaluation research skills, including economists with good statistical and econometric skills. Some CABI staff have basic skills for evaluation research (including support to field research and descriptive statistics), and their skills could be further developed through training in inferential statistical techniques.



Support activities

Support activities

Access and Benefit Sharing

CABI has implemented practices to ensure compliance with the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity. **CABI's Access and Benefit Sharing Policy** describes how CABI uses genetic resources and describes the benefits it provides in exchange for their use. CABI complies with national legislation on Access and Benefit Sharing (ABS) including those who implement the Nagoya Protocol and will perform due diligence regarding access and benefit sharing in all its activities involving these resources.

CABI will work with other international organizations (eg Secretariat of the Convention of Biological Diversity, Commission on Genetic Resources for Food and Agriculture (**CGRFA**) of the **FAO**, Commission on Biological Control and Access and Benefit Sharing of the International Organisation for Biological control (**IOBC**) amongst others) to support the implementation of mechanisms that do not impede science and recognize the public good as a benefit to be shared from genetic resource use. When appropriate, CABI will make its expertise in this area available to CABI Member Countries and, through consultancies, to assist external stakeholders.

CABI's aims are to engender trust, to facilitate science, and to ensure that benefits are shared. Hence, CABI will not exploit genetic resources for monetary gain without involving the provider country and will be transparent in all its uses. CABI will implement its policy and best practice in all activities where genetic resources are accessed and utilized, in accordance with host and provider country regulations and/or requirements and in the spirit of the Convention of Biological Diversity.

CABI will coordinate and resource mechanisms and approaches to support its staff to remain aware of compliance needs, secure compliant access and use and identify and share appropriate benefits. Support activities in this area will include keeping abreast of the country positions and outstanding issues (eg digital sequence information) in relation to planned and on-going CABI activities; regular review of CABI ABS policy in light of external changes; seeking recognition of CABI centre best practices with national authorities, and regular reporting of the use of genetic resources and ABS compliance.

Data management and data sharing

CABI's Knowledge Management Policies states 'Data and publications generated from our scientific work and development projects should be open and public as default'. We have already made good progress with regard to publications, but need to take further steps regarding open research data. CABI should then be in a position to better advise Member Countries and will use its expertise and global influence to support changes in policy and practice with regard to data use and data sharing, such as the concept of FAIR (findable, accessible, interoperable, reusable) data.

CABI will develop a data strategy and investment plan for research data (including big and complex data sets) to ensure visibility, sustainability and greater use of CABI's data by CABI and its partners, and of the platforms and data infrastructure built over the years. The data strategy will also cover bioinformatics, particularly metagenomics and/or ecological studies so that CABI will continue as a global player in areas such a pest distribution and diagnostics.

A taskforce will be established to produce a data strategy and investment plan which covers how we capture, store, use and disseminate CABI's research data including key areas where metrics and incentives can be implemented on a CABI-wide basis. Representatives across key CABI business areas and Regional Centres will promote full internal stakeholder involvement. Based on a review of CABI's key data assets, where research data is generated, how data is currently stored within projects and programmes, and how these data are currently used, the taskforce will discuss best practice approaches and recommendations for inclusion in the data strategy. We will need to invest in building or partnering capacity and infrastructure to manage and utilize big data, which is inclusive of CABI's Regional Centres. The data strategy will also take into consideration how CABI encourages and incentivizes the adoption of FAIR data principles in-house.

Ethics

CABI is in the process of setting up an ERB for review of all CABI research that involves human subjects. A key aim of the ERB is to protect the rights of research participants. The ERB will consist of the Chair, Vice-Chair and external reviewer as permanent members and call on a body of CABI scientists with additional skills as appropriate for each review. The review process will ensure that all research complies with national and international legislation and regulations, including data protection and retention laws, in line with CABI's Privacy Policy. The ERB will focus on the possible benefits of the research versus the risk to the participants of the research. CABI scientists will need to describe the validity of the research, the research methods, the sampling strategy, the approach to voluntary participation, consent and confidentiality, any potential conflicts of interest and any cultural sensitivities. The ERB will ensure consistency with any national ethics requirements eg the National Commission for Science, Technology and Innovation, Kenya, to ensure CABI and national requirements are streamlined as much as possible.

Commercialization

CABI's research has stimulated the development and use of commercial biocontrol agents. The availability of such agents for priority pests of crops grown in low- and lower-middle-income countries is one of the gaps that we seek to address under the PlantwisePlus programme. Before 2000, CABI was already involved in the development of an effective mycoinsecticide, Green Muscle, for the biocontrol of locusts and grasshoppers particularly in Africa. Green Muscle consists of spores of the fungus *Metarhizium flavoviride* and is applied as an oil suspension using ultra low volume spinning disk spray equipment. CABI owns the product licence and assigned rights to the biocontrol manufacturer Éléphant Vert in 2019 to produce and sell Green Muscle, which is now the sole producer for Green Muscle in Africa and beyond. CABI receives a royalty fee based on the annual product sales. More recently, CABI contributed to several donor-funded project consortia (including the involvement of biocontrol manufacturers) to develop microbial and/or macrobial biocontrol products under strict intellectual property and product licence agreements, although this has not led to commercial returns to CABI. One example is the development of a commercial product for the biocontrol of the western corn rootworm using the entomopathogenic nematode *Heterorhabditis bacteriophora*. The biocontrol manufacturer e-nema is the licence holder of the commercial product dianem and sells the product in Europe based on the project agreement.

CABI's first and most successful research-based commercial venture was the formation of a spin-off company, Conidia Bioscience, in 2000 to develop, manufacture and supply fuel tests in the aviation, marine and land diesel sectors. The product detects microbiological contamination in the fuel tank for middle distillate fuels using a fast, easy-to-use immunoassay antibody technology that gives results in minutes and a digital platform to record the results in the field. CABI retains an equity stake in Conidia, under which it receives a share of profits from the business, and is represented on Conidia's Board.

Another route that CABI has pursued is research collaboration and licensing agreements to develop novel products from CABI's extensive collection of fungi and bacteria. The CABI collection contains 30,000 living microbes (~27,000 fungi ~3,000 bacteria) isolated from agro-ecosystems and the environment. Around 55% are plant-associated, and include endophytes, pathogens and opportunists. The remainder represents strains isolated from environmental systems (rivers, lakes, farmland, extreme environments etc.), supplemented with smaller collections such as entomopathogenic fungi. These fungi are a potential source of enzymes, novel products, novel genes and gene clusters and biologicals for use as nutraceuticals, insecticides, herbicides, nematocides and adjuvants. A research collaboration agreement was signed in 2021 with the company Polypharmakos to evaluate a selected set of extracts from CABI's collection to identify and characterize compounds or mixtures with potential application in therapeutic or consumer products. CABI will earn royalty payments should Polypharmakos succeed in licensing or commercializing products, and also gained an option to acquire an equity stake in Polypharmakos.

In parallel with continuing work to forge specific research and licensing agreements, CABI intends to explore options in partnering with an external, independent expert service provider who would work more broadly across CABI's science output to protect and commercialize the results of research. Under such a partnership, the expert service provider would manage the activities involved in patenting, licensing and/or setting up spinout companies so that CABI can benefit financially from successful commercialization.



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Author(s) Minter, D. W.; Soliman, G. S.
Publisher CABI
Publication IMI Descriptions of Fungi and Bacteria, 2022, 231, pp Sheet 2300

[Abstract](#)

★ [Phallus impudicus](#). [Descriptions of Fungi and Bacteria].

A description is provided for Phallus impudicus. Some information on its morphological characteristics, associated organisms and substrata, dispersal and transmission, economic impacts, habitats and conservation status is given, along with details of its geographical distribution (Africa (Algeria,...

Author(s) Minter, D. W.; Soliman, G. S.
Publisher CABI
Publication IMI Descriptions of Fungi and Bacteria, 2022, 231, pp Sheet 2298

[Abstract](#)

★ [Insect herbivore populations and plant damage increase at higher elevations](#).

Elevation gradients are used as a proxy to simulate climate change effects. A field study was conducted along an elevational gradient in Nepal to understand the effects of abiotic conditions on agriculturally important insect herbivore populations (tobacco caterpillar: Spodoptera litura, tomato...

Author(s) Paudel, S.; Kandel, P.; Bhatta, D.; Vinod Pandit; Felton, G. W.; Rajotte, E. G.
Publisher MDPI AG
Publication Insects, 2021, 12, 12,

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Publication and communication

Publication and communication

Monitoring and evaluation of CABI's research

The quality and quantity of CABI's research outputs and their contribution to achieving CABI's mission will be monitored and assessed within CABI's Medium Term Strategy and associated KPIs and milestones.

Quality and quantity of CABI's research will be monitored based on:

- 100% of peer-reviewed journal papers with CABI as lead/corresponding author are open access
- move towards 100% open data in support of all peer-reviewed publications
- annually 25+ publications have a socio-economic focus, including ten which show the impact of CABI's programmes
- annually 100+ peer-reviewed publications
- annually 30+ publications in journals with an impact factor >2; and
- other metrics to be formulated and tested, including:
 - top 50 CABI scientists have an average h-index of > 15
 - annually, 20 papers with more than 20 citations in first three full years from publication

As stated in the previous Science Strategy 2016–2019, CABI would like to move away from the emphasis on impact factors in assessing quality, and has now signed DORA (The Declaration on Research Assessment). However, despite monitoring developments in the field and consulting partners and staff, we cannot yet define a simple, objective contemporary measure of the quality and quantity of our published outputs. We will therefore continue monitoring the present KPI (100+ publications, 30 in journals with impact factor >2), while testing these alternative metrics and compiling longer term statistics on citations.

Since 2016, CABI has prepared an annual science report, capturing details of papers published and in the pipeline, technical reports, posters and presentations at scientific meetings, appropriate social media activity, students undertaking research at CABI, extension materials and other scientific outputs, as well as key science roles and achievements of staff including journal editors and board members, learned society positions, roles in national and international working group, organizers of scientific meetings, honours, degrees awarded, etc. This received positive endorsement from the Science Review, and we will continue to use this to facilitate year-on-year comparisons of important scientific outputs.

CABI has embedded a systematic monitoring and evaluation approach in its project and programme delivery. This is essential to measure and optimize the results of interventions and to ensure relevance and efficiency in the implementation. Evaluation of CABI's research will continue through internal and external evaluation activities, including impact assessments and associated special studies to measure outcomes. The choice of evaluation approach will be pragmatic and driven by what is suitable, feasible and affordable in the given situation.

Dissemination of CABI's research outputs

Under CABI's Knowledge Management Policies, CABI ensures that the knowledge it generates and the information and data it collates is communicated and shared with as wide an audience as possible through open content, open processes and open infrastructure. At present, CABI aims to publish open access research in peer-reviewed journals with a CABI first or corresponding author and all papers from projects where open access is a requirement of the sponsors. CABI will move towards open access publishing for all publications arising from programmes and projects which CABI manages by 2025. CABI will also encourage the use of open access for other co-authored publications. Further, CABI will review its older scientific publications (legacy material) and identify important and relevant material to digitize and become open access.

In 2015, CABI set up the **CABI Scientific Outputs Portal** as an open access website which presents indexed bibliographic details and abstracts of scientific papers by CABI scientists taken from CAB Abstracts. This currently features over 6,000 publications going back to the earliest days of CABI. The initiative is on-going and the number continues to grow as more historical CABI scientific content is identified and new content added. The CABI Scientific Outputs Portal will become a single point of access for all CABI's original scientific outputs, including working papers, project reports, case studies and materials that do not meet the criteria of having been formally published such as extension materials or factsheets. Scientific Reports are being added in 2021–2022. We aim to make this complete from the year 2000 and will then explore the scope to include older content more comprehensively. Full text content will be made openly accessible when permitted by publishers and open access policies. Thus, we will present CABI's science output so that anyone can find what CABI scientists have published on a particular subject, enabling CABI to demonstrate impact and meet documentation requirements from donors.

In order to make the data from its research available to others, CABI's data management and archiving will become critical. As presented in the section on Data management and data sharing above, CABI will invest in capturing its research data outputs in an accessible and usable way, so that they can be reused and shared as open data.

We will also implement a programme to raise awareness of our scientific outputs using online, print, broadcast and social media, and encourage scientists to help disseminate their own work to other scientists and to non-specialists. We will respond timely to enquiries from media where CABI can share its areas of expertise. CABI has various social media accounts with large followings, which can help promote and share news about new research papers. With support from CABI Marketing, CABI scientists can help raise the profile of their research outputs using media relations (offering news and opinion pieces to editors of trade – including agricultural science and development press – as well as general news media about their research paper), traditional social media (Facebook, LinkedIn, Twitter) and research-specific social media and online tools (Google Scholar, Researchgate, etc.). Securing media coverage in online, print and broadcast (radio and TV) news outlets is a good way of raising the profile of research papers, the contributors' personal profile and any associated CABI projects as well as, in some cases, meeting publicity requirements of donors and even helping to attract future funding. We will also work to publish articles about our science in partner newsletters and platforms such as SciDev.Net, the GFAR Blog (Global Forum on Agricultural Research and Innovation) and Agrilinks platform. Media training and social media workshops will help to build staff capacity in this area.

CABI Publishing products and services

Our journal *CABI Agriculture & Bioscience* was launched in 2020. It is an open access, multidisciplinary journal publishing high-quality, peer-reviewed research focused on global agriculture, food security, environment, social, and related biosciences. The journal encourages inter- and cross-disciplinary research that connects 'vertical' subject areas through 'horizontal' themes, bringing science and policy together. *CABI Agriculture and Bioscience* augments the accessible knowledge pool in agricultural science and supports the concept of Open Agriculture. Its international Editorial Board encourages submissions of both large and incremental advances in science across the wide array of primary and cross-disciplinary topics the journal covers. CABI's scientists will continue to support the editorial process, contribute papers and encourage and facilitate publication by project partners and collaborators.

CABI also provides agriRxiv. This is an open access preprint service, supporting the dissemination of science and research across all aspects of the agricultural and allied sciences. It gives researchers the opportunity to share scientific discoveries and explore new research to inform agricultural science, policies and practice. The major benefits of this service include: (1) speeding up access to new findings to support new discoveries, (2) providing an early forum for scientific discussion and access to early findings which can inform and support new policies and practices, and (3) allowing free open access to authors and readers which maximizes for dissemination. When appropriate, CABI scientists will use this platform to help make their publications widely available as early as possible.

A related service is searchRxiv, which supports researchers in reporting, storing and sharing their searches consistently, thereby enabling them to review and re-use existing searches. In any discipline a well-constructed search strategy is at the core of evidence-based research, enabling the comprehensive retrieval of eligible studies to be assessed for relevance, and ensuring that relevant research is not missed. Evidence-based study is a complex process typically involving teams of people to identify a question and formulate the protocols and searches which retrieve the evidence for the study. The resulting searches can be long and complex to handle. Consistency in how searches are reported, shared and stored for possible re-use by other users is key to ensure quality across these activities.

CABI's Author Education Resources have been curated by CABI's team of publishing experts to provide free access to a set of educational tools, services, and resources to support researchers in agriculture and bioscience to better understand and navigate the evolving landscape of scientific publishing. CABI offers free tailored webinars covering key topics critical to success in publishing science, while webinars are posted regularly on the CABI Author Education YouTube channel. Within CABI's Author Education Resources offering, CABI has partnered with Editage to offer the CABI Author Services. Created to build capacity of researchers in agriculture and bioscience worldwide, the service offers world-class English language editing, translation with editing and research promotion services to authors. The Editage team of experts cater to researchers' needs at each step of the academic journey – helping accelerate publication success and overcoming a barrier for some non-native speaking researchers.

One of CABI's open access, free to use products is the **Invasive Species Compendium**. It is an open access knowledge-base providing decision support for identification, prevention and management of invasive species to stakeholders. Content includes thousands of peer-reviewed datasheets, maps and research articles to create the most extensive and authoritative global compilation on invasive species. Its data also supports CABI's invasive species Horizon Scanning Tool and is being widely used for species identification, pest risk assessments, identifying control options, and as a gateway to the literature. Maintaining this compendium as a free to use resource for those working in invasive species management will be an important contribution to tackling this global challenge.

A photograph of a scientist, a Black woman with her hair pulled back, wearing a white lab coat. She is focused on looking through the eyepieces of a microscope. The microscope is a compound light microscope with a black frame and white body. The background is a laboratory setting with shelves containing various glassware and equipment. The lighting is soft and focused on the scientist and the microscope. The text 'CABI context' is overlaid in the lower-left quadrant of the image.

CABI context

CABI context

Management

The CABI Board has overall responsibility to oversee the implementation of CABI's Medium Term Strategy including this Science Strategy. The periodic CABI Science Reviews have reported to the Board with recommendations, which have been taken into consideration by CABI's management. CABI's Executive Director Global Operations is the Executive Member Team member responsible for overseeing CABI's science and the implementation of the Science Strategy. CABI's International Development Management Board, and in particular the Global Theme Directors, will provide scientific and technical leadership, inputs and guidance. Day-to-day management of the science programme will continue to be carried out through each centre's existing management structure, supported by corporate departments such as Information Technology and Monitoring and Evaluation.

CABI aims to reduce its own CO₂ emissions relating to research

CABI recognizes its own impacts on climate change through its activities and will actively seek to minimize its greenhouse gas emissions (specifically CO₂) and environmental impacts in the implementation of this Science Strategy. CABI scientists fly around the world to take part in conferences, workshops and meetings with country partners to exchange ideas face-to face. The associated greenhouse gas emissions from air travel can be reduced by maximizing the use of virtual meetings technologies, minimizing air travel to only essential trips (and less scientists attending the same conference) and using other public transport options when available and appropriate. These activities should align with CABI's (forthcoming) sustainable travel policy and other requirements from research funding organizations relevant to CABI. Here are some concrete ideas for combatting greenhouse gases from air travel which should be piloted during the implementation of this Science Strategy.

- Compensating mechanisms for CO₂ emissions
- CO₂ levies on flights, especially for designated CABI climate change related research
- No intercontinental flight for any science event that lasts just one day
- First class tickets for long train journeys as an alternative to flights
- Award for sustainable travelling
- Introduction of an airline travel decision tool to identify alternatives

Furthermore, in its science activities, CABI will consider issues of sustainability including:

- operation of controlled environment rooms and glasshouses optimized to minimize power consumption
- procurement of materials and services, for example, sourcing materials locally
- a review of lab materials to avoid single use plastics when feasible
- no conference bags at CABI meetings unless they can be recycled

Staff skills base

Our scientific research and technology base will need continued investment to maintain a world-class position. Furthermore, succession planning and talent management will be critical to maintain continuity. Under the four Priority Research Areas and five cross-cutting areas described above, we identify various skills that need to be strengthened or added, either within the organization or through partnerships. Interdisciplinary and transdisciplinary thinking and working will be encouraged, including building our competence in managing programmes and projects holistically. It will be important that CABI's Human Resource department will develop and outline a career path planning/support strategy for young CABI scientists.

In addition to maintaining its core scientific strengths by developing or recruiting staff to replace key individuals that retire, CABI will strengthen research capacity of existing staff through various mechanisms including training, mentoring, participating in scientific meetings and incoming and outgoing attachments. Staff will develop their awareness of the implications of climate change for all aspects of their work and explore new ways of working to minimize international travel and CO₂ emissions.

Furthermore, CABI will increase its in-house skills base through recruitment based on strategic investment and project positions as follows:

- there is an on-going need for social and economic science to support and evaluate CABI's programmes in all themes and regions. This is being facilitated by embedding gender and diversity awareness across CABI's programmes, but additional expertise in these areas is needed
- several of CABI's themes and Priority Research Areas require new and increased numerical skills, including modelling, geographic information systems, using remote-sensing data, data analysis, bioinformatics and statistics
- to facilitate the application of bioinformatics in our Priority Research Areas, we need to develop capacity in state-of-the-art skills regarding genetic data management, analysis, interpretation, and gene expression
- for projects requiring digital services and tools, CABI should strengthen capacity in user experience, product ownership and data analytics. Additional expertise in evaluation research and impact assessment will also be crucial for demonstrating progress in this area

Building university-level capacity of young researchers

CABI will continue to build individual capacity in national programmes, for example through a newly-developed digital learning programme in Integrated Crop Management offered in collaboration with the University of Neuchâtel in Switzerland. This remote learning course will offer three stand-alone Certificate of Advanced Studies programmes via enrolment at the University of Neuchâtel. Furthermore, it allows enrolled students to obtain a university degree (Diploma for Advanced Studies) on successful completion of all three Certificate of Advanced Studies and a scientific thesis. This new programme will replace the former Masters of Advanced Studies (MAS) programme in Integrated Crop Management in Switzerland, which 12 students attended in person each year from 2015 to 2020. In the former programme 69 students (42% female students) completed the Masters of Advanced Studies programme, 67 obtaining a Masters of Advanced Studies and two a Diploma for Advanced Studies degree. However, in future it will be possible to reach up to 60 students each year through remote online learning. It is anticipated that more African and Asian students will subscribe compared to South and Central American students due to the English language barrier.

Based on our good partnerships with universities around the world, CABI will continue to employ research students and interns to undertake research and provide support to CABI projects. This primarily involves interns working for short periods (1-6 months) and research students (MSc or PhD) for longer periods (1-3 years). The former are usually employed from project funds, the latter may or may not. Centres will be identified where appropriate projects or programmes are in place that could facilitate employing students or interns to strengthen research capacity.

Science awards

A scientific publications recognition scheme for CABI's scientists was designed, resourced from the CABI Development Fund and piloted across CABI in 2017. Since then, annual awards have been made to recognize the work of individual scientists based on the number and quality (impact factor and citations) of their publications each year. Separate awards were made for socio-economic publications and early-career researchers. In 2020, five awards to recognize achievements in 2019 were made, each received £2000 to be spent as the awardee decided in support of CABI's scientific programme. Amongst other things, awards have been used to pay for student conference attendance, travel costs for extra survey work and staff time to work on additional publications. In light of positive feedback, this practice will be continued, although the criteria will be adjusted to reduce the importance of journal impact factors, in line with the Declaration on Research Assessment (DORA).

A new award in a similar format was introduced in 2021. Named after our late colleague, the Carol Ellison Science Award will be awarded annually to a student doing her/his research with CABI, or an early career CABI researcher, with the objective of enriching their research experience with CABI.

Investment

As anticipated in the CABI Science Review 2020-21, in order to fully implement this Science Strategy, investment will be required. Much of this may be derived from effective design of externally-funded research and development cooperation projects, but some support will need to come from the CABI Development Fund (continuing at £100,000 or more per annum), and some aspects will be funded by the CABI Designated Fund or through centre or corporate budgets. Examples where support may be needed (and the relevant Science Review recommendation number) include:

- continuing to increase CABI's capacity for social and economic science, and ensure gender and diversity are integrated through the whole project cycle (R4)

- building internal capacity in climate change science relating to CABI's key strengths and integrate this perspective through the whole project cycle (R5)
- developing and implementing a strategy and investment plan for data (including bioinformatics, big data and data science) (R6)
- supporting CABI's role to encourage changes in policy and practice with regard to data use and data sharing, such as the concept of FAIR (findable, accessible, interoperable, reusable) data (R7)
- developing joint products and applications with commercial partners (R8)
- ensuring DNA sequencing capacity is available to all parts of CABI and integrated into ongoing research where appropriate (R9)
- supporting global initiatives to facilitate access to genetic resources for use in biological control (R10)
- developing and evaluating metrics to monitor and assess our science publications (quality, quantity, collaboration, impact) that do not rely on journal impact factors (R11)
- allocating staff time to publish completed research when not covered by project funds (R11)

In support of these mostly high-level activities, specific activities to be supported from CABI or project funds include:

- funding recognition awards to further incentivize staff to publish important, high-quality papers
- The Carol Ellison Science Award to enrich the research experience of a student or early career scientist at CABI
- paying for open access publication of CABI's science outputs
- maintaining and improving the coverage and presentation of **CABI's Scientific Outputs portal**
- paying for access to necessary scientific publications that are not open access and not available through CAB Abstracts
- developing staff research skills and enabling participation in selected scientific meetings
- carrying out socio-economic impact case studies of historical and on-going successes
- developing strategically important reviews and thought leadership pieces
- employing research students and interns to address strategic research priorities

Science Strategy milestones, 2022–2025

| Key milestones | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|
| Maintain CABI's annual publication record | Overall 100 publications; 30 in journals with impact factor > 2 | Overall 100 publications; 30 in journals with impact factor > 2 | Overall 100 publications; 30 in journals with impact factor > 2 | Overall 100 publications; 30 in journals with impact factor > 2 |
| | 15+ publications have a socio-economic focus | 20+ publications have a socio-economic focus | 25+ publications have a socio-economic focus | 25+ publications have a socio-economic focus |
| | 100% of peer-reviewed journal papers with CABI as lead/ corresponding author are open access | 100% of peer-reviewed journal papers with CABI as lead/ corresponding author are open access | 100% of peer-reviewed journal papers with CABI as lead/ corresponding author are open access | 100% of peer-reviewed journal papers with CABI as lead/ corresponding author are open access |
| | Plan in place for the capture of CABI's data, particularly all supporting data for peer-reviewed papers | Infrastructure and protocols in place. Open data available in support of 25% of peer-reviewed publications | Open data available in support of 50% of peer-reviewed publications | Open data available in support of 75% of peer-reviewed publications |
| | Top 50 CABI scientists have an average h-index of > 15 | Top 50 CABI scientists have an average h-index of > 15 | Top 50 CABI scientists have an average h-index of > 15 | Top 50 CABI scientists have an average h-index of > 15 |
| | Annually, 20 papers with more than 20 citations in first three full years from publication | Annually, 20 papers with more than 20 citations in first three full years from publication | Annually, 20 papers with more than 20 citations in first three full years from publication | Annually, 20 papers with more than 20 citations in first three full years from publication |
| Capacity for climate change, social and economic science increased | One gender specialist recruited, funded by global programmes | One climate-change specialist recruited funded by project income | One socio-economist or gender specialist recruited; funded by global programmes | One climate-change specialist recruited funded by project income |
| Open access CABI Scientific Outputs Portal (CSOP) further developed and updated | All project reports since 2015 included with full text in CSOP | All project reports since 2000 included with full text in CSOP | 50% of last century's project reports added with full text | 100% of last century's project reports added with full text |
| Maintain and use BIOCAT (CABI database of all introductions of insects for the biological control of insects) for scientific research outputs | BIOCAT up-to-date until 2020 | BIOCAT kept up-to-date | BIOCAT kept up-to-date | BIOCAT kept up-to-date |
| Availability of key numerical skills (including bioinformatics) increased | At least one new recruit with key numerical skills funded by project income | At least one new recruit with key numerical skills funded by project income | At least one new recruit with key numerical skills funded by project income | At least one new recruit with key numerical skills funded by project income |
| Biological control agents (BCAs) studied and submission of introduction applications supported | At least 50 BCAs studied across all CABI centres; five introduction applications submitted by national partners | At least 50 BCAs studied across all CABI centres; five introduction applications submitted by national partners | At least 50 BCAs studied across all CABI centres; five introduction applications submitted by national partners | At least 50 BCAs studied across all CABI centres; five introduction applications submitted by national partners |
| Research outcomes and impact measured (through internal / external evaluations, special studies, etc.) | At least three publications / evaluation reports |

Acronyms used

| | |
|--------------|--|
| ABS | Access and Benefit Sharing |
| ACIAR | Australian Centre for International Agricultural Research (https://www.aciar.gov.au/) |
| BCA(s) | Biological control agent(s) |
| BIOCAT | A CABI database of all introductions of insects for the biological control of insects |
| CGIAR | Consortium of International Agricultural Research Centers |
| CIAT | International Center for Tropical Agriculture (https://ciat.cgiar.org/) |
| CIMMYT | International Maize and Wheat Improvement Centre (https://cimmyt.org/) |
| CSOP | CABI Scientific Outputs Portal (http://www.cabi.org/cso) |
| DNA | deoxyribonucleic acid |
| EMT | CABI's Executive Management Team |
| ERB | Ethical Review Board (CABI) |
| FAIR | Findable, accessible, interoperable, reusable (of data) |
| FAO | Food and Agriculture Organisation of the United Nations (https://www.fao.org/) |
| G20 | Group of Twenty (intergovernmental forum) |
| GRC | Genetic Resource Collection (CABI) |
| IAS | Invasive alien species |
| IITA | International Institute of Tropical Agriculture (https://iita.org/) |
| ICT | Information Communications Technology |
| IPM | Integrated pest management |
| KPIs | Key performance indicators |
| MALDI-TOF MS | Matrix-assisted laser-desorption and ionization time-of-flight mass spectroscopy |
| NGS | Next-generation sequencing |
| SDGs | Sustainable Development Goals (http://www.un.org/sustainabledevelopment/sustainable-development-goals/) |



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