CABI Science Strategy

Annex to the Medium Term Strategy 2017-2019

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KNOWLEDGE FOR LIFE

Contents

Acronyms used 4

Executive Summary 5

Introduction 6

Strategic Objectives and Priority Research Areas 7

- Internal and External Strategic Alignment 7
- CABI's Priority Research Areas: 7
- Cross-cutting Issues for CABI's Priority Research Areas 15

Publication and Communication 19

- Monitoring and Evaluation of CABI's Research 19
- Dissemination of CABI's Research Outputs 19

CABI Context 20

- Management 20
- Staff Skills Base 20
- Building Capacity of Young Researchers 21
- Partnerships 21
- Investment 22

Science Strategy Milestones, 2017–2019 23

Acronyms used

BCA(s)	biological control agent(s)
BIOCAT	CABI database of all introductions of insects for the biological control of insects
CGIAR	Consultative Group for International Agricultural Research
CSOP	CABI Scientific Outputs Portal (www.cabi.org/cso)
EO	Earth Observation
GIS	geographic information systems
GODAN	Global Open Data for Agriculture and Nutrition (www.godan.info)
IF	impact factor (of scientific journals)
IPM	integrated pest management
KPIs	key performance indicators
M&E	monitoring and evaluation
MALDI-TOF MS	matrix-assisted laser-desorption and ionization time-of-flight mass spectroscopy
NGOs	non-governmental organisations
NGS	next-generation sequencing
SDGs	Sustainable Development Goals (www.un.org/sustainabledevelopment/sustainable-development-goals)
SMEs	small and medium-sized enterprises

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'. 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 biological control agents which can control them. The principal beneficiaries of CABI's scientific research programmes are farmers (men, women 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 to support the delivery of the CABI Medium Term Strategy, 2017–2019. It provides a medium-term context for shorter-term decisions and to guide programme and project development, planning and resource allocation.

The research to be conducted will contribute to the intermediate outcomes anticipated in CABI's Theory of Change from the CABI Medium Term Strategy, 2017–2019, which here represent the strategic objectives: (i) greater linkage to value chains (on /off farm); (ii) farmers have better information and support; (iii) improved diversity, yields and quality of crops; (iv) major pest threats (particularly invertebrate pests, plant diseases and weeds) managed more effectively; (v) stronger plant, soil and seed health systems; (vi) evidence-based decisions and policies; and (vii) effective, innovative public and private sector partnerships.

In order to achieve these strategic objectives, CABI will align its research programme with its development agenda by investing in the following priority research areas:

- ***Priority Research Area 1***: Assessing the impact of pests (invertebrate pests, plant diseases and weeds)
- ***Priority Research Area 2***: Improving prediction and prevention methods for pests
- ***Priority Research Area 3***: Evaluating safe and effective integrated pest management (IPM) and biological control practices
- ***Priority Research Area 4***: Designing and validating new extension approaches and communication tools
- ***Priority Research Area 5***: Developing ecosystem management approaches for invasive species

Complementing CABI's priority research areas, we anticipate several cross-cutting research areas which will underpin and add value to the priority research areas:

- ***Cross-Cutting Research Area 1***: Monitoring and evaluation (M&E)
- ***Cross-Cutting Research Area 2***: Gender and diversity
- ***Cross-Cutting Research Area 3***: Management and analysis of 'big' data sets
- ***Cross-Cutting Research Area 4***: Advanced technology

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 Key Performance Indicators and milestones. This Strategy also explains how CABI's research will be disseminated in line with our policy on open access publication [1], and how its external impact will be measured and monitored.

1 CABI's Knowledge Management Strategies, 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 nutritious 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 approach[2] 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 recognised as a world leader with a strong scientific reputation in identification, diagnosis, prevention and control of invertebrate pests, plant diseases and weeds. 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 IPM 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. For example, CABI has played important roles in developing the science of different biological control approaches, particularly weed biological control and the use of fungi as biopesticides (e.g. for locust control), new pest risk assessment methods for managing the spread of non-native species, and a test kit for fungal fuel contamination. Recently the development of Plantwise from the plant clinic concept has received widespread recognition for its contribution to strengthening national agricultural extension systems.

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. More recently, 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.

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 48 member countries keeps it in touch with governmental priorities, while staff and partners working on projects around the world are experiencing daily the concerns and challenges of farmers working on the ground. The Plantwise programme keeps CABI in close contact with national agricultural systems in more than 40 countries; this collaboration, and data from the plant clinics, 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 organisation 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
www.cabi.org/about-cabi/business-policies-and-strategies

Strategic Objectives and Priority Research Areas

The goal of the CABI Science Strategy is to provide strategic objectives and define priority research areas to support the delivery of the CABI Medium Term Strategy, 2017–2019. 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 2014-2016 as well as the recommendations of the external CABI Science Review 2015, 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 2017–2019. In particular, the research to be conducted will contribute to the intermediate outcomes anticipated in CABI's Theory of Change. 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 17[3].

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
- Global GAP (Good Agricultural Practice)
- The Global Action Plan for Agricultural Diversification

CABI's Priority Research Areas:

This research strategy sets out how CABI's research agenda will support CABI's mission, specifically the intermediate outcomes in the CABI Theory of Change from the Medium Term Strategy 2017–2019, which here represent the **Strategic Objectives** and provide the focus of the CABI Science Strategy.

- Greater linkage to value chains (on /off farm)
- Farmers have better information and support
- Improved diversity, yields and quality of crops
- Major pest threats (particularly invertebrate pests, plant diseases and weeds) managed more effectively
- Stronger plant, soil and seed health systems
- Evidence-based decisions and policies
- Effective, innovative public and private sector partnerships

Not all of CABI's strategic objectives need strong support from research, and priority research areas will normally support more than one strategic objective. CABI has identified the following as priority research areas where it will focus its efforts in biological, social and economic science. This will be reflected in programme development, allocation of internal resources, staff recruitment and selection of student research opportunities.

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

Priority Research Area 1

Assessing the impact of pests (invertebrate pests, plant diseases and weeds)

Scope

Much of CABI's work is based on the understanding that indigenous and introduced pests (invertebrates, plant diseases and weeds) cause significant economic and/or environmental damage, which in the case of crop plants reduces yield and has a knock-on effect on livelihoods. In order to demonstrate the need for improved pest management approaches and evaluate the impact of those implemented, it is critical to improve our understanding of the impacts of these pests. Disentangling the factors which affect yield and livelihoods to obtain objective data on impact is not straightforward. If simple, easily applied methods could be developed, they would be of great use. CABI plans to collect and generate improved baseline data on the damage caused by crop pests and invasive species in order to (1) justify the development and implementation of prevention and management activities, (2) predict impact in newly invaded areas, and (3) measure the economic, social and environmental impact of improved plant health advice and invasive species management.

CABI's approach

Crop plants (including pasture and forestry) are affected by many different pests, including invertebrate pests, plant diseases and weeds, the effects of which are interactive, both between pests and with the crop plants. Yield is further affected by seed variety choice, soil health and deficiencies, agronomy, action of natural enemies, weather, harvesting, etc. Livelihoods also depend on access to markets and market prices. Critical reviews and modelling approaches can focus on information gaps and research questions and provide a framework to interpret other approaches. CABI will look into established and novel approaches, including traditional crop-loss assessment methods, survey methods, socio-economic evaluations, remote sensing, new computational methods, and opportunities to combine data, to try and develop more efficient approaches to address this issue. Monitoring changes in pest populations, crop yields and management practices as an introduced species spreads and then as effective control measures are brought into action should provide better insight than evaluating stable situations.

Potential research outputs, 2017–2019

- Good baseline data to support objective assessments of the impact on livelihoods of selected effective classical biological control and IPM programs
- Estimates of the environmental, social and economic costs of selected invasive species
- New baseline estimates of crop losses causes by all types of pests with a breakdown by groups and species
- Comparisons of the impacts of invasive species in different countries to compare effectiveness of management strategies and to generalise conclusions for regional approaches

Key areas of scientific skills which CABI will need to develop

Development of staff skills, recruitment of staff with key expertise, or external expertise should be considered for modelling, geographic information systems (GIS), data analysis, environmental analysis and social and economic science.

Priority Research Area 2

Improving prediction and prevention methods for pests (invertebrate pests, plant diseases and weeds)

Scope

Improved understanding of the impact of climate change and other factors on future pest, disease and weed distribution is needed for better targeted prevention and management strategies. To address this, CABI will carry out research on risk assessment, predicting invasions, phytosanitary measures and legislation relating to invasive species, leading to prevention measures and strengthened market access and trade. Prediction and prevention of the spread of invasive pests and diseases is based on risk assessment. Risk is defined as the product of the probability of an event occurring, multiplied by the expected impact if it does. For invasive species, the event is the introduction, establishment and spread of the species; and the impact is the damage that it could cause, directly and indirectly. Introduction (via pathways), establishment, spread, and impact or damage can all be analysed, modelled and predicted through applied research.

CABI's approach

CABI has an increasingly broad range of skills to handle a range of critical data, including remote sensing, climate and weather data including the outputs of climate change models, on the ground data including pest surveillance data (surveys, clinic data) and biological data (ranging from laboratory and field observations to outputs from CABI's advanced genetic characterisation technology).

Various analyses and approaches will be used, including:

- Existing modelling systems (e.g. CLIMEX) or bespoke models of many types: quantitative and qualitative, spatial and temporal, statistical and simulation, rule-based and mathematical
- Biological and ecological studies (e.g. sentinel plant studies, life cycle studies, surveys and surveillance)
- Data mining from CAB Abstracts, plant clinic data, observations reported on the internet, crowd-sourced data, etc.

Such analyses and tools can provide information to improve decision making (=risk management) for various actors at international, regional, national, community and household levels.

Potential research outputs, 2017–2019

CABI will use its research capacity and strengths (capability of researchers, global network of centres and partners, data and information resources) to support our programmes and themes by producing outputs such as:

- Predictions of likely spread of known invasives and pests at different spatial scales, under current and changed climate scenarios
- Targeted early warning systems for potential new invasives, collating all sources of existing information supplemented with new real-time data, e.g. collected through using nurseries of sentinel plants
- National and/or regional plant biosecurity strategies, for priority crops/sectors, supported by analyses of major risks, actual and potential pathways of introduction, and surveillance and management systems to best manage the risks
- Near real time forecasting of pest movement and outbreaks to support national decision making, using earth observation and environmental data
- Household/farm level decision support tools (models) for pest management decision making, starting with one or more specific pests in a high value crop. Such tools are used in developed countries, but rarely in developing countries

Key areas of scientific skills which CABI will need to develop

Areas where additional skills should be developed include modelling of various types, and the rigorous analysis and interpretation of big data sets (see Cross-cutting Research Area 3 Management and Analysis of 'Big' Data Sets for how this will be addressed).

Priority Research Area 3

Evaluating safe and effective IPM and biological control practices

Scope

Improved IPM and biological control 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. Working with national extension services, e.g. through the Plantwise programme, will facilitate the identification of missing or inadequate IPM options and hence research gaps to be addressed with national programmes in spin-off projects. Research will be carried out with consideration of the local socio-economic context, including gender and diversity implications. The development of biological control agents is an important specific area where CABI's science programme supports its developed member countries as well as developing countries.

CABI's approach and types of research questions to be addressed

CABI has an increasingly broad range of skills to implement the research topics envisaged within this priority research area. Various approaches are used for the development of biological control agents (BCAs):

- Literature and field surveys to discover classical and inundative BCAs
- Traditional, behavioural and molecular methods for identification and characterisation of BCAs
- Lab and field host-specificity and efficacy studies to develop safe and effective BCAs
- Adaptation or development of mass production systems and release technologies for BCAs in less developed/developing countries, in collaboration with small and medium enterprises (SMEs)
- Ecological and socio-economic studies to assess the establishment and effectiveness of BCAs

Approaches for the development of effective and sustainable IPM strategies will include:

- Molecular methods for identification and characterisation of pests
- Novel technologies (e.g. remote sensing, pest image recognition systems) to improve monitoring and forecasting of pests
- Development, testing and validation of 'best-bet' crop and location specific IPM strategies with local partners
- Development and validation of novel approaches (e.g. endophytes, increased resilience, improved water management)
- Monitoring and modelling the potential impacts of climate change on the efficacy of IPM approaches/tools, and their potential adaptation and modification.
- Socio-economic studies to identify and assess the barriers to increased uptake of less hazardous IPM options, such as biopesticides, and map options to overcome impediments

Potential research outputs, 2017–2019

These research ideas utilise CABI's capacity (capability of researchers, global network of centres and partners, data and information resources):

- Risk-benefit assessment methods for classical BCAs based on best practice
- New BCAs and management tools for recalcitrant or emerging pests that threaten crops and livelihoods
- Transfer of effective IPM strategies for field and post-harvest pests to new crops/regions/habitats taking into consideration local socio-economic and/or specific food safety issues
- Strategies and tools for mitigation of the effects of climate change on the performance of BCAs and efficacy of integrated crop management and IPM solutions
- Strategies to overcome the key barriers to adoption of microbial and macrobial BCAs (e.g. regulatory constraints, efficacy, local acceptance, availability, practicability, safety, affordability, etc.)

Key areas of scientific skills which CABI will need to develop

Skills in social science, modelling and statistics will be needed. Gaps in technology or local knowledge can be filled through partnership with, for example, universities or national or provincial research institutes and SMEs.

Priority Research Area 4

Designing and validating new extension approaches and communication tools

Scope

There is a general consensus that lack of information is one of the major constraints to smallholder farmer adoption of new technologies and practices. CABI is directly involved in developing and testing new extension approaches and exploring cost-effective ways to reach large numbers of farmers. Research will inform the evolution of CABI interventions and provide evidence that can be used by others to plan services and scale-up activities. There are a series of other socio-economic and environmental constraints including lack of market access, poor availability of inputs, insecure land tenure etc. that affect adoption and must be considered or addressed in designing research.

CABI will carry out research to understand how information is generated and shared amongst stakeholders and how different members of smallholder farming families source and use information. Studies will also consider how different delivery approaches can be complementary and lead more effectively to practice change at farm level and positive outcomes in terms of productivity and income. Action research will be a strong component of our work, implemented in ways that allow data collection to evaluate how different approaches and combinations of delivery channels contribute to technology adoption.

CABI's approach

Mixed quantitative and qualitative approaches are already being used to collect data. Survey data will be collected from randomly selected households and complemented with data collected from farmers recruited during mass media campaigns. Telephone interviews will be used to provide more cost-effective ways of data collection. Qualitative approaches will be used to understand in more depth actions and outcomes of different stakeholders and to study community interactions and intra-household dynamics and information flows.

Potential research outputs, 2017–2019

Using this approach, CABI will generate valuable insights and guidance for improved extension approaches and communication tools, such as:

- Improved dissemination methods for the uptake of agricultural technologies by smallholder farming families to reach all members of the household including younger and older people, men and women regardless of their level of literacy.
- Improvements in the reach and effectiveness of mixed media campaigns that capitalize on delivery of information associated with input supply chains
- Sustainable business models for mobile-based agro-advisory services, for example by bundling with transactional services such as input supply and micro-finance.
- Cost-effective strategies to improve access to, and capacity to use, market, agronomic and other information and knowledge by poorer smallholders, especially women and youth, to achieve sustainable intensification.
- Guidelines on the value of different kinds of information to farmers and therefore where best to focus efforts in delivery. This may involve consideration of how farmers and other stakeholders respond and the value of resulting benefits.

Key areas of scientific skills which CABI will need to develop

Additional social science capacity, with experience in diverse methods, including gender expertise, is needed to be able to establish a well-grounded research program that ensures that development interventions and actions are well-informed and based on a sound understanding of how local context influences outcomes.

Priority Research Area 5

Developing ecosystem management approaches for invasive species

Scope

Invasive species are key drivers of human-caused global environmental change as they threaten native biodiversity and ecosystem processes that are fundamental to human well-being. Both economic and non-economic valuation information is needed, as the ecosystem services approach to conservation and human well-being is becoming an important instrument in environmental policy and decision making. Yet, there is still limited understanding of the mechanisms that link invasive species to the delivery of ecosystem services and to human well-being, and how they interact with other drivers of global change, including land-use change and climate change. Invasive species may be the main reason for the loss of ecosystem services, but often they are a feature of more fundamental environmental change, such as altered disturbance regimes or climate change. In both cases, managing invasive species should be understood as a key element of an integrated ecosystem management that aims to restore characteristic ecosystem processes and improve human well-being in the invaded habitats.

CABI's approach and types of research questions to be addressed

CABI will integrate multiple tools and technologies to develop an ecosystem management approach for invasive species, based on:

- Ecological studies, e.g. standard and modern methods to assess impacts; evaluate integrated management methods using population dynamics at local and landscape scale
- Socio-economic studies, e.g. to assess impacts on environmental services and rural livelihoods; to evaluate acceptability of land management strategies to manage and restore invaded habitats
- Remote-sensing, e.g. mapping of current and predicted invasive species distribution, overlapping with maps of multiple ecosystem services delivery
- Modelling and statistical tools, e.g. species distribution models, models to relate invasion level to economic costs

Potential research outputs, 2017–2019

Using this holistic approach will lead to outputs such as:

- Ecosystem management plans for landscapes where rural people live next to biodiversity hotspots
- Management options for flagship invasive species likely to affect key ecosystem services, e.g. invasive weeds increasing densities of vectors of human or animal diseases
- Case studies on how the impacts of invasive species on the provision of ecosystem services interact with or are affected by other drivers of global change (e.g. land-use change or climate change) and the implications for restoration efforts
- Landscape management to mitigate the negative impacts of invasive species in agricultural areas
- Re-establishment of native biodiversity and ecosystems functions following the management of key invasive species

Key areas of scientific skills which CABI will need to develop

We will need to develop CABI's skills in socio-economics. Partnering may help with using remote sensing data, sustainable land management strategies, statistical analysis, and interdisciplinary research, but CABI will also need to develop its capability in these areas through staff development.

		Strategic objectives based on CABI's intermediate outcomes						
		Greater linkage to value chains (on / off farm)	Farmers have better information and support	Improved diversity, yields and quality of crops	Major pest threats managed more effectively	Stronger plant, soil and seed health systems	Evidence-based decisions and policies	Effective, innovative public and private sector partnerships
CABI's priority research areas	Assessing the impact of pests, diseases and weeds							
	Improving prediction and prevention methods for pests and diseases							
	Evaluating safe and effective IPM and biological control practices							
	Designing and validating new extension approaches and communication tools							
	Developing ecosystem management approaches for invasive species							

Matrix to show how CABI's priority research areas (rows) support the intermediate outcomes planned in CABI's Theory of Change for the Medium Term Strategy (columns). Dark shading indicates that the focus area is directly relevant and strongly supports the strategic objectives (intermediate outcomes); pale shading less strongly so; and unshaded is only indirectly relevant.

CABI's priority research areas support all the intermediate outcomes planned under CABI's Theory of Change. Research to improve the prevention of invasive species and pest management options reflects CABI's core strength in identification, prevention and control of plant pests and diseases as identified in the CABI Theory of Change. Equally, CABI's impact in the management of pests and strengthened plant health systems will benefit most from CABI's research strength. Although CABI's research capacity in biological science is well established, capacity in social and economic science will need to be strengthened to deliver this leading up to 2020.


BIG

Cross-cutting Issues for CABI's Priority Research Areas

Complementing CABI's priority research areas, we anticipate several cross-cutting issues which will provide significant inputs to the priority research areas.

Cross-cutting Research Area 1

Monitoring and evaluation (M&E)

Scope

CABI is embedding a systematic M&E approach in its project and programme delivery, which will include an important research element. Evaluation of CABI's research will take place through internal evaluation activities, different types of external evaluations, including impact assessments and associated special studies to measure outcomes. Evaluations should include clear analyses of attribution and evidence to build a rigorous body of impact-evidence that strengthens CABI's reputation and accountability. These impact assessments and studies to measure outcome are a research activity in their own right and critical for all CABI's research activities.

CABI's approach

M&E research will be integrated from the earliest stages of project design, so that CABI's projects and programmes include an experimental design with a hypothesis to test and appropriate control and treatment groups. CABI's M&E research will prioritize evaluation methods and tools that emphasize programme results in terms of outcomes, impacts and causality. Context analysis will be used to assess how country or regional contexts 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 is anticipated, from complex quantitative randomized control designs to rapid methods of data collection and analysis. Data sources may include plant clinic data, household surveys, focus group and key informants interviews, and direct observations of male and female farmers throughout the project life. The main approaches will be:

- Base-line studies (existing statistics or field surveys) for comparison with the situation after interventions
- High quality case studies showing outcomes/impacts at scale, tracking food security, climate, gender and nutrition as appropriate
- In-depth impact studies using rigorous methods to demonstrate the impact of CABI's work against the pre-project situation ensuring gender analysis is embedded throughout the study

Examples of research questions, 2017–2019

This cross-cutting element will contribute to the evidence-based evaluation of outcomes and impacts from all CABI's priority research areas, for example:

- What is the reduction in crop losses caused by crop pests after the adoption of new management / extension approaches?
- What are the benefits of an improved pest forecasting system / invasives prediction system? Is the spread of invasive pests delayed or prevented, and what is the value of this?
- Has the use of hazardous chemicals decreased and implementation of IPM measures increased and is this as a result of plant clinic advice?
- How can the monetary and non-monetary multi-sectoral impacts of many invasive species be balanced to assess their total importance and the value of their successful management?
- How does an improved pest management system for a particular invasive species affect rural livelihoods and incomes?

Key areas of scientific skills which CABI will need to develop

Scientific skills required by CABI include social science, statistics and econometrics. The first of these needs to be internally available, but the others, particularly the more specialised aspects, should be the basis of external partnerships.

Cross-cutting Research Area 2

Gender and diversity

Scope

As set out in the CABI Project and Programme Gender Strategy, CABI is embedding a gender sensitive approach to project and programme delivery including ensuring that research takes women, men, youth and other diverse groups into account. CABI will not normally undertake research into gender issues specifically, but in any work that involves people, CABI will aim to ensure that the research recognises that people are not all the same. CABI's work will be tailored to recognise that women, men and youth have different needs, drivers and priorities that govern their interests, motivations and decision making.

CABI's approach

Data are collected at all stages of CABI projects, including contextual analysis and baselines in project design, research conducted as part of implementation, and data collected for monitoring and evaluation. Where data are collected relating to people, it is important to disaggregate the data by gender and diversity, to consider from whom to collect data, and ensuring meaningful input from all stakeholders (e.g. to ensure that both men and women are able to engage with the data collection process and give their views).

CABI has changed its approaches to ensure that gender considerations are integral throughout the project from design to implementation and evaluation. Thus, CABI will now carry out gender analysis at the start of projects to ensure gender considerations are fully embedded and budgeted for within the project. A gendered value chain analysis may also be undertaken to understand the involvement of men, women and youth in the value chain, and any opportunities or barriers to increase their involvement.

Examples of research questions, 2017–2019

CABI will increase its knowledge and awareness of gender and diversity factors through answering research questions such as:

- What are the motivators and drivers for women and men to uptake a technology including suitability of design, effects on time and labour burdens, cost, decision making and cultural suitability?
- Do the same factors prevent women and men from increasing their productivity of a certain crop and how can we address these barriers?
- What factors influence women's management of assets and resources (including money) and how can or will the project influence or affect these?
- What communication methods are most suitable for women, men and youth and why, and how is information shared both within a community and within a household?
- How will existing social norms influence or affect project implementation and how do we adapt implementation to ensure we achieve our goals?

Key areas of scientific skills which CABI will need to develop

There has been a general lack of gender skills and understanding within CABI. Addressing gender issues in CABI's research will build staff capacity in this area and increase the application of gender sensitive approaches throughout CABI. In the short term, additional expertise will be needed to implement this, either by selecting appropriately skilled social scientist recruits or through partnerships (cf. Cross-cutting Research Area 1, M&E).

Cross-cutting Research Area 3

Management and analysis of 'big' data sets

Scope

Big data is about capturing relevant data from the huge number of available sources and translating that into actionable information to solve problems at scale and speed and improve business processes. Collection, management and use of big data will become a key driver for countries seeking to grow and become part of global networks. With the availability of modern information technology, there is an opportunity in agriculture to make more informed decisions based on available data, e.g. for predicting disease outbreaks. Hence, CABI is increasingly becoming a contributor in the management and analysis of big, complex, linked and open datasets. CABI is in a pivotal international role hosting the Global Open Data for Agriculture and Nutrition (GODAN) Secretariat. GODAN advocates and encourages the creation, sharing and use of open data initiatives and programmes particularly by and for rural and urban poor. Thus, CABI is well positioned to develop and offer resources to facilitate data mining and collation, manipulation and analysis by interdisciplinary teams to generate new scientific insights. The need for investment in key software and increased computing capacity will be assessed, prioritised and resourced as this develops.

CABI's approach

There are already datasets (both of numerical data and granular content) being compiled throughout CABI. These range from the farm-level records, through the research data collected from individual projects, to the multi-million record CAB Abstracts. These datasets exist, however in different stages of structure and utility. CABI is in the process of understanding what datasets it possesses and can create, discovering what relevant external datasets (open or otherwise) there are, completing its systems for handling data, building and integrating its internal skills and determining which opportunities it wishes to pursue. Several approaches are already being used:

- Plantwise clinic data is validated and analysed to assess the quality of plant doctor recommendations, gender differences, effects of plant doctor training, knowledge dissemination among plant doctors, research gaps, pest importance, etc.
- New information architecture is being tested to probe disparate CABI datasets in a connected environment
- Earth Observation (EO) data is being used to track and map the spread of invasive pest species and target the application of control measures.
- Large genomic datasets generated by the new next generation sequencing capabilities will be managed and analysed

Potential research questions, 2017–2019

In addition to working with existing Plantwise data, important opportunities will come from linking multiple datasets, and research ideas will be developed in support of the priority research areas.

- Can plant clinic data be used to 'ground-truth' systems that use extensive EO/environmental datasets to model current, new pest outbreaks or spread?
- Can analysis of historical datasets show any link between peaks in particular pests and environmental conditions or market price of crops at the time?
- Can linking plant clinic data to databases of available (biological or synthetic) solutions, rapidly determine if there is a need for new registration of more effective or safer products or product use, or key research gaps that need to be addressed?
- With CGIAR climate analogues, can suitability maps be created of crops / invasive species / pests / biological control agents based on their current range and conditions and model how this will change with climate change?
- Can social network analysis of knowledge dissemination through social media chatrooms be used to assess the dissemination of knowledge beyond plant clinics?

Key areas of scientific skills which CABI will need to develop

CABI will need to continue to develop external partnerships for complementary skills and access to relevant datasets, e.g. with Rothamsted, UK Agrimetrics centre and GEOGLAM[4] . However, CABI's internal capacity in data management, analysis, statistics, modelling and the ability to publish research outputs from this area also needs to be strengthened through recruitment and staff development. Furthermore, data management and archiving will become critical, and investment will be needed to capture CABI's data outputs in an accessible and usable way, so that it can be reused and shared as open data.

Cross-cutting Research Area 4

Advanced technology

Scope

Microbes interact with almost every part of the world we live in. Molecular analysis is essential for the identification of these organisms, along with understanding ecosystem composition, biological properties and processes, and microbial potential. CABI has now invested in MALDI-TOF MS (matrix-assisted laser-desorption and ionization time-of-flight mass spectroscopy) and NGS (next-generation sequencing) technology, powerful tools for the study of microbial community composition in soil, rhizospheres, plant tissue, water, and environmental samples. Image recognition systems will be evaluated for their complementarity to identification and diagnosis processes, interfacing on the one hand with molecular data, and on the other hand with plant clinic data.

CABI's approach

CABI's core strength and reputation in identification, diagnosis and characterization of plant pests and diseases will be extended with these new technologies.

- MALDI-TOF inexpensively allows identification of the microorganism of interest, enabling an evolutionary continuation of CABI's long-standing history in microbial identification
- NGS, in contrast, is a more revolutionary methodology; enabling the investigation of completely new areas of science for CABI, with a 250,000-fold increase in sequencing capacity compared to previous technology

This will open new opportunities in many of CABI's research projects and programmes. Soil, water, and environmental studies through the metagenomic analysis of microbial populations will lead to a much deeper understanding of agriculturally-significant and/or environmentally-significant viruses, bacteria, yeasts, fungi, nematodes, insects, and plants. From the sequence data obtained, the identities of the organisms in the sample ecosystem can be derived, along with an indication of their abundance that is not distorted by the need for culturing on agar plates (which creates an enormous bias against microorganisms that cannot be grown in culture; i.e. the majority).

Potential research questions, 2017–2019

Equipped with MALDI-TOF MS and NGS, key questions to address will be:

- Can we develop powerful soil health analyses using NGS-based metagenomic analysis of bacterial and fungal populations?
- Can we better understand biological control agent efficacy and environmental impact by NGS-based genetic, epigenetic, and transcriptomic analysis?
- Can we better understand insect and nematode behavioural changes from analysis of their microbiomes using NGS-based metagenomic analysis?
- To support host range studies, can we determine which plants insects have recently eaten by NGS-based metagenomic analysis of chloroplast genes in their gut?
- Can we develop rapid identification of obligate plant pathogens, such as rusts and powdery mildews, on infected plants by MALDI-TOF MS?

4 Group on Earth Observations Global Agricultural Monitoring Initiative: www.geoglam-crop-monitor.org/

Key areas of scientific skills which CABI will need to develop

Skills to develop will be hands-on practical experience in NGS and bioinformatics. Requisite external skills to develop this experience have been incorporated into recruitment plans, and additional skills, such as bioinformatics and image recognition systems would be provided through strategic project-based partnerships.

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 Key Performance Indicators (KPIs) and milestones.

Quality and quantity of research is currently addressed as one corporate KPI, i.e. 'annually at least 100 publications (peer-reviewed and not peer-reviewed) of which 30 are in journals with an Impact Factor of >2'. However, journal Impact Factor is not the same as the impact of individual papers, and quality of a publication is not necessary reflected in the extent of uptake. Uptake reflects global activity in the subject area, as well as factors such as the higher impact of some thought leadership, synthesis and review papers. CABI is therefore piloting the use of alternative systems for monitoring the impact of individual publications and their uptake in different ways and by different stakeholders (e.g. through sharing and commenting), and based on this, the scope to develop and use more realistic and more targeted indicators will be assessed.

Starting in 2016, CABI will prepare 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, organisers of scientific meetings, honours, degrees awarded, etc. This will facilitate year-on-year comparisons of these other important scientific outputs.

CABI is embedding a systematic M&E approach in its project and programme delivery. This is essential to measure and optimise the results of interventions and to ensure relevance and efficiency in the implementation. Evaluation of CABI's research will take place through internal evaluation activities, different types of external evaluations, including impact assessments and associated special studies to measure outcomes. The choice of evaluation approach should 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 undertakes to ensure 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. By 2020, CABI will aim to publish its research open access and will make the supporting data for its research publications openly available, in line with the requirements of the sponsors[5]. Further, CABI will review its older scientific publications (legacy material) and identify important and relevant material to digitise and make available open access.

In 2015 CABI set up the CABI Scientific Outputs Portal as an open access website, **www.cabi.org/cso**, which presents indexed bibliographic details and abstracts of scientific papers by CABI scientists taken from CAB Abstracts. This currently features close to 3000 publications going back to 1931. The initiative is on-going and the number continues to grow as more historical CABI scientific content is identified and new content added.

To facilitate measurement of the use and dissemination of these publications across the internet we have added an altmetric tool, the Plum Analytics "widget" to the website. The Plum widget makes it possible to monitor the reach and frequency of user interactions with our scientific publications relatively easily. The potential to use some of these as performance indicators to monitor impact of our scientific outputs will be investigated.

5 CABI's Knowledge Management Policies.

Our medium term objective is to make the CABI Scientific Outputs Portal 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. We will aim to make this complete from the year 2000 and 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 out what CABI scientists have published on a particular subject, enabling CABI to demonstrate impact and meet documentation requirements from donors.

We will also develop and implement a strategy to raise awareness of our scientific outputs using social media, and encourage scientists to help disseminate their own work to other scientists and to non-specialists. 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 relevant outlets about their research paper), traditional social media (Facebook, LinkedIn, Google+, Twitter) and research-specific social media and online tools (Google Scholar, etc.). Getting 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. Media training and social media workshops will be needed to build staff capacity in this area.

In order to make the data from its research available to others, CABI's data management and archiving will become critical. 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.

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. The Executive Director Global Operations is the EMT member responsible for overseeing CABI's science and the implementation of the Science Strategy. CABI's Chief Scientist, Chief Information Officer and 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 IT and M&E.

Staff Skills Base

Our scientific research and technology base is relatively weak and needs significant continuing investment to maintain a world-class position. Furthermore, key individuals in science will be leaving the organisation due to retirement over the next 5 years so succession planning and talent management will be critical to maintain continuity. Under the five priority research areas and four cross-cutting areas described above, we identify various new skills needed, either within the organisation or through partnerships. In addition to maintaining its core scientific strengths by developing or recruiting staff to replace key individuals that retire, CABI will also strengthen research capacity of existing staff through various mechanisms including training, mentoring, participating in scientific meetings, and incoming and outgoing attachments (secondments and sabbaticals). Furthermore, CABI will increase its in-house skills base through recruitment based on strategic investment and project positions as follows:

- The greatest need is for social and economic science to support CABI's programmes in all themes and regions. This will be facilitated by embedding gender and diversity awareness across CABI's programmes. This evolution will strengthen the social science and economic capability of the organisation so that we are able to design our projects at the development stage in ways which allow them to be more gender responsive and also to make them more amenable to rigorous measurement of impact. By 2019, existing staff will have deepened their understanding of these areas and at least five new appointments will be made, distributed across CABI's centres to match demand.

- Several of CABI's themes and priority research areas require new and increased numerical skills, including modelling, GIS, using remote sensing data, data analysis, bioinformatics and statistics. By 2019, at least two new positions will be primarily concerned with these aspects.

Building Capacity of Young Researchers

CABI will learn from the positive experiences within CABI's centre in Switzerland of employing 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.

CABI will also continue to build individual capacity in national programmes, for example through its Masters of Advanced Studies programme in integrated crop management in Switzerland.

Partnerships

CABI will continue to work in partnership with other high profile research groups (universities, national and international research organisations, etc.) in order to gain access to complementary scientific skills (and where appropriate develop its own skills base) and facilitate university student involvement. Our role as an implementation partner in collaboration with the CGIAR Consortium (particularly International Institute of Tropical Agriculture (IITA), International Center for Tropical Agriculture (CIAT), International Maize and Wheat Improvement Centre (CIMMYT) and International Rice Research Institute (IRRI)) in the next generation of Core Research Programmes 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, **www.airca.org**), increasing food security by supporting smallholder agriculture and rural enterprise within healthy, sustainable and climate-smart landscapes to deliver sustainable agricultural intensification at the landscape scale.

CABI will maintain its active programme of research, development and implementation, working closely with farmers, extension systems, national research institutes, non-governmental organizations (NGOs) 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, especially with regard to the Aid for Trade agenda. 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 CABI's priority research areas will be relevant to CABI's developing member countries, but areas 2 (improving prediction and prevention methods for pests) and 3 (evaluating safe and effective IPM and biological control practices) will be most relevant to our developed member countries. CABI's science will therefore make a difference in both developed member countries and developing member countries, taking into consideration local context including policy and institutional frameworks.

Investment

As anticipated in the CABI Science Review 2015, 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, and some aspects will be funded through centre budgets. Examples where support may be needed (and the relevant Science Review recommendation) include:

- Increasing CABI's capacity for social and economic science (R14, R18)
- Funding reward options to further incentivise staff to publish important, high quality papers (R12)
- Paying for open access publication of CABI's science outputs (R11)
- Maintaining and improving the coverage and presentation of CABI's Scientific Outputs portal: **www.cabi.org/cso** (R10)
- Paying for access to scientific publications that are not open access (R10)
- Developing staff research skills and enabling participation in selected scientific meetings (R13)
- Facilitating secondment and sabbatical options to strengthen staff research capacity (R13, R21)
- Carrying out socio-economic impact case studies of historical and on-going successes (R16)
- Ensuring that staff time is allocated to publish completed research when not covered by project funds (R10)
- Developing strategically important reviews and thought leadership pieces (R17)
- Piloting the use of new approaches and techniques to support CABI's research priorities, e.g. use of MALDI-TOF MS and NGS, management and analysis of big data and geographical information systems (R17)
- Employing research students and interns to address strategic research priorities (R17, R20)

Science Strategy Milestones, 2017–2019

Key Milestones	2017	2018	2019
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
Incentive programme in place to publish important, high quality papers beyond project objectives	Incentive programme designed, resourced and implemented across CABI	KPI of 100 publications annually, 30 in IF>2 journals increased	KPI of 100 publications annually, 30 in IF>2 journals increased
Open access CABI Scientific Outputs Portal (CSOP) further developed and updated	At least 3000 publications in portal 100 additional publication records from 2016 300-400 retroactive publications (e.g. publications, extension materials, project reports, and selected others) from 2016 to 2000	At least 3500 publications in portal 100 additional publication records from 2017 300-400 retroactive publications (e.g. publications, extension materials, project reports, and selected others) from 2016 to 2000	At least 4000 publications in portal 100 additional publication records from 2018
Research data captured and made openly available.	Data archiving strategy and guidelines prepared, mechanisms set up and their use piloted	Data archiving established as part of project routine and reflected in CABI's Project Management System	Data archiving routinely carried out
Effective mechanisms implemented to monitor publications, reports, talks and posters presented, research students, major scientific contributions, etc.	Annual Science Report and monthly publications pipeline report	Annual Science Report and monthly publications pipeline report	Annual Science Report and monthly publications pipeline report
CABI's research published open access	At least 75% of first and corresponding author publications open access	85% of first and corresponding author publications open access	100% of first and corresponding author publications open access

Key Milestones	2017	2018	2019
Staff access to non-open access publications increased	Budget available at centre level	Budget available at centre level	Budget available at centre level
Social media used to promote scientific outputs	Strategy in place to use social media and on-line network opportunities to promote CABI scientific outputs; guidelines, staff awareness raising and staff training in place to implement strategy. Social media strategy piloted and indicators refined	Social media strategy implemented and its impact monitored with selected indicators.	Evaluation of the impact and value of promoting CABI's scientific outputs using social media and on-line networks, compared to other approaches.
Capacity for social and economic science increased	Selected cohort of 10-15 CABI scientists trained in embedding social science 2 new social scientists employed (Asia and Europe & the Americas)	New cohort of 10-15 CABI scientists trained in embedding social science 2017 cohort of scientists attended follow-up training 2 new social scientists employed (Africa, Asia)	New cohort of 10-15 CABI scientists trained in embedding social science 2017 and 2018 cohorts of scientists attended follow-up training 2 new social scientists employed (Africa and/or Europe & the Americas)
Availability of key numerical skills increased in-house	Attachments, partnerships or recruitment enable CABI to meet project needs with regard to numerical skills	At least one new recruit with key numerical skills	At least one new recruit with key numerical skills
Availability of software and computing capacity to support big data analysis	Inventory complete; key needs identified and their acquisition planned	Software and computing upgraded based on resource planning	Software and computing upgraded based on resource planning
Use of incoming and outgoing attachments (secondments and sabbaticals) increased to strengthen research capacity	Minimum of 2 attachments implemented and evaluated	Minimum of 2 attachments implemented and evaluated	Minimum of 2 attachments implemented and evaluated

Key Milestones	2017	2018	2019
Employment of research students (MSc, PhD etc.) and interns (summer students) increased to address strategic research priority areas	At least 5 research students and 15 interns across CABI (total 20), of which 5 are at centres other than Switzerland	At least 7 research students and 17 interns across CABI (total 24), of which 7 are at centres other than Switzerland	At least 9 research students and 20 interns across CABI (total 29), of which 9 are at centres other than Switzerland
Strategically important scientific review / synthesis papers published	At least 3 publications	At least 3 publications	At least 3 publications
Biological control agents studied and submission of introduction applications supported	At least 50 BCAs studied across all CABI centres; 5 introduction applications submitted by national partners	At least 50 BCAs studied across all CABI centres; 5 introduction applications submitted by national partners	At least 50 BCAs studied across all CABI centres; 5 introduction applications submitted by national partners
New tools/technology (e.g. genetic, GIS, big data) applied in research projects	At least 3 publications	At least 4 publications	At least 5 publications
Research outcomes and impact measured (through internal / external evaluations, special studies, etc.)	At least 3 publications / evaluation reports	At least 3 publications / evaluation reports	At least 3 publications / evaluation reports
Research involving people implemented using a gender sensitive approach	At least 3 publications using disaggregated data	At least 4 publications using disaggregated data	At least 5 publications using disaggregated data
Maintain and use BIOCAT for scientific research outputs	BIOCAT up-to-date until 2010 At least 1 publication using BIOCAT data	BIOCAT up-to-date until 2015 At least 2 publications using BIOCAT data	BIOCAT fully up-to-date At least 3 publications using BIOCAT data

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