

icipe PERIODIC EXTERNAL REVIEW (IPER) (2013 – 2017)



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***icipe* Periodic External Review 2013 – 2017**

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Acronyms and Abbreviations

AAS	African Academy of Sciences
ACCES	Adaptation to Climate Change and Ecosystem Services
AFERIA	Adaptation for Food Security and Ecosystem Resilience in Africa Project
ARC	Agricultural Research Corporation
ARPPIS	African Regional Postgraduate Programme in Insect Science
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AU-IBAR	African Union Inter-African Bureau for Animal Resources
AVRDC	World Vegetable Centre
BMZ	German Ministry for Economic Cooperation and Development
CAADP	African Union's Comprehensive Africa Agriculture Development Program
CAP-Africa	Combating Arthropod Pests for Better Health, Food and Resilience to Climate Change
CBID	Capacity Building and Institutional Development Programme
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
CHIESA	Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa project
CIAT	International Centre for Tropical Agriculture
CIM	Centre for International Migration and Development (CIM) of the German Development Cooperation GIZ
CIP	International Potato Center
CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Development
CORAF/WECARD	West and Central African Council for Agricultural Research and Development
DRIP	Dissertation Research Internship Programme
EANBit	Eastern Africa Network for Bioinformatics Training
EIAR	Ethiopia Institute of Agricultural Research
ERP	Enterprise Resource Planning
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
GC	Governing Council
GIS	Geographic Information System
GPS	global positioning system
HAT	Human African Trypanosomiasis
IBCARP	Integrated Biological Control Applied Research Programme
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INSEFF	Insect for Food, Feed and Other Uses Programme
IPER	<i>icipe</i> periodic external review
IPM	integrated pest management
IPR	intellectual property rights

IRD	Institut de Recherche pour le Development
ITOC	<i>icipe</i> Thomas Odhiambo Campus
IVDM	Integrated Vector and Disease Management
IVM	Integrated Vector Management
KALRO	Kenya Agricultural and Livestock Research Organisation
KEMRI	Kenya Medical Research Institute
KEPHIS	Kenya Plant Health Inspectorate Service
KPMG	Klynveld Peat Marwick Goerdeler
M&E	monitoring and evaluation
MARI	Mikocheni Agricultural Research Institute, Tanzania
ML-EID	Martin Lüscher Emerging Infectious Diseases
MOU	memorandum of understanding
NARO	National Agricultural Research Organisation, Uganda
NGOs	Non-governmental organisations
NIH	National Institutes of Health
Norad	Norwegian Agency for Development Cooperation
OIE	World Organization for Animal Health
PASET	World Bank's Partnership for Skills in Applied Sciences Engineering and Technology program
PMEL	Planning, Monitoring, Evaluation and Learning
POPs	Persistent Organic Pollutants
R&D	research and development
R4D	Research for Development
RBM	Results Based Management
RSIF	World Bank's Regional Scholarship and Innovation Fund for Applied Sciences, Engineering and Technology
RVF	Rift Valley Fever
SDGs	Sustainable Development Goals
SGI	Sponsoring Group of <i>icipe</i>
Sida	Swedish International Development Cooperation Agency
SMC	Senior Management Committee
SSA	sub-Saharan Africa
SSIA	Social Science and Impact Assessment Unit
TAAT	Technologies for African Agricultural Transformation
ToC	theory of change
TTU	Technology Transfer Unit
UNESCO	United Nations Educational Scientific and Cultural Organization
USDA	United States Department of Agriculture
WHO	World Health Organization
WHO-AFRO	WHO Regional Office for Africa
YESH	Young Entrepreneurs in Silk and Honey

Preface

Review Team Mode of Operation

icipe (International Centre of Insect Physiology and Ecology) considers the regular external and internal monitoring and evaluation of its performance an important activity to regulate both the quality of its research and development (R&D) activities and continued relevance of its strategy to ensure compliance to its mandate and mission. Since 1983, the Sponsoring Group of *icipe* (SGI) together with the Governing Council (GC), have commissioned the *icipe* Periodic External Review (IPER). These reviews are undertaken every 5 or 6 years. The last IPER was accomplished in 2013. While generally applauding *icipe*'s achievements, the 2013 IPER made the following key recommendations: (1) Adopt a more systems approach to the research by: (a) taking advantage of *icipe*'s 4-H themes to build a One Health approach, and (b) employing stronger consideration of whole value chains rather than only on-farm or postharvest foci; (2) Focus more on development outcomes; (3) Build socio-economics capability; and (4) Expand *icipe*'s influence more strongly into other parts of sub-Saharan Africa.

With the revision of the Centre's strategy in mind, the GC of *icipe* commissioned the current IPER of the Centre in 2018 for the period of 2013-2017. The purpose of this IPER is to review the impact of *icipe*'s R&D programmes, to assess trade-offs across programmatic and strategic priorities and to offer recommendations for the future planning of its R&D programmes and the institutional requirements to support those programmes (More details are given in the terms of reference in Annex 1).

The IPER Review Team (RT) included three international experts (see Profiles in Annex 2), Drs. John Lynam (Chair), Bruce Pengelly and Prof. Serap Aksoy, all with different academic and societal backgrounds and professional careers. For this review, the RT took as its point of departure the major recommendations from the 2013 IPER. We put emphasis on evaluating the R&D programmes including capacity building, technology transfer mechanisms and impacts in the field. Based on our analyses we have attempted to formulate our views, draw conclusions and express general and specific recommendations which we offer to the management and staff of *icipe*, to the GC and the SGI.

The RT met and reviewed experiences made during the days of on-site review period (1-18 March 2018). These meetings allowed the RT to share and align views, discuss problems, draw common conclusions and formulate important recommendations in a very open and trustful ambience. The programme visits of RT were very intensive but highly productive. The final report of this IPER is the synthesis of project/programme/field visits, individual and group discussions with *icipe* staff, presentations made by *icipe* staff, meetings with the Director General (DG) and the two Directors of the Centre, information compiled from stakeholder and partner visits, reading of *icipe* internal documents and scientific literature published by *icipe* scientists and, finally, of personal impressions and judgements.

The information, on which the RT based its decisions regarding the R&D achievements, key concerns and issues, and its assessments and conclusions, was gathered in a number of ways. These included: briefings given to the RT by the Senior Management of *icipe*; extensive documentation provided by *icipe* and data provided to the RT in response to its particular needs, all provided at a portal created by *icipe*; review of GC and Executive Board (ExBo) reports and interaction with some GC members; briefings and communications with the Director General (DG), the Senior Management Committee (SMC), Theme/Unit/Programme Heads and other research staff, the finance and administration team and research support units; information gathered during RT member field visits in Kenya to review *icipe* research project activities in the field and meet with its clients and collaborators, and email correspondence with a variety of *icipe* donors and partners.

The RT could not assess every aspect of the Center operations in-depth in such a short period and hence relied, to the extent possible, on the GC commissioned external review reports and donor reports. The Center was kept informed of the RT's activities and progress during the review. The RT Chair and *icipe* DG were in regular contact. The draft report prepared by RT was shared with the Center for checking its factual accuracy prior to finalization.

The Chair of RT presented the main findings and recommendations of the IPER at the ExBo meeting in Rome and at the Annual GC meeting at which the *icipe* staff were also present.

We hope that our review will contribute to the development of new and improved R&D programmes at *icipe* that may better comply with the changing demands and hopefully strengthen *icipe*'s comparative advantages. Although we undertook an extensive review in fulfilment of our terms of reference, we realize that a few weeks of work would necessarily be limiting for a full understanding of everything about *icipe*. Our conclusions therefore are based on those aspects that we reviewed and our report summarizes those observations and recommendations arising therefrom. The implementation of these recommendations should support *icipe* in re-positioning itself to meet new challenges and opportunities in tune with its institutional mandate and the development needs of its beneficiaries.

Acknowledgements

Drs. John Lynam, Bruce Pengelly and Prof. Serap Aksoy would like to express their appreciation and extend special “*THANKS*” to all *icipe* faculty, management and staff for putting together a massive amount of data on Centre activities for assessment by the review team, arranged and accommodated complicated travel schedules and last minute scheduling changes and requests, and accompanied the review team on multiple site-visits. The document “Review of *icipe*'s achievements” was put together for the IPER team and we found this a most valuable overview of the Centre. We particularly thank Annah Njui for being the point person on all things related to the review and for doing this with the usual efficiency she applies to all her work. We thank *icipe*'s leadership for their frank and open discussions and for making all requested materials at our disposal immediately. The review team considers it a privilege to have this opportunity to interact with such a committed and creative staff and the Centre.

John Lynam (Chair)

Bruce Pengelly

Serap Aksoy

Executive Summary

The IPER review of 2018 found *icipe* to be delivering a strong, innovative research and development (R&D) program addressing a wide range of critical issues associated with human, animal, plant and environmental health in Africa. Its research is based on a number of defining factors, including its: (a) focus on research domains in which insects have critical roles as vectors, pests or are the basis for sustainable utilization in small to medium enterprises, (b) innovation that it applies for sustainable and safe alternatives to the growing reliance on agro-chemicals, and (c) highly valued Capacity Building and Institutional Development (CBID) Programme.

While these fundamentals of *icipe*'s R&D philosophy have not changed to any great extent over the review period, operationally it has demonstrated its ability to continue its commitment to long standing challenges across all its four thematic areas, while at the same time responding rapidly to new opportunities and challenges, including emerging invasive pests arriving into Africa, insects for food and feed for a growing protein economy, the role of microbial symbionts in vector transmission capabilities, nematodes and soil health, and Bioresources Innovations Network for Eastern Africa Development (BioInnovate Africa, <http://bioinnovate-africa.org>), Africa's largest regional innovation-driven science initiatives, began in November 2016. BioInnovate Africa, funded by the Swedish International Development Cooperation Agency (Sida), supports scientists and innovators in the region to link biological based research ideas and technologies to business and the market.

The review period of 2013-2017 has been marked by the appointment of a new Director General (DG) and two Directors. Under their leadership *icipe* has committed to implementing the recommendations of the previous IPER. Among these responses have been stronger focus on taking its research to impact through appropriate partners and through building its own capability in key areas. The Social Science and Impact Assessment (SSIA) Unit has been greatly strengthened, and a Technology Transfer (TT) Unit has been created since 2016. Just as importantly, the research team at *icipe* has taken on board the imperative to have their research and innovations taken to communities. There has also been significant progress in responding to the recommendations to broaden its influence and impact into other sub-regions of Africa, to put more emphasis on systems research (One Health) and raising the visibility of *icipe* through improved communication, both outside and within the Centre.

In the past five years, the Centre has succeeded in expanding and upgrading its outstanding research facilities. *icipe*'s outputs, outcomes and impacts are delivered via four research themes — Human Health (HH), Animal Health (AH), Plant Health (PH), and Environmental Health (EH) — and a CBID Programme. These thematic areas and CBID are fully supported by nine functional R&D Units, two major Programmes (Insects for Food and Feed; Bioinnovate Africa) and a Country Office in Ethiopia (additional country offices in other countries include Uganda and Somalia). *icipe* plays critical and significant roles as a key global focal Centre. *icipe* is an FAO designated Reference Center for vector-borne animal diseases; a Stockholm Convention Regional Center for reduction of persistent pollutants; World Organization for Animal Health (OIE) Collaborating Center for Bee Health in Africa, and a key Centre for malaria vector management working with the World Health Organization (WHO).

The 4-H Themes and CBID Programme have a long history of delivering high-quality science outputs leading to development outcomes and impact. *icipe*'s R&D work addresses major issues for Africa, such as malaria control, management of the parasitic weed *Striga* in cereals, control of a range of crop pests through development of biopesticides and other technologies, and control of tsetse flies and trypanosomiasis, biting flies and surra in livestock. In addition to controlling diseases and reducing losses in production, where appropriate it encompasses the entire value chain.

The R&D portfolios of *icipe* include a large number of projects which aim to build incomes and better livelihoods via the direct benefits of insects, such as beekeeping, silkworm farming and more innovative programmes focusing on insects as food and feed, which harness the rapid and efficient growth and reproduction of suitable insect species. Research for development (R4D) continuum constitutes four distinct stages: discovery, proof of concept, piloting, and scaling. Special efforts were made by the Centre in the past five years, with support from some key donors, to improve integration among the 4-H Themes, R&D Units and Programmes, and for promoting a range of *icipe*

technologies, tools and management strategies from discovery and proof of concept to piloting and scaling to deliver on the mandate of the Centre.

The Human Health Theme with its main focus on control of malaria in different ecological zones has succeeded in developing several improved monitoring tools, such as odour-baited solar powered field traps as well as biolarvicides, the efficacy of which are being evaluated within the framework of an Integrated Vector Management (IVM) strategy. The Animal Health Theme has pioneered the approach of the use of tsetse repellent collar for protecting domestic animals from tsetse flies and the parasites they transmit, and this approach has entered into an implementation phase. The Plant Health Theme has succeeded in wide-scale dissemination and adoption of push-pull system adapted to both sub-humid and dryland conditions. This system provides an integrated systems approach with multiple benefits to control of stemborers, the parasitic weed *Striga*, the fall armyworm and aflatoxin, as well as increases in soil organic matter and associated soil fertility, while improving crop productivity (up to 3.5-fold) and providing high quality livestock feed resources. The Environmental Health Theme developed an integrated program on bee research which is considered as the most comprehensive in SSA that encompasses the role of bees in providing ecosystem services (pollination) and commercial products, particularly honey and wax, and research on bee health, a global issue of major concern.

As part of the strategy to position the Centre as a key and forward-looking R&D player in agriculture, health and environment, during the last five years, *icipe* has accomplished the following: 1) Established a programme on insects for food and feed; 2) Established a research area on symbionts and their role in transmission blockage in vectors; 3) Initiated research on bee microbiota to explore their role in bee health; 4) Established research work on nematodes; 5) Strengthened its SSIA Unit; 6) Created a TT Unit for effective and comprehensive research translation; 7) Created a Communications Unit for reaching a wide audience globally and significantly enhancing the Centre's profile; 8) Succeeded in diversifying and expanding Centre's donor base and corresponding currencies and geography by bringing in 24 new donors; 9) Significantly enhanced its presence and impact in Ethiopia, Somalia and Uganda; 10) Expanded partnerships and regions to further enhance outcomes and impact; 11) Expanded its technologies and products in Southern Africa, Canada and parts of Asia; and 12) Provided hosting services to 14 international and local organisations at the Centre's two campuses (Duduville and ITOC, Mbita).

A key strategy of *icipe* is to remain alert to emerging developmental challenges facing Africa, and to then identify opportunities to use insect science to respond innovatively to such problems. In accordance, the Centre has established itself as a leader in the globally emerging insects for food, feed and other uses research agenda. Based on *icipe*'s work, Kenya and Uganda have recently become the first African countries to establish official legislation and policy on use of insects as feed. Other new major initiatives of the Centre include a project titled "Young Entrepreneurs in Silk and Honey (YESH)". *icipe* and the MasterCard Foundation launched this 5-year project in 2016 and it aims to enhance youth employment in Ethiopia through beekeeping and silk farming enterprises.

icipe has been using Results Based Management (RBM) as a performance management tool that provides a framework for assessing results, adapting research programs, and accountability to donors. It has been helping the Centre and its donors to better understand, plan, and report the impact of Centre's work. Implementation of the *icipe*'s vision and strategy 2013-2020 for the past five years has resulted in novel solutions for improving food and nutrition security, environmental sustainability, health, youth employment, income generation, private sector development, and capacity building in the target areas. *icipe*'s blend of R&D activities that span the spectrum of new discoveries in fundamental science to strategic applications that deliver practical outcomes have continued to impact its constituents.

In its drive to modernize *icipe* and enhance accountability, the Centre's management succeeded in streamlining and highly improving transparency, efficiency, financial management; creating checks and balances in procurement; and created an internal audit unit. Ten new policies were developed and approved by the Governing Council (GC) of *icipe* while eight others were updated and two are under review. The income and expenditure data for the past five years indicate a funding position that is stable and sufficiently diversified. Management closely monitors cost control measures to ensure that the Centre breaks even every year while building up the financial reserves to

manage risk and financially buffer the Centre. Management also established a currency revaluation reserve as a line item in the financial statements to reduce the risk for the Centre towards currency fluctuations.

Despite the challenging global funding environment over the 2013-17 period, *icipe* has been able to maintain its total level of funding. This has been achieved by a balance of ensuring continued support from several of its long-term donors and by attracting new major donors, such as the MasterCard Foundation, and at the time of writing this report, the Government of Norway has joined *icipe* as one of its major donors. Achieving this continued level of funding and attracting new donors has been largely enabled by the improved financial, human resources management and control systems as well as the high quality of its research outputs.

icipe management, during the past 5 years, developed and implemented a plan to improve infrastructure and to make *icipe* a green Centre by making the entire campus and its research stations solar powered; introducing a water conservation system; implementing energy saving measures; enhancing landscaping; establishing new buildings for bee research at headquarters and student dormitories at Mbita; upgrading and renovations of the infrastructure of buildings, labs and field stations (Muhaka, Nguruman, Mbita); building new insectaries for mosquito and tsetse flies; and upgrading and modernizing laboratory equipment to strengthen R&D Units. The Centre has also established infrastructure for videoconferencing to improve internal and external communications; and enhanced computerised business systems and introduced a standardized pre-populated budget template, job application system, travel requisition and staff requisition using an enhanced e-procure system. Building on these initiatives, the Centre has started implementation of an integrated Enterprise Resource Planning (ERP) system. Furthermore, a protected portal on the web for document repository was developed to promote effective Governing Council (GC) communication, proper management and timely distribution of and access to important records and governance documents.

There have also been various changes in staffing at various non-leadership levels to improve capacity and also to better align skills with functions. Management has developed and actualized a staff promotion system for scientists and initiated job classification processes for improved human resource management.

Notwithstanding the achievements since 2013, *icipe* faces some key challenges as it moves into the next five-year period. The review team's recommendations reflect what it perceives as the most critical of these. These include placing more emphasis on adopting a systems approach to its research through the One Health integrating paradigm, broadening its influence across sub-Saharan Africa (SSA), scaling out its technologies and appointing new scientists in a number of critical disciplines. The summarized recommendations are:

1. One Health as an Integrating Paradigm

The aspiration by *icipe* to build a stronger One Health systems approach to its research is fully supported by this review as it was in the previous IPER. Since 2013 the *icipe* research portfolio has established several examples of projects which draw skills from across disciplines and aim to deliver benefits across multiple "health" themes but more needs to be done before the one-health paradigm is fully established as a research approach within the Centre. A problem framework that integrates across themes is needed to move this forward. There is experience outside *icipe* with zoonotic disease in integrating human, animal and environmental health. The review suggests at several points the potential of invasive species as such a problem framework. As a way of furthering the establishment of the one-health paradigm within the Centre, *icipe* should put in place a range of processes/practices and incentives that encourage projects to take a stronger systems approach in their design. Those processes/practices might include strengthening the role of the Science Committee to initiate design of One Health systems projects which are more inclusive across the Themes, set targets for the number of One Health projects, deploy critical skills into such projects and progress towards one-health research by building internal modelling capability that supports design and analysis of system interactions. Globally, funding for the One Health concept remains a challenge as the donor communities continue to preferentially fund through individual sector programmes. The IPER team recognizes that this can be a major obstacle to fully realize the benefits of implementing the One Health systems approach while fully endorsing *icipe*'s commitment to system-wide research.

2. Strategic Capacity Needs within an Evolving *icipe*

icipe has an impressive management team and range of research and technical staff and skills delivering into all Themes and has made significant progress in attracting highly qualified professionals in science, management, administration and science service units over the past five years. These include: the Director General, Director of Finance and Administration, Director of Research and Partnerships, Head of Capacity Building and Institutional Development, Head of Human Resources, Head of Facilities and Asset Management, Head of Catering and Guest Houses, Head of Security, Resource Mobilization Coordinator, Head of Finance, Head of Social Science and Impact Assessment, Head of Technology Transfer, Head of Ethiopia Country Office, Procurement Manager, Internal Auditor, Station Administration Coordinator at Mbita, Coordinator YESH project, BioInnovate Africa Program Manager, Bee Health Senior Scientist, Gender Specialist, various mid-career scientists, several seconded scientists and visiting scientists, and various technical and administration support staff among others.

In addition, *icipe* has made major efforts and progress in attracting visiting scientists and secondments with long-term agreements with Institut de Recherche pour le Development (IRD), Centre de Cooperation Internationale en Recherche Agronomique pour le Development (CIRAD), the University of New Zealand, the University of Glasgow, and CIM Program of Germany who base their scientists at *icipe* where they are fully integrated within *icipe*'s various programmes. *icipe* Management is also currently drafting agreements and terms of references for new Adjunct Scientist arrangements with key individuals globally.

However, some critical high-level positions remain vacant and there are a number of new science and administrative positions that should be prioritised. Appointments to the Plant Health, Human Health and Environmental Health theme leader positions to round out the full complement of senior leadership positions are considered to be most critical for both the strategic and operational effectiveness of the institute. (NB. offers were made for the Plant Health Theme and the Environmental Health Theme leaders positions in the months after the review).

As noted previously, the highest tier of leadership in *icipe* is quite narrowly defined, consisting of the DG and two Directors; Director of Research and Partnerships, and Director of Finance and Administration. This narrow leadership team is probably commensurate with the size of the Centre but the breadth of functions carried out by this small team puts extreme pressure on their time. At least one, and possibly two new senior executive officers positions to lead the implementation of senior leadership decisions would go some ways in releasing senior management to pursue its higher level functions and further improve the effectiveness of management and administration.

The review team identified three areas of science where priority appointments are necessary. While *icipe* already has modelling skills in the GIS research unit and within its Themes, it would benefit from stronger modeling capability that would assist to conceptualize, engineer and develop a modelling framework to enable *icipe* to fully explore and benefit from the one-health concept. This will be particularly important in epidemiology and early warning systems.

The primary focus of the SSIA unit since its establishment has, appropriately, been oriented towards agricultural economics which supports the key areas of impact evaluation and Monitoring and Evaluation. The review team considers that expansion of the unit with new skills in sociology and/or anthropology would be timely to support *icipe* to develop its research on how best to pilot IPM and IVM programs, gain wider community adoption of its technologies, and scale management intensive technologies.

Data analysis is a critical discipline in a research institute as large as *icipe*, with its range of disciplines, especially with its consistently large number of PhD students and the associated wealth of data being generated each and every year. The current Biostatistics Unit is under-resourced, especially if meta-analysis of large datasets is to be undertaken. Lack of recognised professionals in this discipline might even represent a reputational risk to the Centre, especially given that human health and disease prevention is a key area of research. Strengthening of the biometrics function should be a priority, particularly as this will be a priority of the World Bank's Regional Scholarship and Innovation Fund (RSIF) for Applied Sciences, Engineering and Technology, which *icipe* has competitively won recently.

3. Data Management

icipe has developed outstanding information management in terms of its journal, the digitization of its library, its institutional documents including partner agreements, its web page, and improvements in processing submitted papers to its journal. The Centre already complies with the growing requirements of many mainstream journals (e.g. PLOS family) that authors make their data available to other academic researchers who wish to replicate, re-analyse, or build upon the findings published in their journals. These data are often submitted as publicly accessible supplementary files, or a Data Availability Statement that indicates where data supporting the results published are available, with hyperlinks to relevant datasets. Where appropriate, clinical trials and Randomised Control Trials are archived in repositories such as Clinicaltrials.gov (*Pyronaridine plus artesunate for treating uncomplicated Plasmodium falciparum malaria* (<https://clinicaltrials.gov/ct2/show/NCT02411994>), and the trial register (Solarmal: Solar energy for malaria elimination; <http://www.trialregister.nl/trialreg/admin/rctview.asp?TC=3496>). All researchers at *icipe* deposit sequence and genomic data in the central genome databases, most often via GenBank, and specialized databases such as VectorBase (vectorbase.org), the repository for genomic data for vectors of human disease.

These actions go some way in meeting the growing expectation from the wider research community and donors that data be securely held and over time moved into the public domain where it is available to other research teams. However, more needs to be done, especially in disciplines outside genetic, human health and the social sciences which have tended to lead the way in ensuring data retention and availability.

icipe is already working towards providing an appropriate centralized repository for all data collected and a draft Data Management Policy has been prepared. Such a policy is particularly important in a Centre such as *icipe* that has large numbers of Masters and PhD students and where, because of its research history, large datasets which have been assembled over long periods that are likely to prove of particular value in developing new research insights via meta-analysis.

Currently, normal practice at *icipe* is that data sets are kept by individual scientists, often in excel files, and when the scientist leaves—more so for PhD students—the data are transferred to supervisors. For a research Centre in the era of Big Data, it is essential that primary data are archived regularly and in a consistent manner across the Centre to prevent its loss for future research, particularly given the speed of global change. *icipe* should, as a matter of urgency, finalise and implement a Data Management Policy that will ensure mechanisms are put in place for centralized archiving and backup of data sets that are well labelled and described, that clear protocols under which those data sets might be accessed by other researchers are clearly defined, and that appropriate resources are assigned to implement the policy.

4. Pathways to Impact

icipe research and development agenda encompasses basic research orientated towards new knowledge, the development and testing of new products, innovative on-farm and community practices and policy to control disease and pests, through activities that are focused on development and scaling out a range of technologies. It is important that *icipe* continue to deliver across the R&D spectrum and continue to do this through its impressive and diverse range of partners from the private and public sectors. *icipe* recognises that these partners are crucial to maintaining the quality of its science and to securing widespread adoption be it adoption of multi-faceted pest and disease management practices or its research and development programmes focused on women and youth.

While recognizing *icipe*'s central role in scaling out its technologies, it should at the same time be striving to continually improve the balance of roles that *icipe* and its partners might play. This is particularly relevant in responding to the ever-growing capability and capacity of its African partners. In response to this changing environment, *icipe* should:

- a. Ensure that it builds pathways to impact that specifically include building capacity of development partners. This will enable it to free up its research capability to address emerging constraints to agriculture, livestock,

environment and human health. There is an evolving research agenda in the “science of scaling,” which could be integrated into joint work between the SSIA and TT Units, and BioInnovate Africa Programme.

- b. Put even more emphasis on developing innovative impact pathways and, as much as possible, ensure that these pathways are well resourced in terms of *icipe*'s role, the role of relevant partners and appropriate funding. This greater emphasis will ensure that *icipe*'s three recent initiatives to overcome barriers to adoption, viz., the inclusion of a TT Unit, the Bioinnovate Africa Programme, and a growing SSIA Unit have a stronger framework for working together with research Themes to design and pilot the best options for impact.

5. Operational Modality to Cover the African Mandate Area

icipe's mandate area is sub Saharan Africa, which presents challenges in terms of the heterogeneity across the continent and opportunities given the demand for effective IPM and IVM control strategies. The Centre currently has activities in 40 African countries, but the modality of cooperation varies significantly between East Africa and the rest of the continent. As might be expected in East Africa there is a primary locus of activity in Kenya, where *icipe* has its headquarters and carries out most of its strategic and applied research. In addition, it has country offices in Uganda, Somalia, and a recently more expanded presence in Ethiopia. Just about all donors currently have country priorities, and Ethiopia has been a focus for a significant number of donors. The Ethiopia country office has allowed *icipe* to integrate into both country level priorities of donors as well as into national ministries and agencies. The Ethiopia country office thus functions as more than an implementing capacity for projects developed at headquarters but also as a multi task capacity that gives the Centre operational field capacity, ability to interact within a complicated national institutional framework, and the intelligence on donor funding possibilities.

The operational modality in West and Southern Africa, on the other hand, relies on institutional partnerships, often through ties with former PhD students, in project implementation. Because of the project dependence, these are often relatively short term in nature and limit the visibility of *icipe* in the country. At the same time, the Centre has a range of technologies and methods that would have potential for impact in these countries, a prime example being the current scaling of push-pull in both West and Southern Africa. The fall armyworm offers another opportunity, potentially as a leader in the development of a surveillance and rapid response capability on invasive species. The latter, however, depends on longer term institutional ties, some operational capacity in the country or region, and the ability to mobilize resources, namely similar to the capacity in the Ethiopia country office. Much donor funding flows through donor country offices but to access those funds requires a visible operational presence in the country or region. The IPER team feels that *icipe* is now at the point that it would be advantageous to extend the operational modality of country, or more appropriately regional offices in West and Southern Africa, potentially building on the experience with push pull in those regions. To do so, however, will require an upfront strategic investment from core resources.

6. Capacity Building, Institutional Development, and Expanded Outreach

icipe has a long and enviable record in Capacity Building with about 100 post-graduate students embedded in the research Themes and research Units at any one time. The quality of the students and the training they receive is evidenced by their publication record. There is an opportunity to use the success of the CBID Programme to support institutional development in an expanded outreach strategy into West and Southern Africa, as discussed in Recommendation 5. This would entail building capability in selected core centres in those regions, what has been termed centres of excellence. It is recommended that 15-25% of the postgraduate intake in each year be quarantined for students from those selected core partner institutes so that over time, these graduates will significantly build the capacity of the Partnering Institutes. This will require funding which targets capacity building in those regions-- often difficult given that donors have specific country priorities-- and may be linked to *icipe*'s involvement in the World Bank's Partnership for Skills in Applied Sciences Engineering and Technology (PASET) program in partnership with African and other governments.

7. Ensuring Financial Sustainability

As with any international organization, *icipe* is dependent on donor funding to finance its operations. The Centre is fortunate in having a financing model that combines strategic unrestricted funding with restricted project funding. Core funding has had an important positive impact on the Centre in its support of long term research and has provided a funding mix that supports sustainability and ability to deliver on its strategy. Core resources fund the direct overhead costs of the Centre, primarily administrative and maintenance costs, much of capital improvement, strategic investments in new capacity, and program budgets that do not have sufficient project funding. The Centre over the review period has witnessed a plateauing and gradual decline in core funding, an inability to meet overhead rates from project funding, and an increasing demand on core resources from programs. It is too short a period to say whether these are structural trends, but forward planning is essential to ensure that these three areas remain in balance.

Three options suggest themselves to maintain this financial balance. The intention is to avoid the third option, which is to cut program capacities that do not have sufficient project or core funding to support them. To rectify such a situation would then require some combination of increasing the number and funding from core donors and improving cost recovery from the grant portfolio with the eventual objective of achieving full cost accounting. Both strategies have their own challenges but the IPER team's rather probabilistic assessment is that any medium-term growth in *icipe* will primarily come from restricted funding and that this would argue for further movement—acknowledging that the Centre already is moving in that direction— to increased cost recovery and eventually full cost accounting. To do the latter will require negotiation with donors and shifting from indirect to direct costs in budget development, as well as a significant internal shift in incentives and organizational culture.

I. Introduction

a. Unique aspects of icipe

Established in Kenya in 1970, *icipe* is the only independent international institute working primarily on arthropods. It employs a diverse range of scientific disciplines in a holistic manner to perform original research on pest and beneficial insects and arthropods with the goal of improving human and livestock health, crop production, ecological systems and well-being of communities. *icipe* has carved out a leading role in what may be termed tropical insect science, as reflected in the range, depth and impact of its strong publication record. The focus of this work is sub-Saharan Africa (SSA), particularly the large population of smallholder farmers. At the core of its mission is the development of affordable and effective tools and strategies to combat insect pests and vector-borne diseases in order to help alleviate poverty, ensure food security and improve the overall health of peoples of the tropic. Its mandate is to develop alternative and environmentally friendly pest and vector management strategies that are effective, selective, non-polluting, non-resistance inducing and affordable for uptake by resource-limited rural and urban communities. *icipe*'s Capacity Building and Institutional Development mandate helps train the next generation of African scientists skilled in these disciplines to deliver impacts in academia, research, industry and government sectors of the economy. It is expected that this scientific workforce will play a key role in realizing the development targets and planned investments in science, technology and innovation in aiding the nations of SSA to meet the Sustainable Development Goals (SDGs) by 2030. *icipe*'s research and development (R&D) program supports the policies of African Union's Comprehensive Africa Agriculture Development Program (CAADP), which was developed in 2003 to support regional agricultural development and the AU Agenda 2063 and its strategic framework for socioeconomic transformation of the continent.

icipe's mandate, while unique, also introduces challenges, given that *icipe* works across the four health themes; Human Health, Animal Health, Plant Health, and Environmental Health. To have an effective impact in these diverse areas, *icipe* operates through different impact pathways, employing partnerships with different agencies across the public and private sectors. Few research institutes straddle such different sectors, creating challenges in both downstream delivery and in resource mobilization. Moreover, given the large number of insect and arthropod vectors that carry human, animal and plant diseases, an even larger number that directly attack plants, and many others that provide beneficial ecosystem services, particularly pollination, *icipe* must assess appropriate research priorities and strategies in the context of smallholder communities in Africa, an increasingly dynamic and changing environment, periodic pandemics emerging in Africa, and under resourced national research and delivery agencies.

b. Mission and Vision

icipe's Mission

"Help alleviate poverty, ensure food security and improve the overall health status of peoples of the tropics by developing and extending management tools and strategies for harmful and useful arthropods, while preserving the natural resource base through research and capacity building".

icipe accomplishes its mission through Science and Technology Development and Capacity Building. *icipe* identifies itself as a first-class research organization that addresses core problems of importance for the human, animal, plant and environmental health on the African continent. Its strategic and applied research activities vary from basic investigations on insect physiology and behavior that are most pertinent for the development of downstream control strategies to discovery research on biopesticides, biological control and bioprospecting. Working within an interdisciplinary framework across the four health themes and taking a systems approach to its research, *icipe* is ideally poised to advance the One Health concept (described in the next section). The scientific program provides a stellar training environment to the next-generation of global scholars and scientists who are poised to address the current and emerging issues in the field of pest management and vector-borne disease control, climate change effects as well as advance bioprospecting in SSA.

The majority of *icipe*'s R&D activities are performed at the Duduville and Mbita campuses in Kenya. The Bee Health African Reference Laboratory on the Duduville campus with its five satellite laboratories across Africa, and the Martin Lüscher Emerging Infectious Disease laboratory on the Duduville campus with its collaborations in Dakar serve the continent. *icipe* also has country offices in Ethiopia, Somalia and Uganda. Beyond Kenya and the country offices in East Africa, it serves the people of Africa through institutional partnerships in 40 African countries with 73 collaborative research projects. To disseminate its knowledge and technologies for impact, and to achieve its influence in Africa, *icipe* has entered into partnerships with key African regional organizations, including the Forum for Agricultural Research in Africa (FARA), the African Academy of Sciences (AAS) as well as sub-regional research organizations, such as the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) and the Centre for Coordination of Agricultural Research and Development for Southern Africa (CCARDESA). *icipe* is one of the fifteen regional centres of the Stockholm Convention on Persistent Organic Pollutants (POPs) undertaking capacity building and technology transfer in developing member countries to achieve elimination or reduction of the use of POPs. *icipe* is also designated as a Food and Agriculture Organization of the United Nations (FAO) Reference centre for vectors and vector-borne animal diseases; World Organization for Animal Health (OIE) Collaborating Center for Bee Health in Africa; and work closely with the World Health Organization (WHO) to improve national and regional vector control capability across Africa. *icipe* has also established key partnerships with African universities, which provide co-supervision and grant degrees for the PhD and MSc students, postgraduate training offered through two *icipe* programmes: The African Regional Postgraduate Programme in Insect Science (ARPPIS) and the Dissertation Research Internship Programme (DRIP). The *icipe* alumni (171 MSc, 157 PhD students and 17 postdoctoral fellows as of 2017) represent an outstanding community of researchers in relevant fields who are well poised to advance R&D within the One Health concept on the continent. Although a large proportion of the training activities has been accomplished in Kenya, *icipe* has established linkages with key universities from a wider geographic context in Africa, from which to draw its trainees and help aid in capacity building at the institutional level. *icipe* has formal partnerships with 43 African universities with different levels of engagement. Among these universities, six are key to *icipe*'s training program, including Pretoria and Northwest universities in South Africa, University of Ghana in Ghana, University of Nairobi and Jomo Kenyatta University of Agriculture and Technology in Kenya and Makerere University in Uganda. As additional PhD level scientist training programs are being planned on the continent, it will be prudent to ensure that research/teaching positions for these individuals exist in public/private academic and/or research institutions. *icipe* is well positioned to advance efforts to integrate research programs into partnering public and private institutions and provide postdoctoral training opportunities for additional PhD graduates.

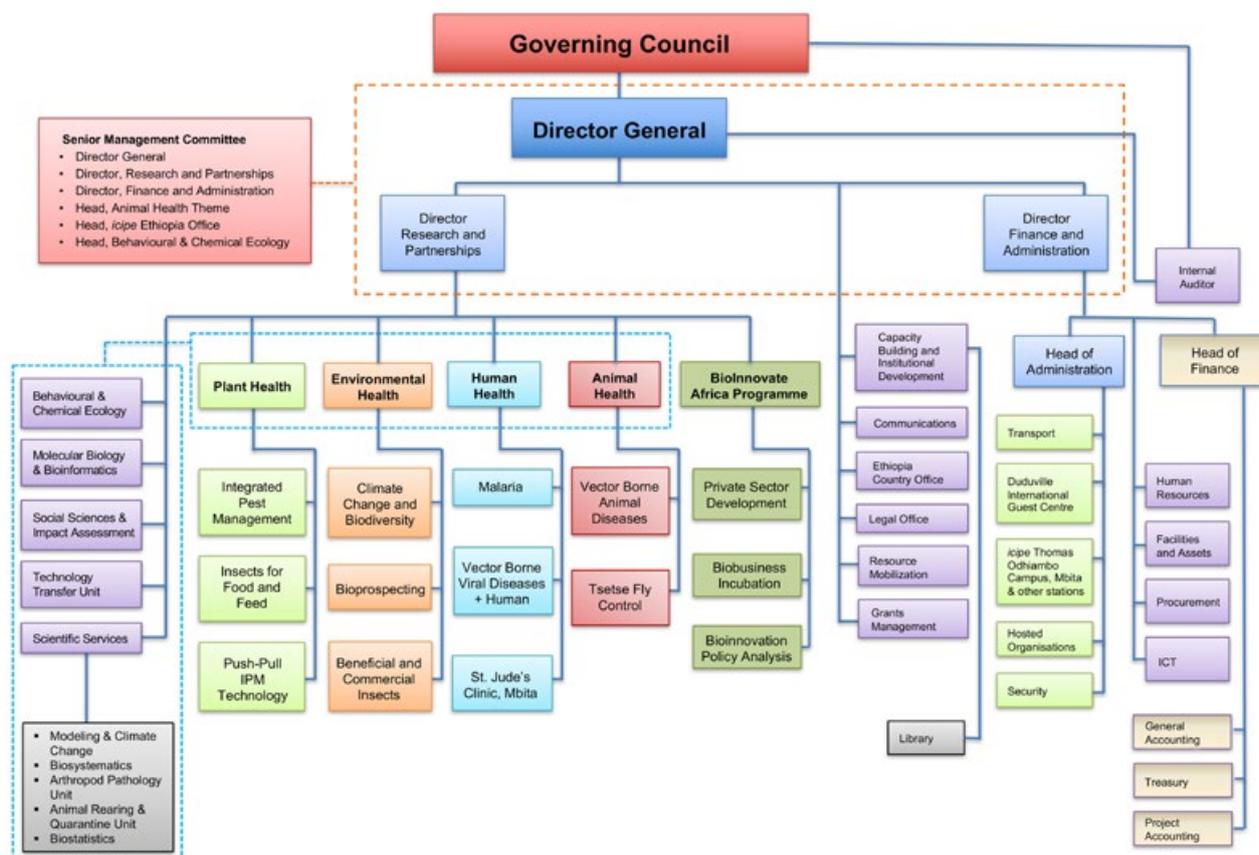
To disseminate innovations and new technologies resulting from its research, *icipe* has entered into partnerships with the private sector in order to ensure that the benefits reach the communities for impact. Through these public-private partnerships, *icipe* has been able to reach markets for its biopesticides and fruit fly attractant products and identify opportunities for these products to be adopted by the communities. *icipe*'s invasive insect pest programs for fall armyworm, diamond back moth, its IPM for fruit flies, thrips, *Tuta absoluta* as well as the tsetse fly control program are already being implemented across various countries in Africa.

c. Research Strategy and Organization

icipe is essentially organized around its four research health themes (4-H), which are identified with specific sectors and defined by their outcomes in that sector: Human Health, Animal Health, Plant Health and Environmental Health. These 4-H Themes are supported by nine cross cutting Research Units, forming a matrix within which research is organized in the Centre (see Figure I.1). The four Themes are strongly aligned with partner organizations and research communities in each health sector, often staffed with quite different disciplines. To foster more interdisciplinary and inter-theme interaction and synergy, the One Health concept has been adopted as a centre-level, strategic framework. The concept envisions the integration of research across the 4-H themes through a social-ecological systems framework designed to organize cross thematic research around specific problem areas.

This concept has been utilized in other fora¹, primarily in the area of zoonotic diseases which integrate animal, human and environmental health. This is done through global networks rather than being institutionalized. *icipe* is extending the concept even further by integrating Plant Health and doing this at a Centre level.

Figure I.1 *icipe* Organizational Structure



The One Health concept can be applied for organizing integrated research as well as for stronger systems-based delivery programs. An application of the concept currently under discussion is associated with the multiple impacts associated with invasive species. *icipe* has demonstrated through research and subsequent high-quality publications that the spread of the invasive plant species *Parthenium hysterophorus* (commonly called “no crop” or “famine weed”) across Africa reduces biodiversity, affects crop production, causes toxicity to cattle and negatively impacts milk quality, and serves as a preferred nectar/sugar source to malaria-transmitting mosquitoes.

The Government of Norway has recently notified *icipe* of its intention to offer *icipe* a grant of NOK 28,100,000 for the period 2018-2023 after selecting its proposal entitled “**C**ombating **A**thropod **P**ests for Better **H**ealth, **F**ood and **R**esilience to **C**limate **C**hange (CAP-Africa)” in response to a competitive call by the Norwegian Agency for Development Cooperation (Norad) to support research institutions and organizations in SSA. This Programme will further provide opportunities to demonstrate the benefits of a One Health approach.

CAP-Africa is a programme grant built upon three of *icipe*'s strategic research thrusts:

1. Global health to reduce the burden of malaria and emerging infectious diseases;
2. Climate change to fill critical gaps in knowledge on climate change impact on ecosystem services and invasive pests and deploying climate-smart technologies to improve food security and systems resilience; and
3. Education to train postgraduate level for leadership in scientific research, development, policy and technology dissemination.

Impact assessment, monitoring and evaluation and gender analysis are factored into the programme.

¹ For example see <http://www.onehealthglobal.net/what-is-one-health/>

Similarly, on the downstream development side, the One Health concept has the potential of producing multiple outcomes for communities via their crops and livestock and the environment, with potential synergies on overall household welfare.² *icipe's* vision of One Health is unique and innovative. The concept of improving well-being within the 4-H structure is a strength that *icipe* can capitalize on and take leadership to demonstrate the efficacy of this approach as projects are developed in this area.

The nine research units providing specialized research inputs across the 4-H Themes include: Behavioural and Chemical Ecology (BCE) unit; Molecular Biology and Biotechnology (MBB) unit; Arthropod Pathology (AP) unit; Biosystematics unit; Animal Rearing and Containment (ARC) unit; Biostatistics unit; Geo-Information (GI) unit; Technology Transfer (TT) unit and Social Sciences and Impact Assessment (SSIA) unit. The core functions of the units support the research activities taking place across the 4-H Themes.

There is a mix of strategic and applied research performed in each of the 4-H Themes. The overall common goal is delivering high-quality science discoveries that are translatable into environmentally friendly tools and strategies that combat insect damage or reduce vector-borne disease transmission to improve human and animal health, nutrition and livelihoods. The goal also includes the introduction of innovative new management strategies that harness the products and environmental services of beneficial insects. To deliver the bioproducts, tools and strategies generated for adoption by target communities, the recently established TT Unit, together with the SSIA Unit, enter into partnerships with the public and private sector. Incorporating these units early into planned scientific research activities can help with timely identification of these potential public-private partnerships that can disseminate the outputs to where they can have the most impact for 4 health outcomes while enabling the research teams to continue with basic and applied research activities.

d. Synopsis of *icipe's* research portfolio in the 4-H Themes

Human Health (HH) Theme: Vector-borne diseases, such as malaria, human sleeping sickness, leishmaniasis, onchocerciasis, filariasis and schistosomiasis, continue to devastate human health, particularly in rural communities in SSA. Lack of efficient tools to target these disease agents in the human host and growing resistance in parasites against the available drugs and resistance in vectors against chemical insecticides necessitates development of alternative tools, which forms the core research in this theme. *icipe's* HH theme has mostly focused on control of malaria in different ecological zones with varying epidemiological traits, with the goal of reducing the *Anopheles* mosquito vector densities and/or the efficacy of their disease transmission potential by understanding their physiology, ecology and behavior. These studies led to the development of several improved monitoring tools, such as odour-baited solar powered field traps as well as biolarvicides, the efficacy of which are being evaluated within the framework of an Integrated Vector Management (IVM) strategy. *icipe's* excellent mosquito research facilities in the Mbita campus has enabled partnerships with key global malaria programs. In addition, the Biovision Foundation-funded initiative has helped build collaborations with KEMRI-Wellcome Trust for operational evaluation of the efficacy of IVM tools for malaria control. In addition to malaria, *Aedes* mosquito transmitted arboviruses, such as dengue, chikungunya, West Nile virus, yellow fever and rift valley fever, cause important emerging and re-emerging diseases that threaten human health in SSA, and hence provide new opportunities for *icipe's* research focus. In addition to vector genetics and ecology, insect microbiota are increasingly implicated in modifying the transmission efficacy of pathogens in vectors. In this regard, recent work initiated on mosquito endosymbionts provides exciting new direction for *icipe's* research in order to interfere with disease transmission in mosquitoes.

Animal Health (AH) Theme: *icipe's* research within the AH theme focuses on improving livestock health and productivity by controlling diseases transmitted by two important vectors on the continent: tsetse flies and ticks. Ability to control these diseases will provide greater availability of meat, milk, hides and draught power, improving human health and well-being. Tsetse flies transmit the pathogenic parasites trypanosomes to humans

² See Kassie, M., S. T. Ledermann, G. Diro, T. Tefera, S. Ballo, and L. Belahun (2017). The economics of multiple interventions to achieve holistic development outcomes: Pilot evidence from Ethiopia. Paper presented at the 30th International Conference of Agricultural Economists (ICAE), July 28-August 2, 2018, Vancouver, Canada.

and animals, while ticks vector many important animal diseases, including the East Coast Fever or theileriosis. The research program encompasses a variety of activities, ranging from the development of environmentally safe methods that can be sustainably adopted by small farming communities to high quality basic science research into vector physiologies that are relevant for the development of new control tools. *icipe*'s integrated pest and vector management approach aims to develop biological control methods that are based on the identification of botanicals and anti-tick pasture plants, repellents and behavior modification – all to be used within the push-pull strategy which *icipe* has pioneered. This research has led to the development of the widely used Ngu traps for tsetse flies, the efficacy of which has been enhanced more recently by discovery and use of odour baits. The use of tsetse repellent collar for protecting domestic animals from tsetse bites is another approach that *icipe* has pioneered and this approach has entered into an implementation phase where its production by business partners and adoption by the rural farming communities is now being planned through community mobilization and empowerment activities. Camel health and productivity is another focus of the animal health program, which is being expanded via better identification of the biting flies involved in transmission of the parasitic agents responsible for disease and development of effective traps against the insect transmitting the disease agents. Acaricides are widely used for tick-borne disease control but resistance of ticks to these chemicals is a growing concern. *icipe* has developed an effective bioacaricide based on the use of entomopathogen *Metarhizium anisopliae*, which has already reached the final stages of commercialization.

Plant Health (PH) Theme: The strategic objective of the PH theme is to stabilize horticultural and staple food production through reduction of pre- and post-harvest yield lost due to pest damage, mites, weeds and fungi. At the core of its focus is the development and dissemination of products and control strategies that are environmentally friendly and reduce use of pesticides. Among its flagship accomplishments are the wide-scale dissemination and adoption of the conventional and climate-smart push-pull which provides an integrated systems approach to control of stemborer, *Striga*, fall armyworm and aflatoxin, as well as increases in soil organic matter and associated soil fertility, while providing high quality livestock feed resources. This included innovative research on pest and plant signaling through semiochemicals. Another major focus is on the development of an integrated pest management (IPM) strategy, particularly for fruit flies and *Tuta absoluta*, that integrate vector-pathogen interactions, enhanced trapping systems based on pest-chemical ecology, and better knowledge on the diversity and impact of natural enemies and potential biopesticides.

A newly explored research topic is in the area of insects for food and feed. In this regard, *icipe*'s research explores the potential use of insects as an alternative protein source for food and feed by identifying insect species and their feed sources and examining cost-effective automated mass rearing facilities that provide reliable, stable and safe products. A key component of this research is policy and dialogue with the general public on issues of food quality and safety and associated environmental benefits and risks.

Environmental Health (EH) Theme: The EH theme seeks to improve and sustain ecosystems for food security, health and economic prosperity of rural communities while conserving ecological function and sustainable utilization of resources. Among its activities are the development of commercial and beneficial insect programs, including establishment of honeybee and silkworm lines, expanding knowledge on pollinators and their diversity, and their role in ecosystems and bee health research. *icipe* has particularly expanded its research on bees through building a large research laboratory devoted exclusively to bee research. This has been designated in partnership with the African Union Inter-African Bureau for Animal Resources (AU-IBAR) as the African Reference Laboratory for Bee Health and which oversees satellite stations in four other African countries, Burkina Faso, Cameroon, Ethiopia and Liberia, and a training site in Madagascar. Bioprospecting is another theme in the program to develop new natural products from plants and insects for the benefit of rural communities and consumers. In addition, this theme also addresses the impact of climate change on ecosystem services and food security.

e. Capacity Building and Institutional Development Programme

icipe considers building the capacity of individual researchers, institutions and communities in Africa is integral to its research and sustainable development activities. In this regard, its mission is to:

“Strengthen African universities and national systems research and innovation capacity in insect science for food and health through high quality and sustainable postgraduate training and institutional development and to increase the capacity of diverse stakeholders in using science and new technologies in Africa.”

There are three capacity building platforms on which *icipe* activities focus: a) professional development of African science leaders and professionals, b) development of African higher education institutions, and c) regional and national agricultural research and advisory services as well as the private sector. The largest emphasis is directed to professional development of African scientists. *icipe*'s capacity building activity involves Postgraduate (PhD and MSc) and Postdoctoral Fellowship Programs. The Postgraduate trainees are recruited through either The African Regional Postgraduate Programme in Insect Science (ARPPIS) or Dissertation Research Internship Programme (DRIP) which supports any nationality enrolled in African or non-African universities to pursue all or part of their research at *icipe*. During 2013-2017, 269 scholars were trained and mentored within *icipe*'s postgraduate programs, with 44% being recruited from Kenya and 48% from the rest of Africa. The postgraduate programmes have an Africa-wide impact, with 92% of postgraduate scholars in 2013-2017 representing 21 African nationalities. Committed to advancing excellence in science through gender equity, 43% of scholars joining *icipe* in 2013-2017; 39% of scholars who graduated; and 49% of ongoing scholars are women. Based on the quantity and quality of the articles contributed by the students, the training potential of this program is outstanding. During 2013-2017, *icipe* also hosted 41 postdoctoral scientists from ten African countries. Postgraduate training at *icipe* provides not only technical skills in specific research areas, but also a much broader development of academic and professional skills, including research compliance and ethics, science paper writing, proposal writing, communications, and research leadership. As a result, postgraduate and postdoctoral fellows make a significant contribution to the research output of *icipe*. For example, of the 646 journal articles published by *icipe* in 2013-2017, 232 (36%) and 54 (8%) were lead-authored by postgraduate and postdoctoral fellows, respectively, and 82 (13%) were co-authored by postgraduate and postdoctoral fellows.

To advance *icipe*'s role in the development of African higher education institutions, a large percentage of the postgraduate students have registered at partnering universities in Kenya and other parts of Africa, particularly South Africa. In addition, several universities from three sub-regions of Africa are involved in the ARPPIS two-year Master's program: University of Ghana in Accra, Addis Ababa University in Ethiopia and University of Zimbabwe. In terms of its influence, a majority of these universities have already good research capacity and have programs in place to expand institutional research and graduate training activities. As *icipe* expands its geographic presence to other regions in Africa, identification of key academic partners in these additional countries would be important to enhance its role in institutional capacity building efforts on the continent.

Besides training at the individual level and enhancing institutional capacity, *icipe* also trained over 12,000 participants in 290 workshops that were offered between 2013-2017 on different skill building topics. In addition, the Push-Pull program trained more than 150,000 persons during this period, including farmers, extension workers, agricultural experts and other stakeholders in east Africa.

f. Publications and Impact

icipe, as with other international agricultural research centres, operates at both ends of the R&D spectrum. *icipe*'s impact can thus be defined in terms of its influence on the scientific research community, as measured in terms of the impact of its publications on the direction of future research, and in terms of the impact of research outputs on the welfare of beneficiaries, particularly smallholder farming households. *icipe* assesses its impact in terms of its publications record and in terms of economic studies of adoption and economic impact as carried out by the SSIA Unit.

The Centre has an impressive publication record over the 2013-2017 review period. *icipe* published 646 articles in peer reviewed journals over the five-year period. This is a respectable 13 publications per scientist, especially considering the other demands on scientists' time, namely preparing grant proposals, project implementation, preparing technical reports, student supervision, administrative duties, and travel. The impact of this publishing

record can be assessed through the citations of the article in other research publications. This is shown in Figure I.2 which charts the number of citations using Google Scholar. This shows over 8 thousand citations, or on average 13 per publication, noting that more recent years underestimate the potential citations. Those articles with over 50 citations tend to be review articles and these give the Centre significant exposure to the wider scientific community. Moreover, a range of research articles have more than 30 citations and these tend to come from either the HH theme or the PH theme. However, the principal point is that *icipe* has maintained an illustrious publishing record over the review period.

Figure I.2 Citations of *icipe*'s Publications from Google Scholar, 2013-2017



For many donors' investments in *icipe*, they are motivated not by the research *per se* but by the impact of that research on development outcomes in SSA. The focus on adoption and impact significantly strengthened over the review period and a number of impact studies have been finalised. These have focused on the two flagship technologies, namely push-pull and fruit fly IPM. Each study shows a very positive return to the research investment, even when the target area is limited to just a few counties. One study assessed the impact of biological control of stemborer across three African countries and found a benefit cost ratio of 33 to 1. Interestingly, by far the largest return to CGIAR research in SSA was also from biological control of a pest - the invasive cassava mealybug. These results demonstrate the returns to investment in IPM techniques are potentially large, and similar results could be expected for *icipe*'s new focus on the fall armyworm. Another study demonstrated the positive effect on agricultural productivity of IVM for malarial mosquitoes, with most of the impact coming through the effect on women's health. These studies respond to a major recommendation of the last *icipe* periodic external review (IPER) for investment in such impact studies, and in a quite short period of time these studies have validated the high returns to investment in IPM and IVM strategies on the continent, with these returns being even more impressive when technologies are adopted over wider geographies.

g. Response to the recommendations of 2013 *icipe* periodic external review (IPER).

The external review conducted in 2013 made several recommendations, which *icipe* has either fully implemented, or has made significant progress in this interim period. A synopsis of *icipe*'s achievements in response to IPER recommendations are summarized below.

i. *icipe*'s research portfolio. It was recommended that *icipe* should consider more direct downstream interventions, perhaps with the aid of carefully selected development partners. The question for *icipe* was what is an optimal balance of R&D and how best to achieve this (a continuing topic for this review). *icipe* has recently

established a TT Unit and has developed several programs (including the WHO- AFRO II malaria control project and integrated pest management (IPM) with various development partners (ie., EU, WHO, IITA, CIP, AVRDC, NGOs, national systems, and CIAT) and private sector partners (eg., Real IPM, Kenya Biologics, Elephant Vert) to ensure that scientific discoveries have an optimal path to be rapidly translated into tangible benefits to the end users. One of these, the Integrated Biological Control Applied Research Programme (IBCARP), funded by the European Union, cuts across the Plant and Animal Health Themes and integrates applied research with impact objectives.

ii. Multidisciplinary science under the One Health concept. It was recommended that *icipe* employ a more comprehensive systems approach in its research. *icipe* has now strongly prioritized selective integration of its research activities across the 4-H Themes under the One Health concept to deliver outcomes that benefit people, their crops, livestock and environment. Within the push-pull strategies developed for the crop stemborer pests, *icipe's* approach has made significant inroads towards incorporating crop and animal health activities in the smallholder farming communities through nutritional supplementation of agricultural by-products. However, One Health concept continues to be a work in progress, and its progress is considered later in this report. Globally, funding of the One Health concept remains a challenge as the donor communities continue to prefer funding through individual sector programs. However, the excitement expressed by potential partners around *icipe's* currently planned program on “Invasive Species in Africa” may provide an opportunity to advance research with this broad concept. Going forward, *icipe* has a unique advantage to demonstrate the economic and public health value of the One Health concept for broader uptake and donor support.

iii. *icipe's* activities in Africa. It was recommended that *icipe* focus its activities, as far as possible, on the whole of Africa. Towards this recommendation, the state-of-the art Bee Health African Reference Laboratory completed in 2014 serves the African continent through its five satellite and training laboratories located strategically in Burkina Faso and Liberia to serve as hubs for West Africa, in Ethiopia to serve Eastern Africa, in Cameroon to serve Central Africa, and in Madagascar. The MBB Unit, which hosts Martin Lüscher Emerging Infectious Diseases (ML-EID) laboratory plays a pivotal role in the pan-African H3BioNet and East African EANBit training consortia, which focus on the bioinformatics of zoonotic diseases. To further expand *icipe's* influence across Africa, collaborations have more recently been established with Nigeria, Somalia and Tanzania scientists and scientific institutes. *icipe* works in 40 countries in SSA but through projects and short-term partnership arrangements. Whether *icipe* should have a more dedicated presence outside East Africa is also addressed later in the report.

iv. *icipe* identifies one key university in each of the East, South and West African countries and forges greater ties with them. *icipe* has commenced the process of more meaningful partnerships with key universities but as yet, this has only focused on the universities associated with the ARPPIS program. In line with this recommendation, *icipe* has recently established an alumni platform to reach out to the prior trainees who are serving in various communities in order to expand its influence more broadly.

v. Development of socio-economic analytical capacity. In 2012, the Social Science and Impact Assessment (SSIA) Unit was established (building on an earlier social science unit) and now hosts six senior and junior scientists and experts with diverse expertise. The SSIA has over the review period undertaken a broad range of adoption and technology impact studies. The unit also leads the work on gender analysis across the Centre and gender research has been significantly strengthened. More recently the unit has embarked on the development of a Centre wide monitoring and evaluation framework.

vi. Public engagement. It was recommended that *icipe* undertake a more rigorous public engagement effort to disseminate its research and expand its influence. In response, the newly established units, SSIA, TT and Communications and Media, have been tasked with developing outreach and communication procedures for *icipe's* science and technology outputs, and their outcomes and impacts. At the present time, *icipe* relies on its newsletters, website, media coverage (TV, print, radio) and social media to disseminate its output to communicate with the public. The enhanced internal and external communication efforts have helped develop a stronger community spirit on campus. The high global visibility of the Director General in key international fora and meetings has significantly enhanced *icipe's* public recognition in the donor and other stakeholder communities. Several high

profile international science, development and leadership awards and recognitions given to *icipe* and its staff have greatly enhanced the profile of *icipe*'s work. For example, the L'Oreal-UNESCO Women in Science Award to the Director General in 2014; the half an hour program of CNN's African Voices featuring the Director General; and the selection and featuring of the Director General on The Mind of the Universe, an international vpro documentary series exploring the human destiny and the world of tomorrow through the eyes of the greatest thinkers and scientists of our time, have introduced *icipe* to millions of viewers around the world; the featuring of *icipe* R&D achievements by the BBC Horizon Programme; and more recently, the selection of the Director General by Bill Gates as one of five "Heroes in the Field" (and the only one in agriculture), and subsequent featuring of the Director General in Time Magazine are some of the invaluable PR values for *icipe*. In addition, a number of *icipe*'s scientists have won high profile international awards for their high quality scientific outputs. *icipe* itself has received several certificates and recognitions from African governments and the African Union for its work and impact.

II. Program

The spectrum of research performed within each 4-H Theme ranges from basic science and high-risk projects to field deliverables. To strategically address the problems associated with arthropod pests and disease vectors and the opportunities for insect conservation and utilization, the 4-Hs are thematically aligned with a) Integrated Pest Management (IPM) with a focus on plant health, b) Integrated Vector and Disease Management (IVDM) – with a joint focus on animal and human health, and c) Adaptation to Climate Change and Ecosystem Services (ACCES) – with a focus on environmental health. Below we discuss the major research goals of each of the 4-H Themes. This is followed by a similar discussion of each of the cross-cutting research units.

a. Human Health (HH) Theme

Vector-borne diseases continue to devastate human health, particularly in rural communities in SSA. Among the major diseases affecting SSA are malaria, filariasis, human sleeping sickness, leishmaniasis, onchocerciasis, and schistosomiasis as well as several recently emerging and/or re-emerging diseases, such as dengue, chikungunya, yellow fever, and Rift Valley fever. There are no efficient and readily affordable tools to target these disease-causing pathogens in the mammalian host, and there is growing resistance in parasites against the available drugs used for chemotherapy. It has been long recognized that vector control, i.e., reducing the vector populations that are essential for disease transmission or interfering with the transmission of the disease agents via their respective vector insects, can dramatically reduce diseases. Many of the most-often applied vector control methods, however, rely on the use of insecticides in one form or another. The downside is that broad and widespread resistance has emerged in insects against the chemical insecticides used for control. Hence *icipe*'s efforts to develop alternative vector management tools, based on biological approaches, is very timely and relevant for improving human health in SSA and beyond, globally. *icipe*'s Thomas Odhiambo Campus in Mbita Point in Western Kenya, where malaria is still highly endemic, is well equipped to undertake these new investigations. It is equipped with outdoor, semi-field cage facilities, an Arthropod Containment Level 2 facility and excellent insectaries which have attracted a number of international partnerships within key global malaria programs. The recently completed infrastructure upgrades on utilities and on housing have added high value to this campus, which represents a major strength for *icipe*'s human health programs.

Research in the HH Theme has been continuously supported by multiple donors over the years. Between 2013-2017, approximately 50 projects received funding from a variety of donors for a total of >US\$ 9 million, for a combination of R&D activities as well as PhD, MSc, and Postdoctoral training fellowships as well as regional training.

icipe's HH Theme research has focused mostly on control of malaria in the different ecological zones with varying epidemiological thrusts. Control of malaria has been an uphill battle reflecting a tug-of-war between malaria parasites and mosquito vectors that are necessary for transmission. In response to widely practiced indoor control efforts, such as the bednet programs that limit human exposure at night, the mosquitoes are noted to shift their biting preferences to outdoors and earlier times during the day. In addition, as the major malaria transmitting *Anopheles* vector populations are reduced, the presence of potential secondary mosquito species is now being reported, which further complicates malaria transmission dynamics.

icipe's program on malaria has a range of activities that vary from basic studies on chemical ecology and vector behavior to identification of chemical compounds that could be used in push-pull strategies and as biological larvicides. Most of the research projects aim to develop non-chemical based tools and methods that can be applied to reduce/eliminate mosquito challenge through enhanced knowledge of vector ecology and behavior. Knowledge on behavioral ecology of mosquitoes can lead to new and improved surveillance and control tools, which, when applied can also mitigate the emergence of insecticide resistance. There are studies on discovery of attractive chemical cues and oviposition behavior in order to develop push-pull and attract-kill strategies for mosquito control, respectively. These studies have already resulted in improved monitoring tools, such as gravid traps for larvi-positioning and a variety of odour-baited traps with solar powered batteries as well as several bio-larvicides

(an insect growth regulator pyriproxyfen, silicone-based surface film and plant derived larvicide, Uzimax). The efficacy of using a combination of these tools in the field within the framework of an Integrated Vector Management (IVM) strategy has been evaluated in Kenya and Ethiopia, through operational research studies funded by the Biovision Foundation for Ecological Development project - a collaboration between *icipe* and KEMRI-Wellcome Trust scientists. The goal of this project is to optimize and enhance IVM strategies through systematic analysis and addressing of gaps that could undermine sustainability of IVM in different ecological and socio-cultural settings taking into account the changing landscape of agricultural practices and climate change. This comprehensive and interdisciplinary project included a strong social science component. Given that malaria control will be an important health agenda in the foreseeable future, with no magic bullets in sight, efforts to demonstrate the role of IVM in disease management in a holistic manner remains a highly laudable goal. *icipe* with its local partners have developed several important biologically-based vector control products and are well positioned to evaluate their utilization in IVM for malaria control in different endemic settings.

icipe's research contributions towards malaria control have been first-class and have been integrated into the WHO-AFRO initiatives. One of these initiatives supported by WHO-AFRO includes *icipe* and Duke University and University of Pretoria in the evaluation of health, social and environmental impacts and policy tradeoffs of sustainable non-pesticide-based malaria control strategies in East Africa. These investigations have led to the development of guidelines for a Malaria Decision Analysis Support Tool, MDAST, for use and adoption for evidence-based decision-making in countries affected by malaria.

In addition to malaria, human health and well-being is being challenged by emerging and re-emerging arboviral diseases, mainly transmitted by *Aedes* mosquitoes. Infections with Rift Valley fever are relevant for both HH and AH themes and this dual relevance provides an opportunity for these two themes to work together. *icipe* has initiated a number of studies to address these new challenges by identifying the epidemiological and social determinants as well as knowledge gaps in these emerging diseases and potential threats. Some of these studies address the development of vector surveillance tools based on olfactory cues mosquitoes utilize for host-seeking behavior. *icipe* with its strong chemical behavioral ecology foundation can advance knowledge in this important area. The refurbished field facilities in the Mombasa coastal region can be an important resource for advancing operational research into these diseases and vector control activities since high levels of human infections are currently reported in this region. Another important but highly neglected disease for SSA with wide global significance is leishmaniasis, which is transmitted by sand flies. Given the lack of effective tools and its global relevance, *icipe* and especially the HH theme could play a key research role into this vector by applying some of its fundamental biological-control methods. A pilot project on tungiasis and another one on schistosomiasis transmitting snail eco-toxicology have also been initiated. To strengthen the impact of these smaller projects, it may be important to recruit local partners with entomological and epidemiological expertise for broader significance.

Besides vector genetic factors, microbiota associated with insects are found to influence the competence of host insects, which in turn provides an applied approach to modify disease transmission potential of these vectors. Studies initiated at *icipe* on field-collected *Anopheles* mosquitoes identified several microbes specific to malaria parasite-positive individuals. One of these microbes is *Microsporidia*, which displays a highly variable infection prevalence in natural *Anopheles* mosquitoes. Establishment of laboratory mosquito lines with and without *Microsporidia* infections, and development of capabilities to undertake malaria transmission studies in these laboratory lines, provides new opportunities to evaluate the role of this microbe for malaria transmission potential. Besides *Microsporidia*, other endosymbionts have been utilized to modify *Aedes* mosquito competence for arbovirus transmission – a method that is being tested in field trials in Australia, Asia and South America. It is thought that replacement of natural mosquito populations with their symbiont populated counterparts can break the disease cycle. Hence, there has been a growing interest on endosymbiont-based disease interference methods throughout the world to control arbovirus transmission in mosquitoes. This relatively new research field provides an opportunity for *icipe* researchers to commence the development of similar strategies for reduction of disease transmission in the African setting.

The HH Theme's research outputs collectively have the power to improve public health and have led to improved entomology capacity and capability through training of students, program staff and communities. The field implementation-focused research programs also supported national and regional networks with linkages to ministries of health and national malaria control programs (in Kenya and Ethiopia) to develop and adapt vector control activities in line with global responses, including WHO-AFRO program.

An External Review of *icipe*'s HH Theme activities is currently being planned and should provide *icipe*'s researchers the opportunity to review and get feedback on the strengths and gaps in their research portfolio in the context of a changing epidemiological landscape, arising scientific and collaboration opportunities internally and externally, evolving donor interests and changing climate. At the present time, there are few linkages between the HH Theme and the other 4-H Themes, yet *icipe* may have several unique opportunities to expand the One Health concept, taking into account agricultural practices, particularly the expansion in small scale irrigation, and changing landscapes in the context of emerging vector-borne human and zoonotic diseases.

b. Animal Health (AH) Theme

Research within the AH Theme aligns well with *icipe*'s vision to extend the area under sustainable land management, increase food supply and reduce hunger, and improve agricultural research, technology dissemination and adoption. The activities focus on developing tools and strategies to control livestock diseases transmitted by two important vectors on the continent: tsetse flies and ticks. Tsetse flies transmit the parasitic trypanosomes to humans and animals. Although the epidemic nature of the Human African Trypanosomiasis (HAT) is largely under control in SSA, foci remain, particularly in countries where political stability is lacking. It is generally thought that implementation of vector control can enhance sustainable control of HAT during the endemic period. In contrast to HAT, wasting animal diseases caused by tsetse-transmitted trypanosomes known as Animal African trypanosomoses (or nagana) are rampant on the continent and inflict a major economic burden, particularly in the small farming communities that reside within the tsetse habitats. Ticks also vector many important animal diseases widely in SSA, including the East Coast Fever or theileriosis, which has devastated livestock health in past epidemics. In addition, Rift Valley Fever (RVF) is a potentially emerging zoonotic disease that threatens both animal and human health and *Aedes* and *Culex* mosquitoes are involved in its transmission. Effective control methods for any of these diseases in the mammalian host are largely lacking, with no vaccines in sight. In contrast, vector control can be a most effective approach and, in this context, biological, environmentally friendly and sustainable methods are highly desirable.

Since 2014, the theme activities have attracted >US\$ 12 million involving six research projects in addition to >US\$ 6 million in training and resource mobilization activities. The AH Theme undertakes a variety of excellent research activities, ranging from the development of environmentally safe and sustainable vector control methods that can be easily adopted by smallholder farming communities to excellent basic science research on vector physiologies that are relevant for the development of novel control tools. The Theme's research activities were recently reviewed by an External Expert Committee and have received very high marks for both its scientific and training activities.

The integrated pest and vector management approach for control of animal diseases aims to develop biological control methods based on the use of botanicals, anti-tick pasture plants and repellents as well as behavior modification – all aligning with the push-pull strategies *icipe* has pioneered. An important historical achievement for tsetse monitoring and control has been the development of the widely used Ngu traps. The efficacy of the traps has more recently been enhanced by identification and incorporation of attractive odour baits from bovid hosts that typically attract tsetse flies. Similar identification of repellent compounds from the waterbuck, which is not frequently fed on by tsetse, has led to the development of repellent compounds which have been incorporated into collars with dispensers for use on domestic animals to prevent tsetse bites. The efficacy of this product has been proven in the field (in Shimba Hills National Reserve and Nguruman) and recently registered. The collar is ready to enter into a large scale implementation phase where its production by public-private business partners and adoption by the rural farming communities is now being planned through community mobilization and empowerment activities involving the local county governments and Ministry of Agriculture. Both the TT and SSIA Units are poised to assist as this product transitions from efficacy studies to community adoption phase.

Recently, an award through the European Union has allowed *icipe* researchers to address camel health and productivity. Camel health is very central to human activities in arid and semi-arid Kenya where there are estimated to be 2.9 million camels, while Ethiopia alone has more than 4.5 million camels. With climate change and increasing temperatures, camels and small ruminants are the most resilient livestock in the Horn of Africa, contributing to household health and incomes. Research has addressed better identification of the biting flies, which are involved in mechanical transmission of the parasitic agent (*Trypanosoma evansi*) responsible for the disease in camels known as surra. Molecular studies performed by the MBB Unit have shown that *T. evansi* infections are highly prevalent – with as high as 68% of camel herds being positive for the parasite. The long-term goal of this research is to improve trapping devices by identifying semio-chemical attractants and repellents for the key vectors of surra and integrating these tools in disease management methods.

icipe scientists in the AH Theme have played a key role in the Tsetse Genome Consortium, which deciphered the *Glossina morsitans* genome in 2014 and more recently the genomes of five additional tsetse fly species. Given its excellent resources in bioinformatics, the *icipe* scientists were tasked with the identification of genes and products that function in the olfactory physiology of tsetse flies. Recently the AH Theme has secured a competitive NIH training grant to help advance bioinformatics teaching activities at several national/international university partners in Africa. To follow up their bioinformatics based discoveries, *icipe* researchers have initiated functional investigations into the molecular biology of the tsetse antenna, the organ that is essential for olfactory responses. To assist with these studies, the laboratories at the Duduville campus are equipped with the necessary high-end instrumentation to carry out functional genomics work on antenna physiology to decipher the molecular basis of olfactory responses. Although high-risk, these studies have the potential to identify downstream compounds that can improve the semio-chemical blends that can then be incorporated into the push-pull strategies.

Among the tick transmitted diseases, East Coast Fever (also known as theileriosis) caused by the parasite *Theileria parva* inflicts major damage. Acaricides are widely used on animals for tick control but emerging resistance in ticks against these chemicals and the undesirable effects of their wide-scale usage necessitates alternative biological control methods. *icipe*'s research has identified an effective bio-acaricide based on *Metarhizium anisopliae*, which is being commercialized by Real IPM Ltd in Kenya. *icipe* has a pipeline of other entomopathogens that have been similarly tested as potential biopesticides for use against the different tick species.

Another potentially emerging disease in the region is RVF, which is a viral zoonosis that primarily affects animals but also has the capacity to infect humans. Infections can cause severe disease in both animals and humans. In addition to blood-borne transmission, *Culex* and *Aedes* mosquitoes could be involved in RVF virus transmission. To promote studies on the transmission of RVF in inter-epidemic periods, a multi-institutional award made by the philanthropic arm of Google, helped establish the Martin Luscher Emerging Infectious Diseases Laboratory, which includes facilities for transmission studies and pathogen culture and genetics. The presence of this state-of-the-art facility equipped with state-of-the-art molecular instrumentation has furthered investigations on arbovirus epidemiology and surveillance. In parallel, these studies benefited from a molecular method that was implemented for in house applications by the MBB unit researchers, high resolution melting (HRM) analysis, which can readily identify mosquito-specific Flaviviruses in surveillance activities.

The AH Theme has supported capacity development efforts at *icipe* very strongly. Since 2014, 11 PhD students completed their training with 19 continuing their studies at the present time. Since 2014, 17 MSc students completed their training with 8 continuing their studies. Based on the papers published by the students during this period, the training and mentoring they receive in this theme is superb.

One of the recommendations made by the external scientific review was for *icipe* to put in place a clear strategy/position for how to be involved in development/extension. *icipe* scientists should be involved in efforts to move the scientific results to downstream applications. A case in point is the tsetse collar which has entered into a phase of field implementation and adoption by relevant communities. In addition, the review has recommended expanding the epidemiology expertise in the group, which would also benefit the HH Theme researchers. Adopting the One Health approach as products are rolled out for implementation would be in line with *icipe*'s strategic vision.

In addition, there are synergistic opportunities between the Plant Health and Animal Health activities that can be approached under the One Health concept.

c. Plant Health (PH) Theme

Since 2013 the PH Theme has undertaken innovative basic research and concurrently taking the outcomes of that research to on-the-ground impact across SSA, with some of those impacts being well documented through its collaboration with the SSIA Unit. The underlying principle of the theme's work is to develop control options for crop pests that significantly reduce the use of pesticides and their subsequent impacts on the environment and the inevitable pesticide resistance that comes from their extended use. Understandably given its long list of successes, the PH Theme has been well supported by donors over many years.

The PH theme is one of the largest with a current list of 89 funded projects, > \$50 million contracted income (over multiple years), 26 scientists, 111 partners and > 60 registered products and patents. The theme's research is largely based on discovery and subsequent strategic use of biopesticides, semiochemicals, and other naturally occurring compounds that can be employed to disrupt the life cycles of a range of insect pests and vectors and through the identification and release of parasitoids.

The breadth of research, the number of pests being targeted by the theme, and the diversity in which integrated pest management (IPM) options that are being successfully deployed into African farming systems is a testament to the innovation of the theme, their associated Research Units and the theme's ability to apply their core science to IPM practices for an array of crops, pests and weeds.

One of the key flagship programmes of the Centre from the PH Theme is the push-pull technology; a remarkable success because its critical intervention addresses a complex set of important production and systems challenges that are common across vast areas of SSA. These challenges range from the crippling damage caused by multiple insect pests and the parasitic weed striga, poor soil fertility and the high costs of inorganic fertilisers, and poor livestock diets. Originally developed for the control of stem borers, the key pests of cereal crops across most of Africa, push-pull involves intercropping cereal crops with insect repellent legumes from the genus *Desmodium* (primarily *D. intortum*) and planting an attractant forage plant such as Napier grass (*Pennisetum purpureum*) as a border around this intercrop. The intercrop emits a blend of compounds that repel ('push') away stem borer moths, while the border plants emit semiochemicals that are attractive ('pull') to the pests. Push-pull has recently been adapted to drier areas using more drought tolerant companion species such as *D. incanum* and the *Urochloa* (syn. *Brachiaria*) hybrid cv Mulato as a border crop. Mulato is both more drought tolerant and under most management situations has higher feed quality than Napier grass. In addition, push-pull also controls the striga, maize ear rots and reduces the accumulation of mycotoxins including aflatoxin. The legumes improve soil fertility and provide higher quality fodder and the effectiveness of crop-livestock integration. Recently, *icipe* scientists discovered that push-pull is effective in controlling the fall armyworm, a recent invasive species to Africa which has the potential to devastate maize crops.

The outstanding basic research that led to understanding the mechanisms of the push and pull components of the system, and the striga control has been ground-breaking science and widely acknowledged. This work was well advanced prior to the period of this IPER, but over the past 5 years it has continued to refine the concept via its research focus on some of the key issues outlined above, viz. the use drought tolerant forage species, assessment on soil improvement and control of fall armyworm. The PH Theme has also been committed to supporting the wider adoption of push-pull technology in SSA.

The PH Theme has several other examples of innovative application of its core science for practices that are having outstanding impacts across SSA. The fruit fly research, which is using a range of bio-tools to sustainably control a number of species of fruit fly in a range of crops, such as mango, has proven highly successful. Also, successful has been the IPM work on thrips in vegetable crops and the use of parasitoids in control of diamondback moth. Pest management strategies are also being explored for key pests in East African coffee and in *Musa* spp. (banana

and plantain) as part of an FAO global project aimed at a multitude of major pests of these crops.

This Theme has also demonstrated its ability to respond rapidly to emerging challenges to food security and livelihoods. The tomato leaf miner, *Tuta absoluta*, was first recorded in Africa in 2008 and has become a major pest of tomato across Africa. *icipe* has, in just a few years, been able to design successful management programs to combat this devastating pest through the combined use of biopesticides, trapping using pheromones, and use of physical barriers. It also initiated a search for biological control agents from Peru, South America, the origin of the leaf miner and introduced it into Africa for wide-scale releases.

In addition to its considerable research portfolio on within-crop pest management, the Theme is also undertaking a number of projects targeting post-harvest pests and losses including key research in pulses.

The Theme has also been leading a range of capacity building programs across SSA to strengthen adoption of IPM of key pests in those countries. Training programs over the six year period have been held in Uganda, Zimbabwe, Botswana, Zambia, Cameroon, Tanzania, Ethiopia and Namibia. The Theme has been central to the establishment of manufacturing protocols and processes of some of its products, many of which are registered and in use in a number of African countries.

The socio-economic impacts of the Theme's work are substantial. Analyses by the SSIA Unit have estimated that biological control of the maize stem borer in Kenya, Mozambique and Zambia alone had delivered a net present value of US\$272 million and that that intervention had taken about 130,000 people out of poverty. A similar scale of impact is expected in Western Kenya as adoption of push-pull in that region strengthens. The SSIA Unit also estimates that the fruit fly research and its scale out had delivered a net present benefit of about US\$75 million across Africa.

The scientific achievements of the PH Theme suggest a potential expanding impact beyond Africa. There are already two projects underway, both with US partners, to develop management strategies for two grasses which are recognised weeds in the US; *Imperata cylindrica* and for *Megathyrus maximus* (syn. *Panicum maximum*). Breakthroughs in the control of *I. cylindrica* also have the potential to provide major benefits for SE Asia where this rhizomatous, unpalatable grass species dominates vast areas of otherwise productive landscapes. However, it is in the area of innovative pest management that *icipe*'s expertise in devising options for pest control without the use of conventional pesticides could be revolutionary in those parts of the world where use of genetically modified crop varieties is not approved. The Theme's many international partners and other agencies are undertaking similar approaches to pest management to those employed by *icipe*, but the *icipe* PH Theme should, where IPM approaches have been shown to be efficacious in an African context, seek to expand its reach beyond the continent.

The PH Theme has also contributed to *icipe*'s recent research focus on the potential use of insects for food and feed at scale. This emerging potential role for insects is being considered in response to the combination of need to feed a rapidly growing global population, the limitations of industries such as poultry, fish and pig to meet that need and the quest to develop options which demand fewer resources and are better aligned to meet the needs of climate change mitigation and biodiversity conservation. Since identifying the insects for food and feed (INSEFF) as a strategic research area in 2013, *icipe* has compiled an inventory titled "African edible insects for food and feed: inventory, diversity, commonalities and contribution to food security," published in Journal of Insects for Food and Feed, and commenced a research program to identify insect species that can be mass-reared, including knowledge on breeding, production management, and ways to pre-empt and control diseases and environmental risks.

Despite its development of many innovative pest management practices, the PH Theme's impacts across Africa are constrained by resources, awareness, national regulatory guidelines on biological imports, and because the IPM options developed are often more demanding of farmers in the short term than conventional pesticide application. The overall dominance of projects targeting pest and disease challenges in East Africa has been supplemented by

a number of research projects and capacity building programs to take IPM elsewhere in SSA. However, achieving widespread IPM adoption is an arduous task. The most critical challenge for the Theme is realising wider adoption of its existing IPM practices in East Africa and more widely in SSA. At the same time, it should be considering how it might apply its unique research capability to major crop-pest challenges peculiar to sub-regions other than East Africa. The role of the TT Unit, the Bioinnovate Africa Programme and the private sector and better definition and resourcing of well-defined impact pathways will be critical in achieving wider adoption. The PH Theme's and *icipe*'s communication and awareness priorities need to be especially focused on gaining appropriate policy outcomes and supporting its on-the-ground delivery through its existing and, where appropriate, new private and public-sector partners.

d. Environmental Health (EH) Theme

The EH Theme has defined as its strategic focus “to broaden knowledge on arthropods and their diversity and role in ecosystems and contribute to conservation and sustainable utilization of biodiversity and climate change mitigation and adaptation”. The task of how to understand and beneficially utilize biodiversity is a broad challenge, particularly when it encompasses more than just agricultural systems. There is certainly an accumulation of evidence that there is an increasing loss of biodiversity due to increasing pressures on land, land use change, and land degradation. In an African context the impacts of these processes on large fauna populations have been striking. What the impacts are on arthropod species distribution, population dynamics and their role in ecological food webs is minimally researched. The issue for *icipe* is how to bring focus to such a strategic area and how that research in turn translates into actual application.

The EH Theme over the review period has pursued specific lines of research. Of particular merit has been the integrated program on bee research, in many ways the most comprehensive in SSA. The research encompasses the role of bees in providing ecosystem services (pollination) and commercial products, particularly honey, and research on bee health, a global issue of concern presently. The latter issue has extended into work on bee gut microbiota. *icipe* over the review period has built a strong capacity in bee research. This includes a large building and set of laboratories devoted exclusively to bee research, which has been designated in partnership with the African Union Inter-African Bureau for Animal Resources (AU-IBAR) as the African Reference Laboratory for Bee Health and which oversees satellite stations in Burkina Faso, Cameroon, Ethiopia, Liberia and Madagascar. The facility provides a platform for monitoring and controlling bee disease and pest outbreaks on the continent, in many ways congruent with a potential invasive species program. Part of a possible control strategy for bee diseases and pests includes the nascent work on endosymbionts in the gut. A recommendation of the recent bee strategy workshop includes “the surveillance and monitoring of bee diseases, diagnostics of bee diseases, analysis of pesticide residues in bees and their products, and the development of environmentally friendly biopesticides”. This would constitute a surveillance and control strategy for potential bee diseases and pests, which *icipe* could coordinate on the continent.

The new strategy on bee research outlines four focal areas, namely bee health, symbionts, nutrition, and pollination. Gaps in knowledge are laid out for each of these. This is a well-structured research agenda and there is a very notional theory of change. Several issues could be noted in relation to the strategy. First, there is as yet little connection between the research and its potential downstream application, although there is the potential to measure impacts through monitoring of bee diseases in managed hives. This is illustrated by lack of a clear impact pathway between the research agenda and the downstream work carried out by *icipe* in developing supply systems for honey, as for example, in the very large YESH project in Ethiopia focused on market development for honey that impacts both youth and gender. Second, bee nutrition and the spillover to pollination services is dependent on habitat and stronger recognition of this in some impact pathways would move the program into greater recognition of land use or habitat management as an implementation focus. There would also be potential backup should there be a problem with bee health. Finally, the strategy implies that the research areas would have spillover into policy, but this is not developed in terms of how policy might impact on bee health or pollination services. Drawing the causal links between the research and the downstream impact is a crucial area of research but it is one that is hampered by funding. More secure funding, in particular, larger grants, are required to support research that draws

together the various aspects of honey production and markets, bee health, ecosystems services and associated policies.

The other primary area of work of EH Theme is in bioprospecting, particularly for plants producing potential biopesticides or medicinal plants. One project extended this work into the promotion of selected insecticidal and medicinal plants as potential new cash crops. The possible crop plants produced *icipe*-BH-01 and *icipe*-BH-02 plant-derived products against varroa mites (*Varroa destructor*). This appeared to be something of an early pilot as there was no apparent link to processing or market development for either the plant extracts or harvested plants. This work, as with honey, moves the Theme into supply system or value chain development, for which there is limited capacity in the Theme or *icipe* more generally. There is a larger issue discussed in section III on how far *icipe* goes in product development, in supply chain creation, and in public-private partnerships. As well, there is a question of where capacity to undertake this type of work should be “housed” in the Centre. Bioprospecting has a potentially broad scope and to date has generated little funding. A more strategic orientation is probably needed to move this area forward.

The actual work on biodiversity and the role of arthropods in the ecosystem has been limited to two large projects carried out in the Eastern Afrotropical ecosystems in Ethiopia, Kenya and Tanzania. These are areas of endemic biodiversity but with increasing population pressure on the natural ecosystem. The two projects (CHIESA and AFERIA), funded by the government of Finland, combined selective work on arthropod biodiversity with research on climate change and a large component of adaptive research with smallholder farmers, particularly on biocontrol and water conservation. These projects are an example of how research is combined with downstream, impact-oriented piloting. The arthropod biodiversity research was framed around biocontrol (AFERIA) and assessing the interaction between crops, pests and associated parasitoids across a climatic gradient—which allowed the assessment of the effect of climate change, particularly increasing temperature on ecosystem services. An overarching question is what the future direction of this work should be given that it ostensibly lies at the strategic core of the theme. Its direction should probably be shaped in part by its role in supporting adaptive responses of farmers and communities to climate change, and by what the Environmental Health research concepts and methodologies bring to the research and subsequent interventions that are usually considered more central to those of the PH Theme. Finally, the future direction of this work will need to be cognisant of *icipe*'s special niche in the extensive international climate change research community, particularly in relation to understanding of impacts on arthropod distribution, population dynamics, and biodiversity through longer-term monitoring.

Environmental health within a 4-H framework encompasses the critical area of habitat management, which supports biodiversity, pollination ecosystem services, alternative hosts for pests and diseases (as for example with Napier stunt disease), and vector management, as for example with tsetse. Moreover, habitat management is, in general, organized at a landscape level, which over the last decade has developed as an organizational framework for integrated development approaches.³ Bee research will continue to be an important part of the EH Theme research agenda, but it has little interaction with the other themes apart from PH Theme. Habitat management, on the other hand, cuts across the other three themes and integrates research with downstream impact, with an interesting research domain within the area of community-based strategies at a landscape scale. With the development of the next strategic plan for *icipe*, there is an argument for a more critical assessment of the research agenda of the EH Theme.

³ See for example Gray, E., N. Henninger, C. Reij, R. Winterbottom, and P. Agostini. 2016. “Integrated Landscape Approaches for Africa’s Drylands.” World Bank Studies. Conference Edition. World Bank, Washington, DC.

e. Specialized Research Units

The research in the 4-H Themes are supported by the special skills and resources provided by nine specialized research units.

i. Behavioural and Chemical Ecology (BCE) Unit

The unit contributes to *icipe*'s mission to improve the livelihoods of communities through innovative research that leads to the development of environmentally-sound methods to reduce or suppress target pest populations and to increase populations of beneficial insects including natural enemies of pests.

The unit performs research activities that are central to all 4-H Themes by supporting the development of push-pull strategies through the identification of chemical cues and insect behavior. Application of this research in the HH Theme helped improve trap catches of RVF virus transmitting mosquitoes through identification of the skin odors of RVF hosts, which in turn helped build RVF disease monitoring capacity and capability for animal and public health workers in several communities. Using similar methodologies, attractive odors were identified from locally available plants (cowpea), which has in turn improved the efficiency of sand fly traps. Current projects also address development of chemical attractants which can be deployed as odor-baits to increase the efficacy of existing traps for sylvatic *Aedes* mosquitoes. Researchers also identified the plant cues (attractants) that are most commonly detected by multiple mosquito vectors – a finding that can now be applied in vector surveillance studies. Working with the AH Theme researchers, the unit works to understand the oviposition site preferences of stable fly, *Stomoxys calcitrans*, an important mechanical vector of parasites and microbes. The unit's research has been pivotal for the identification of tsetse repellents and attractants and the olfactory responses of the tsetse antenna. Working with the PH Theme, the unit identified the host marking pheromones in *Ceratitis* species, as well as in the brown spiny bugs *Clavigralla* species. The unit also has multiple projects that support the PH and AH Theme activities, such as the nutritional and therapeutic components of select edible insects and the nutritive value of available indigenous feed resources for milk production. The activities in the unit support capacity development efforts through employing PhD and MSc students in research activities. The mentoring and publications are stellar. For *icipe*'s flagship programs, it is essential that the expertise in this unit be continued and supported. Given that scientific expertise in the field of chemical ecology is highly specialized, efforts should be made proactively to ensure that the unit is staffed adequately by excellent researchers going forward. *icipe* has made several excellent appointments within this unit from home-grown scientists and these efforts should be continued.

ii. Molecular Biology and Biotechnology (MBB) Unit

The MBB unit provides relevant expertise to facilitate molecular and bioinformatics components of *icipe*'s research across the themes, while also spearheading research projects that employ and develop cutting-edge molecular and bioinformatics techniques applicable to functional genomics and surveillance efforts. The unit has strong links across *icipe*'s multiple themes and projects, as well as external collaborations within Africa, Europe and North America. The unit is very actively engaged in training and mentoring young scholars to equip future generations of scientists with skills that will enhance the use of insect science to address Africa's current and future developmental needs. Between 2013-2017, the unit has received > US\$3 million towards research and training activities.

Current studies include understanding the ecology of plant and animal diseases, diversity and population genetics of medically and economically important arthropod taxa, pathogen and endosymbiont diagnostics, genomics and bioinformatics. The researchers in the unit have contributed to the annotation of the tsetse genome data in recent years. Recently the unit has received a training award "East Africa Network for Bioinformatics Training" from the NIH. Another important achievement has been the application of a novel cost-effective high-throughput molecular biology approach (multiplex reverse transcription-Polymerase chain reaction - high-resolution melting analysis; multiplex RT-PCR-HRM) for detecting and differentiating broad diversities of arboviruses. Using this technique, unit scientists have identified diverse medically important arboviruses in mosquitoes, including for the first time in Kenya an isolate of Wesselsbron virus, which has caused isolated cases of severe human morbidity in South Africa. MBB Unit has also applied the nested PCR-HRM assay to detect and differentiate *Plasmodium* malaria parasite species

at sub-microscopic titers that could even identify triple species infections, and viruses from ticks from savannah, wildlife and livestock. Work on characterization of the endosymbionts of mosquitoes have led to the identification of *Microsporidia*, which appears to be preferentially associated with *Plasmodium* negative flies.

iii. Arthropod Pathology (AP) Unit

This unit leads *icipe*'s basic bioprospecting research with the intent of identifying entomopathogens that could be developed into biopesticides on which some of *icipe*'s novel solutions to pest management are built. As well as undertaking its research, the unit also maintains a living collection of about 500 beneficial microbes, which it employs as possible tools for new and emerging pest and vector management challenges in Africa. Many of the products identified by the AP Unit have been patented and some have progressed to commercialization. The application of their work is across the whole spectrum of *icipe*'s research portfolio. Their recent work on the possible role of endophytes in inferring resistance to maize lethal necrosis disease is an example of the innovation that this unit brings to the quest of overcoming emerging animal and plant health challenges in SSA. This example, and the example of the identification of biopesticides that are effective against fall armyworm just two years after it was first identified in Nigeria in January 2016 also demonstrate the responsiveness of the unit to emerging challenges.

While much of the unit's work is aimed at control of plant pests, it also provides solutions in animal health, in particular in identifying bioacaricides. It has recently identified isolates of the soil fungus *Metarhizium anisopliae* that are effective in the control of at least two important tick species. A formulation from these isolates, *ICIPE 7*, has now been patented and commercialised.

This unit has consistently demonstrated its innovation and its connectivity with aligned research elsewhere. It has a history of research partnerships with national and international institutes in Africa and with universities from the developed world, mostly Europe (e.g. Universities of Bonn, Berlin, Wageningen, Hohenheim, Finland, Copenhagen).

As a unit that provides key tools for Themes, AP Unit is not, and should not be, focussing on delivery of impact directly, except perhaps through its key roles of taking bio tools to commercialisation and its work with private sector partners. However, the impact AP Unit is having is considerable and is realised through collaborative roles with *icipe*'s Themes, especially the AH and PH Themes. The AP Unit is considered by the review team to be a unique, invaluable research team that enables *icipe* to deliver on its vision and mandate of affordable, effective and environmentally friendly pest and vector management strategies for Africa, especially African agriculture. The work of the unit, including the ongoing curation of the repository of beneficial microbes is seen as essential for *icipe*'s mandate.

iv. Biosystematics (BS) Unit

The BS Unit provides the necessary arthropod taxonomic and systematic expertise that is essential for *icipe* to undertake much of its research, such as identifying potential natural enemies for use in biological control in Africa or from the region of origin of a new pest species and defining relationships between species so as to define initial parameters for epidemiological work. The unit undertakes its own research on biodiversity of African insects, has a long history of describing new African species (142 species new to science described over the past 5 years) and plays a key role in identifying new invasive species.

It also maintains an irreplaceable collection of African insects. The long-term value of that reference collection is recognised by *icipe* and it is essential that the associated database continues to be digitized. More importantly, *icipe* must ensure that sufficient resources are allocated to ensure the collection's long-term curation (storage conditions and skills) are not threatened. This is especially so given the global decline in insect biodiversity where presumably pest, but more likely, important natural enemy species, might be threatened and where conservation plans and/or alternative insect species for beneficial roles will need to be identified.

This small unit is particularly vulnerable as its function is heavily dependent on one internationally recognised

taxonomist who has already reached retirement age and a small number of highly trained technical staff. Putting in place a succession plan has been a priority for *icipe* for some time but finding the right people has not been successful because biosystematics expertise in insects, plants and animals is in short supply across the globe.

icipe should ramp up its search for appointments in this area as a matter of urgency. Ideally, *icipe* needs to have two experienced biosystematists in the BS Unit at any one time. More immediately *icipe* should be putting in place contingency plans of how it would respond if critical expertise were to leave BS Unit suddenly.

v. Animal Rearing and Containment (ARC) Unit

The role of the ARC Unit is to provide cost-effective and quality services from its insectaries, animal breeding and biocontainment facility to enhance research as well as capacity building activities at *icipe*. These services are extended to *icipe* stakeholders within the various themes, collaborators and academic institutions including the national agricultural research systems, schools and local universities. Newly introduced parasitoids and predators for use in studies as biological control agents are contained in the bio-containment facility, to facilitate clearance from the phytosanitary organization in Kenya, KEPHIS, before they can be released for field testing. The unit maintains continuous cultures of several insects, such as 4 species of mosquitoes, 3 species of stemborer, fall armyworm, desert locust, long-horned grasshopper, and short horned grasshopper, 2 species of tsetse flies, 2 species of ticks, 10 species of fruit flies and their natural enemies, and larger grain borer and its parasitoid. In addition, small mammals, such as rabbits, rats and mice are also maintained and supplied to *icipe* stakeholders from various themes and projects. The unit performs essential services for the research community. As the ARC Unit is also playing a role in the insects-for-feed program, which is gaining growing external support, contingencies in resources and staff are likely to be required to facilitate its almost certain need for expansion.

vi. Geo-Information (GI) Unit

The GI Unit, as with the other research units, brings specialized skills, in this case in spatial analysis, to support the work of the research themes. Spatial analysis has now become a principal input into agricultural research. This is particularly so in an East African context where there is such spatial heterogeneity in factors such as agroecology, market access, population density and farm size; all factors which influence both the design and uptake of agricultural technologies. Although administratively based in the EH Theme, the GI Unit provides services to all four themes. The overall thrust is to provide spatial analysis for better targeting of the research of the themes, but particularly in the scaling out of theme products and methods. Remote sensing data is a major input into this work and the resolution of this data has been increasing significantly, allowing quite fine scale analysis to augment the regional and even continental analysis that can now be done. The work of the GI Unit operates at these different scales depending on the need of the theme.

The sophistication and potential of spatial analysis in agricultural and vector borne health research comes in the ability to collect and assemble data on variables that cannot be detected through remote sensing techniques, such as animal and human health disease incidence. There is an increasing ability to detect plant diseases through remote sensing and phenological modeling, as with the unit's work on fine scale mapping of maize lethal necrosis. For animal disease risk assessment, the unit used GPS (global positioning system) collars to track cattle movements in the arid and semi-arid regions of Kenya. As the unit provides increasing input into scaling of new technologies and methods, this will involve the collection and mapping of socioeconomic data, which usually involves either interpolation or extrapolation techniques. Better integration of field data gathering techniques by the themes with spatial applications will allow improved mapping capacity. This in general will involve spatial sampling frames.

The other area of potential development is in the area of predictive modeling. This would become particularly important if there were more program focus on surveillance and management of invasive species. This type of work has already been initiated with the risk assessment of *Parthenium hysterophorous* in Somaliland. However, this mapping was done through the spectral signature of the weed. For insects this will not be possible, nor will it be possible to predict and then monitor the spread of the invasive species. This would require a process-based

niche modeling capacity such as CLIMEX (CLIMatic indEX), although with much more tailoring to the physiology of the insect and the epidemiology of the spread of the species. The GI Unit would play a particularly important role in a surveillance and risk assessment program for invasive species, as well as potential work on predicting the effect of climate change on insect distribution and population dynamics-- initial work which began in the CHIESA project.

The GI Unit has also begun to explore the targeting of One Health interventions by essentially mapping the overlap of important stressors in each of the themes and identifying those areas where multiple interventions would have the most potential impact. However, this does not imply that these stressors are the most important in affecting livelihood outcomes, only that they overlap. Moreover, as is discussed elsewhere in the report, overlapping disease and pest constraints across humans, animals and crops has not provided a sufficient framework for organizing control strategies within or across the three sectors, because, with the exception of integrated control strategies around zoonotic diseases, there has not yet been a sufficient empirical base of projects to demonstrate the benefits of such integration. A 4-H intervention and dissemination strategy will be justified on the basis of interactions on welfare improvement in the livelihood system. There is significant potential in the GI unit's approach, but it will require more refinement in the spatial targeting and an assessment of the institutional framework that would lead to effective implementation of an integrated approach. The GI unit will have a necessary role in the further development of the 4-H concept.

vii. Social Sciences and Impact Assessment (SSIA) Unit

The SSIA unit is one of two units which is undergoing very significant change (the other being the Technology Transfer Unit). *icipe* has had a social sciences unit virtually from its inception. However, within a Centre with a focus on insect science, the unit has always had difficulty finding direction and its funding has varied. Over the review period the unit has strengthened considerably and now has a mandate and internal demand that often exceeds its capacity. The unit has placed particular focus on impact assessment for which a range of high quality papers have been produced. The SSIA Unit has also been given the responsibility for implementing *icipe*'s recently developed gender strategy.

A notable paper in the context of this review is the evaluation of a 4-H intervention and dissemination approach in the Oromia region of Ethiopia. The analysis estimated that, together, the four technologies (Integrated Vector management (IVM) for malaria control, traps for tsetse and trypanosomiasis control, push-pull technology for maize stem borers control and improved soil fertility, and beekeeping to improve nutrition and relax financial constraints) increased household income from US\$1,573 to US\$5,163 per annum. The combined interventions produced a synergistic increase of 35% in per capita income over the four individual contributions, suggesting significant returns to an integrated approach. These modeling results however did not take into account potential increases in costs of integrated delivery methods or tease out interaction effects. Nevertheless, the results provide an estimate of potential returns from the approach and need to be followed up with actual impact analysis, along the lines of some of the other work on push-pull and fruit fly IPM.

SSIA Unit provides the social science support to other projects that require a monitoring and evaluation (M&E) framework. This increasing *icipe*-wide demand for project level M&E expertise has resulted in SSIA considering the development of the Planning, Monitoring, Evaluation and Learning (PMEL) framework. This is an important initiative, as it meets both increasing donor demand for accountability in project investments and provides a tool for planning, impact assessment, and what increasingly comes under the rubric of "learning" within the Centre. In particular, the unit plans to develop a M&E system to "guide research prioritization and understand constraints to, and incentives for, faster adoption of technologies". This "learning" objective is congruent with the intent of the Results Based Management (RBM) system, currently within the Grants Management Office. The SSIA Unit intends to hire a senior M&E scientist and to develop a sub-unit within SSIA. An M&E data management capacity provides the basic infrastructure for an RBM and there is logic in the migration of the RBM to the M&E sub-unit,⁴ particularly with the development of a more analytical approach to project evaluation, results definition and measurement, and feedback into annual budgeting and forward planning.

⁴ Such a migration of the RBM capacity to SSIA Unit is set out in the draft strategy for the PMEL

The recent PMEL strategy argues that “*icipe* supports the use of mixed methods (eg. RCT, quasi experimental, case studies, economic surplus, mathematical programming) that measure change against some counterfactual scenario (i.e. what would have happened without project intervention) as well as against a theory of change (ToC) that could explain how the project contributed to the change”.⁵ This is wise as the methodology should be chosen on the basis of the problem structure. Nevertheless, it is noted that a significant number of RCT designs are being planned or are already in the field. RCT’s are considered by most in the field to be the gold standard in evaluation but they have a number of significant drawbacks. Firstly, they are costly and best done within a large, ongoing development project where sample size is not limiting. At the same time, they are costly to implement, particularly in maintaining the integrity of the control sample in an ongoing project. However, most importantly for *icipe*, they are very limited in terms of what can be tested; often the impact of quite simple interventions compared to a counterfactual. For *icipe*, which works on integrated approaches within a systems framework, RCT’s have limited utility except in relatively specific product or component testing. The SSIA Unit understands these limitations and as is represented in its publications adapts the method to both the data and the particular problem at hand.

The PMEL strategy document defines three impact pathways for *icipe*’s work, namely technology development and adoption, capacity development (principally through human capital development), and policy influence. The SSIA Unit primarily focuses on the first pathway and within that there are two primary and more specific impact pathways, namely product development and distribution and IVM and IPM approaches. The SSIA Unit is in the process of developing a research area in markets and value chains to tackle the first impact pathway. *icipe* has developed a range of products including the tsetse collar, biopesticides, pheromones, insects for food and feed, and, of course, honey and silk. Apart from honey, none of these are well developed markets and most require a product launching and market development strategy, that can only go forward in partnership with the private sector and sometimes involving negotiation over intellectual property rights. Work in this area involves piloting, testing of alternative business models, and adaptive innovation in market development. This has the potential of being quite innovative research and essential to achieving impact. One difficulty is how to fund this type of research and whether there is potential for private sector investment, potentially through IPR (intellectual property rights) royalties. This is a new area of research that will require other types of expertise in the SSIA Unit, which raises the issue at a Centre level of priorities in developing new capacities.

The other dominant impact pathway is IVM and IPM approaches, which in general involve public sector and civil society actors. Some of these, such as tsetse traps, must be deployed at community level, rather than adoption by individual farmers, in order to reach effective levels of control. As understood by *icipe* staff, IPM approaches are information intensive and effective dissemination methods are not well studied, much less well developed in extension or advisory services programs. Much of the IPM work over the review period has focused on fruit fly in mango, particularly the invasive species *B. dorsalis*. Five components are integrated in the IPM strategy, two of which rely on product delivery by the private sector—the biopesticide Campaign and the food bait Fruit Fly Maniania®—which interfaces with the product delivery pathway. One potential constraint in this regard is that the private company only has incentive to market its own product, rather than an integrated approach. At the same time the available adoption studies suggest farmers adopt a limited number of the components, in this case sanitation, male trapping and the food baits.⁶ Important research was done evaluating the net income impact from different combinations of these components, suggesting the design of a dissemination and scaling program. However, it says little about the design of effective dissemination methods, which requires an understanding of farmer knowledge, social networks, quite complex learning by doing and farmer experimentation, and how the farmer understands component integration. Building relevant capacity in this area within the SSIA Unit is also an issue but should be explored in close collaboration with the TT Unit.

The SSIA Unit also proposes work on policies and institutional innovation for technology/product supply. The proposed work on business models is integral to the value chain work. A significant program in the policy area

⁵ *icipe*. 2017. Planning, Monitoring, Evaluation, and Learning Strategy. unpublished

⁶ Korir, J. K., H. D. Affognon, C. N. Riitho, W. S. Kingori, P. Irungu, S. A. Mohamed, and S. Ekesi. 2015. Grower adoption of an integrated pest management package for management of mango-infesting fruit flies (Diptera: Tephritidae) in Embu, Kenya. *International Journal of Tropical Insect Science*, 35(2), 80-89.

would overload a program already with demands that go beyond its present capacity. Policy work is probably best done on a case by case basis, dependent on the needs and objectives of the project.

viii. Technology Transfer (TT) Unit

The TT Unit was recently resurrected, primarily in response to the availability of funding to extend push-pull to Southern and West Africa and is one of the two units undergoing considerable change (the other being the SSIA Unit). The TT Unit had previously been based within the PH Theme and its activities essentially became a part of the theme's work. The unit has been redesigned as a cross cutting program. Moreover, this redesign comes at a time when *icipe* is exploring means of increasing the impact of its work and debating the question of how far and in what manner the Centre should move into the development sphere in achieving such impacts at scale (see Section III). The design and strategy of the TT Unit is not independent of the work of the themes; rather they rely critically on the methods and technologies coming from the themes. A crucial issue is defining the interface with the themes, particularly given the interaction that the themes need with farm and community level testing in the design of their technologies. An even more central issue is how funding affects the design of the unit and the interface with the themes, with the tendency of the larger bilateral donors to build a downstream, impact orientation into project design. The challenge is whether the TT Unit designs its own project proposals, building on the impact impetus in the unit's creation, or it provides support and innovation to theme proposals that integrate research with downstream work, realizing that funding research is by the far the larger resource challenge.

The draft strategy for the unit defines its mission as the identification of "methods, approaches, processes and technologies within *icipe*'s research portfolio and to communicate them to a broader community of scientists, donors, the private sector and the end-users – e.g. farmers – in order to stimulate uptake".⁷ The strategy is designed around a particular focus on communication and encompasses five work streams, namely database and knowledge management; packaging and innovation; communication, capacity building, delivery and impact assessment; strategic partnerships; and backstopping and legal framework. There is significant overlap in activities between the TT and the SSIA and Communications units. In part this recognizes the need for these components in downstream dissemination but in proposal design there will need to be a clear articulation of the division in unit responsibilities. What is missing from the strategy is a clear articulation of potential impact pathways and how these define dissemination approaches, a research agenda for the unit, a division of labor with the themes, and some initial ideas on scaling, which runs through the presentations given by the four themes. The one mention of scaling in the strategy lays out the challenge: "Various extension models that encompass knowledge management, community development, adoption diffusion, the filling of research gaps, the capacity to innovate with multiple actors to enhance uptake, training in intellectual property rights, and all aspects of technology transfer will form part of the major operations of the unit".⁸ How this challenge is implemented will be the key to the success of the unit.

The TT Unit is at a very early stage of development and has limited capacity. The push-pull dissemination work will give the unit important on the ground experience, which will lead to clearer definition of its role. Moreover, there are important synergies between the work of the GI, the SSIA and the TT units, which will require close interaction in project design. The section on resource mobilization in the strategy seems to argue that the unit will take the lead in proposal development for the technology dissemination and scaling work. This, too, will have to be tested with experience in proposal development going forward, particularly in whether the theme takes the lead and the TT Unit provides support or whether the unit assumes responsibility for the design of downstream scaling work. These will be important issues going forward and will influence the agility of the Centre in its resource mobilization strategy.

ix. Biostatistics Unit

Biostatistics Unit (BU), which has been the source of biometrics support to the research of *icipe*, has, over the review period, lost some of that traditional role as scientists rely on their area of specialization in experimental design, sampling methods, data management and analysis. This runs the gamut from spatial statistics to bioinformatics and econometrics. Traditional experimental design is often a small part of the research that is undertaken in an

⁷ *icipe*. 2017. Strategic Plan of the *icipe* Technology Transfer Unit (TTU) 2017-2020. Unpublished.

⁸ *Ibid.* p 13.

international research Centre like *icipe*. The unit is currently staffed by one senior scientist, who primarily provides biometric support and training to the MSc and PhD students who are less well prepared in this critical area. As with many agricultural research institutes, the traditional biometrics unit has had to reinvent itself, often under the title of research methods that have skills in database management, design of on- farm experiments where control of non-experimental variables is not possible, systems-based experimentation, and planning of long-term monitoring programs. These are areas where disciplinary training seldom provides the necessary design and analytical skills. The question is always whether to build such skills in a cross-cutting unit or rather within themes or units which has that particular problem focus.

An important area that the BU has been developing over the last couple of years is a policy on data management in the Centre. There is a growing culture of data archiving, public access to data developed with public funds, and ability to repeat experimental or monitoring work after an extended period of time. Data sets are kept by individual scientists in excel files and when the scientist leaves—more so for PhD students—the data are transferred to the supervisors. For a research Centre in the era of Big Data, it is essential that primary data are archived in a consistent manner across the Centre to prevent a loss for future research, particularly given the speed of global change, for the multiplication of research done on the data by other scientists, and for ensuring the scientific integrity of the research that was done. The latter is reflected in policies of both journals and donors to put the data in the public domain. The BU could be a focal point for such an initiative, but it cannot be done without a clear policy and support from senior management that the policy be developed and implemented.

III. Supporting and Realizing the Benefit of the Science

icipe, as with other international centres, is organized around its research mandate that runs the gamut from strategic to adaptive research. Because most of its larger donors are international development agencies, there is as well expectations that the research products developed by the centre will be utilized to produce development outcomes. This ability to translate sophisticated, upstream or strategic research (discovery, proof-of-concept) into impacts at farm and community level is seen as one of the particular comparative advantages of *icipe*'s work in the IPM and IVM area. Nevertheless, there is a continuing dilemma of how far *icipe* extends its work into the development sphere, how it organizes its downstream activities and interfaces this with the research programs, what type of partnerships and capacities are required to achieve impact, and what geographic focus should circumscribe these activities. Getting this balance right, particularly in the competition for funding the research, and how to most effectively organize these activities within the Centre are continuing challenges. This section surveys the principal issues in how the Centre is approaching these challenges.

a. Delivering impact

Taking research results to impact in SSA remains one of the most difficult and challenging tasks for researchers, extension agencies, NGOs and donors. The challenge has led to a vast research literature on technology adoption and greater attention by all stakeholders on how dissemination (piloting and scaling) is planned and implemented for each project and technology and how resources might be best deployed.

icipe's research delivers outputs ranging from new products, technologies, management options and new scientific knowledge and policy underpinning the dissemination of these outputs. This range of deliverables demands *icipe* develop a matching range of impact pathways and partners to take their innovations to the scientific, government, commercial and rural communities, where the target beneficiary depends on the individual circumstances of each innovation. For their science, *icipe*'s publication record in international journals is strong, scientists work closely with national agencies in developing and implementing policies and recommendations to overcome old and new challenges across the 4-H spectrum, and they work with and train extension services, NGOs and the private sector to scale out new products and technologies.

Perhaps the more orthodox examples of impact pathways are associated with *icipe*'s range of commercialized biopesticides, which are made available via commercial partners such as Real IPM Ltd. Training of the commercial partner and extension services (public and private) by *icipe*, or supported by *icipe*, is undoubtedly critical in securing adoption. The impact pathways used in taking the more multi-faceted IPM practices to communities are more complex as they are not built around a particular product. *icipe*'s success in empowering women and youth to become small scale entrepreneurs in beekeeping and honey production and in silkworm farming are two such high profile research outputs that don't involve a new product but rather inclusive value chain development. The YESH project in Ethiopia that engages young entrepreneurs is an example of such a value chain approach. *icipe* is at the forefront of responses to new invasive species into Africa, the most recent example being the fall armyworm, and helps national agencies develop new policies to deal with the new pests and train the extension services that will provide the frontline to deal with the new threats. In these cases, early warning, contingency planning, surveillance and monitoring, early detection, rapid response and management research feeding into policy initiatives and extension training are all part of delivery that has to be enacted as quickly as possible if the impacts of new invasive species are to be minimized.

While *icipe* will undoubtedly continue to use an appropriate range of impact pathways and partners to extend its research outputs to benefit communities, it should also aim to evaluate different pathways, and use these evaluations to better define and plan its future roles across the spectrum of R&D. This is a research area that is often overlooked and encompasses the relative efficacy and cost effectiveness of alternative impact pathways, especially for knowledge intensive pest control methods. At the same time, it should be defining what is not their role in delivering technologies to communities and where delivery relies on devolution to development partners. Developing and enacting exit strategies should be viewed as a critical aspect of *icipe*'s transition to its upcoming

strategy beyond 2020 and this is closely tied to its capacity and institutional development strategy.

icipe recognises that if it is drawn into providing ongoing capacity building in extension services too widely, and especially if these training programs require significant input from research staff, *icipe* will lessen its capacity to devote its very special research expertise and innovation to other challenges across a wider African geography. *icipe* should be congratulated for seeking more effective and efficient delivery of impacts through its establishment of a TT Unit, often in partnership with Bioinnovate Programme, and through strengthening its SSIA Unit. *icipe* is still in the process of defining the role of the TT Unit and its relationship to the research themes. Will it have a research role on dissemination methods or will that be in conjunction with the SSIA Unit? There are two stages in assessing technology dissemination strategies, namely assessing the effectiveness of different extension approaches, often in pilot programs with a comparative design, and then in actual programs taking these methods to an appropriate scale. *icipe* can define a research role in this “science of scaling” of IPM or IVM programs or in the design of response programs for invasive species. At the same time, it should be cognisant of being drawn into devoting its skills and resources too strongly to implement downstream scaling out programs.

The issue of geography is particularly important. Focus on delivering impacts and building capacity in Kenya in particular, and East Africa more generally is very much recognised and appreciated by East African agencies/partners. Discussions with key Kenyan partners during the review confirmed the high value that these partners place on *icipe*'s role in capacity building and in delivering impacts directly to communities. However, the opportunity costs of intensive roles in East Africa, in fruit fly IPM for instance, should continue to be considered.

This all comes down to having better defined paths to impact, working out who the key partners are, what each partner is responsible for, how they are resourced, and coordination to bring the partners together within required timeframes to deliver impact. Of critical importance is the issue of adequate resourcing. The role of the newly established TT Unit will be just one aspect of how *icipe* progresses on resourcing scale-out but if real scale-out is to be achieved, then mechanisms that the partners, including the TT Unit, employ, such as innovation platforms and communication fora need appropriate budgets. *icipe* has demonstrated its intention to initiate change, but it also has to avoid the all too common scenario where the vast majority of research funds are devoted to the bio-physical science, and research on scale-out is not adequately planned and resourced.

In summary, *icipe* should monitor, evaluate and learn from its current and future scaling out design and practices so that it becomes better equipped to match the project design and needs with the most appropriate scale-out model and associated support from the range of partners and *icipe* itself. This will become even more important as *icipe* moves to a stronger systems and 4-H approach to its research. A systems approach should have the advantage of defining and delivering multiple benefits for adopters and consequently, more adoption. However, it also has the potential to make messages of benefits more complicated to deliver.

b. Partnerships

icipe recognises 300 partners inside and outside Africa. Many of these are strong, long-term partnerships which form the basis of *icipe*'s donor community, research partnerships and delivery of impact. The number and diversity of the partnerships reflect *icipe*'s recognition as a long-term, high-achieving member of the African research and innovation community. National agencies, such as KALRO, KEPHIS, KEMRI, NARO, ARC, MARI, EIAR, Ministries of Health, Agriculture and Livestock and larger universities (University of Nairobi, Makerere University, Addis Ababa University in East Africa) are just some of most important research partners in Africa. These African partners work with an equally impressive number of key research partners from outside Africa, including a large number of European and US universities. Many of these, such as CIRAD, IRD, Rothamsted Research, Wageningen University, University of Florida, Texas A&M University, University of Hawaii, USDA and Smithsonian are long-term partners, having had continuous involvement in research projects with *icipe* for over a decade. These partnerships are mutually beneficial as they enable transfer of state-of-the-art research methods and technologies to *icipe* laboratories, allow *icipe* scientists to remain on the front-lines of the scientific discoveries and enable the partners in the North to benefit from *icipe*'s expertise and research insights, deep understanding of and access to African

agricultural, biological and socio-economic environments and infrastructure. And of course, both partners benefit from the joint publications emanating from the collaborations.

Over the past seven years, *icipe* has adopted public–private partnership models to assist in delivering the product outputs of its research. This effort is further strengthening *icipe* commitment to ensuring that innovations and new technologies are adopted for the benefit of communities, the region and globally, although the development of inclusive commercial value chains requires attention. The most prominent of these is currently with the Kenyan-based company, Real IPM Ltd., but other similar partnerships have been developed with Morocco’s Elephant Vert Company, Kenya’s Farm Track Consulting, Kenya Biologics Ltd., and Sanergy. These partnerships serve as conduits for delivering a raft of newly discovered and commercialized biopesticides, fruit fly products, animal feed and other R&D products. Real IPM Ltd. has recently been bought by the Belgian company BioBest.

This network of partners has mostly evolved to meet the current *icipe* R&D priorities and project portfolio. However, high profile partners are less apparent in southern, central and western Africa. *icipe*’s expansion into Ethiopia has demonstrated how partnerships can quickly lead to new R&D roles and opportunities. The YESH project for example is a partnership between *icipe*, multiple Ethiopian Ministries and the MasterCard Foundation, a new donor partner, and focuses on supporting youth to move into small enterprises via honey and silkworm production.

A repeat of this approach to reach more strongly into Southern, Central and West Africa would almost certainly lead to greater impact flowing from *icipe*’s research. *icipe* already has tools and methodologies that would underpin responses to new invasive species, such as the fall armyworm, *Tuta absoluta*, Asian citrus psyllid, ticks, and fruit flies. Having *icipe* staff locally based, as they are in Ethiopia, would seem to be essential if *icipe* is to make an Africa-wide contribution. Unlike in other disciplines, such as plant and animal breeding and genetics, farming systems research, and soil science, there are fewer alternatives for combatting the many pest and disease challenges by using technologies that are affordable, ecologically sustainable, and avoid the challenges of rapid buildup of resistance to agrochemicals. Here *icipe*’s technologies related to improved traps to attract and kill insect pests, baited-collars to repel pest insects and bio-larvicides to reduce pest numbers provide novel tools for incorporation into ongoing vector control programs. *icipe* needs to address how best to move these new tools from field trials into the implementation phase working with its research and extension partners along with TT and SSIA Units.

Selecting partner institutes should be based on alignment of their skills base (e.g. strength in entomology or one or more of the 4-H Themes), exposure to key challenges (e.g. those in particular crops, such as cocoa or control of ticks), or environmental and political alignment. For instance, forging strategic partnerships which can address challenges in the humid and sub-humid regions of West Africa, or in francophone West Africa may be an important strategic goal. Such strategic partnerships would be enhanced by closer alignment of the *icipe* Capacity Building and Institutional Development (CBID) Programme with those institutes.

c. Capacity Building and Institutional Development

icipe is recognised as having one of the most sustained and high valued capacity building and institutional development programmes in SSA. It has more than 100 post graduates every year with most of them being PhD students. Both the ARPPIS and DRIP programs are long-standing and these are likely to be supplemented by a large World Bank capacity building program. The model of having students invariably supervised by *icipe* staff as co-supervisors alongside university supervisors has proven most effective with almost no students failing to complete their degrees. Most PhD students have warranted co-authorship of at least one scientific paper by the completion of their degree and several have published their research in prestigious scientific journals as senior authors. Overall about 50% of all *icipe* scientific publications are co-authored by post graduate students. This not only demonstrates the high quality of the academic training, but also demonstrates the commitment that is instilled in students during their time at *icipe*. Clearly, the CBID Programme has consistently provided participating students with an excellent research experience and training, and there is probably no parallel African institution outside the university sector that could equal the quality and number of students trained. Despite its success, the Programme should consider fine tuning the Programme to help address the issues of:

- Providing opportunity to a wider geographic/national base in SSA
- Assisting ongoing careers of some graduates after their *icipe* experience, and
- Using its success to help build stronger institutional capacity in selected core SSA research partners.

The program in its present form is one that is heavily targeted towards Kenya nationals, and to East African students in general. Currently, 44% of students are Kenyan citizens. This is reducing towards 27%. The dominance of Kenyan participants in the Programme appears to be the result of a number of factors. The location of *icipe* and its close relationships with Kenyan Universities makes potential students more aware of *icipe* and its CBID Programme. *icipe* also had a predominance of research projects focusing on Kenyan problems, which again makes alignment with Kenyan universities easier. Also, Kenya has a well-advanced education system and so Kenyan applicants might be more likely to meet the demanding education eligibility requirements. The challenge for *icipe* is to move to a model which has greater participation from across SSA, while at the same time not compromising on the quality of student intakes. This will take some time to implement, but the long-term benefits to the wider Africa will be worth it.

The question of what eventuates for graduates after their degree and their time during training, in this case, at *icipe* is critical. Many universities in Africa do not have a strong research function and if they do, they are often resource-poor. The return of successful *icipe* PhD graduates to their countries and home institutes too often leads to them not being able to continue their research career. It will not be possible for *icipe* to change this substantially, but it should consider how it might align the CBID Programme with the job of building capacity in the core African institutional partners as suggested in Section II. One option might be to quarantine 15-25% of the postgraduate intake in each year for students from those selected core partner institutes so that over time, these graduates will significantly build the capacity of the Partnering Institutes Africa wide. Another option to help build institutional capacity may involve *icipe* widening its current practice of having more active dialogue with selected University mentors through joint grant submissions or short-time visits to *icipe* to gain unique research or grant-writing skills. While a few of the advanced universities, which currently partner with *icipe*, are already building these initiatives on their campuses, other local universities lack these resources. As the pool of PhD level scientists will undoubtedly increase sharply on the continent within the next 5-10 years, the next challenge will be to advance research programs into the African academic settings. To advance scientific thinking and training on the continent, linking teaching and research in the academic setting should be a high priority, which *icipe* is well placed to help move forward - a recommendation that was also made by the 2013 IPER committee.

icipe has already commenced a program to build institutional capability of SSA research institutes through its recent expansion into Ethiopia. A key commitment of that expansion has been the placement of *icipe* staff members within the country. This has resulted in close relationships between *icipe* (especially via Ethiopian-based *icipe* staff) and Ethiopia universities which is seen as contributing significantly to the advancement of the participating national universities. Placements of *icipe* staff at core partner research institutes would appear to be an extremely valuable practice that *icipe* might consider using more widely to underpin more rapid institutional capacity building.

d. Communications Unit and ICT

The Communications Unit provides expertise to the full range of *icipe*'s institutional and Theme needs using a range of media from programs aimed at national television, production of annual reports to written communication material associated with particular research programs such as push-pull technology and ongoing development of what is already a well-designed and informative web page. It works closely with senior management and Theme teams to provide material which is of highest quality.

icipe's monitoring of communication between 2014 and 2017 recognised 490 articles on *icipe* being published or broadcast in local, regional and international media. Most of this coverage continues to be available online. As a result, *icipe* news items have appeared in over 2,450 outlets during that period. That translates to a cumulative potential reach of approximately 300 million people during the period of this review. The Centre regularly

achieves broad coverage of its featured articles across the spectrum of Kenyan media and more widely across other media outlets in Africa. Some of the international media outlets that have covered *icipe*'s activities include: CNN International; The Mind of the Universe; BBC; The Washington Post; National Geographic; SciDev.Net; The Guardian, UK; Reuters News Agency; Xinhua News Agency; ARD, Germany; The Conversation; Al Jazeera; Daily Mail UK; Voice of America; The Japan Times; Fox News; NBC News, CBS News; Chicago Tribune; Huffington Post; Science; Science Daily; New Scientist and The Scientist.

In February 2016, *icipe* launched a new website that provides a comprehensive and easy-to-navigate platform for communication with stakeholders. Between February 2016 and December 2017, the site had approximately 135,000 visitors and the site had 675,000 page views with large number of visitors from as many as 20 countries.

During the period under review, *icipe* quarterly e-bulletin published approximately 300 articles in 45 issues, all available at: <http://www.icipe.org/publications/newsletters>. Noteworthy in the e-bulletins, are the DG's Thought Leadership columns which have covered the following topics: Insects for Food and Feed; Microbiome Research; *icipe*'s technologies and Invasive Species. Over the past five years *icipe* has enhanced its social media presence, generated continued visibility and also conversation with various stakeholders.

The communications team has also successfully introduced a monthly internal communication newsletter in the past five years which has improved communication within the institute along with regular visits of senior management to Mbita and Ethiopia. The newsletter is making all staff more aware of the institute's strategic focus and how it is being implemented, its research and development highlights, staff issues and awards, key international visits to *icipe* and by its leadership teams, funding opportunities and newly acquired research grants. The newsletter has already proven as a valuable tool in strengthening cohesiveness and unity of purpose within the Centre.

External communication of research outputs is important for scale out of technologies, for broader public awareness of what *icipe* does and its successes, and as a key tool for senior management in their efforts to maintain relationships with current donors and to access new funding opportunities. Senior management believe that *icipe* has growing external exposure which is having a matching impact on awareness of *icipe*'s role and research capability in Africa and elsewhere, including awareness by new donors and the general public.

However, the resources of the communication capability within *icipe* is limited and senior management has to remain vigilant in directing where those limited resources are committed. This is a major challenge for any institute, especially one with the diversity of science, geography and partners that *icipe* already has. The vast breadth and number of R&D initiatives and outcomes within *icipe* demands that well defined priorities continue to be set to make the best use of the resources at hand. It is the view of the review team that the Communications Unit's first and foremost function should remain to be to support senior management especially in an environment in which larger funding opportunities are increasingly more challenging to attract, and where *icipe*'s international exposure is an important factor in enabling it to attract international researchers. Such a focus does not preclude project-based communication teams and efforts, which are also essential.

One function of communication that might be expanded is the role of the communication team in assisting the scaling-out of technologies within the framework of well-defined project paths to impact. As noted previously, *icipe* has, over the past 5 years, made the strategic decision to put more focus on having its technologies adopted and has done that in part by strengthening both the TT and SSIA Units. The review team believes that there is an opportunity to tie some proportion of the institutes communication capability (corporate and project-based) to the TT and SSIA priorities, or indeed other Theme-based scale out priorities (which have been set by senior management) with particular emphasis on developing events and products that support scale-out through national policy initiatives and on the ground technical advisory material. The experience and learnings that the communications team will gain and later apply in focussing on these particular areas will be particularly valuable to *icipe* and its ambition for even more on-the-ground impacts.

icipe is congratulated on developing outstanding information management in terms of its digitization of its library and the wealth of information available on its well-designed web page. The Information Unit has significantly reduced its costs associated with journal access by switching to a few arrangements with key international journal-access databases. It also maintains a comprehensive digital library of all MSc and PhD theses arising from *icipe*-based students.

icipe for many years has published the International Journal of Tropical Insect Science. The prime purpose of the journal is to provide an avenue for African scientists to publish their research. It is not a journal of sufficient quality to attract *icipe*'s science publications. While *icipe* has invested recently in adopting better, more efficient editorial processes, the journal currently has an impact factor of only 0.375. Given the cost of housing the journal, low impact factor and the growing number of alternative journals available now, *icipe* should consider if the Communications Unit resources assigned to maintaining the journal would be better allocated elsewhere.

e. Data management and analysis

The outstanding progress in communications and ICT has not yet been matched by progress in the related issue of data management and security. Certain programs in the Centre have responded to best practice in the field, particularly in the HH theme and in bioinformatics, but this is not universal across the institute. On the positive side, the Centre already complies with the growing requirements of many mainstream journals (e.g. PLOS family) that authors make their data available to other academic researchers who wish to replicate, re-analyse, or build upon the findings published in their journals. These data are often submitted as publicly accessible supplementary files, or a Data Availability Statement that indicates where data supporting the results published are available, with hyperlinks to relevant datasets. Where appropriate, clinical trials and Randomised Control Trials are archived in repositories such as Clinicaltrials.gov (*Pyronaridine plus artesunate for treating uncomplicated Plasmodium falciparum malaria* (<https://clinicaltrials.gov/ct2/show/NCT02411994>), and the trial register (Solarmal: Solar energy for malaria elimination; <http://www.trialregister.nl/trialreg/admin/rctview.asp?TC=3496>). All researchers at *icipe* deposit sequence and genomic data in the central genome databases, most often via GenBank, and specialized databases such as VectorBase (vectorbase.org), the repository for genomic data for vectors of human disease.

However, more broadly in the Centre the security of data generated is primarily the responsibility of the researchers and there are no formal institute wide processes in place to assemble, store and secure research data. There is a growing expectation of the wider research community and of donors that data be securely held and if appropriate, made available to other research teams, as for example in the PLOS family of journals. This is particularly important in an institute such as *icipe* that has large numbers of Masters and PhD students who have a short period of high achievement at *icipe* and then leave, but it is just as important to secure data held by staff. Furthermore, large datasets such as those developed by annual surveys over long periods are likely to prove of particular value in developing new research insights via meta-analysis. *icipe* should, as a matter of urgency, put in place mechanisms that have centralized backup of data, that ensure data sets are well labelled and described, and that protocols under which those data sets might be accessed by others are defined.

An associated data issue for *icipe* is its capacity to support its staff and students in data analysis. The large numbers of postgraduate students at any one time makes it likely that some will be lacking in deep understanding on biometrics and data analysis. This issue is exacerbated by the wide availability of statistical software packages which can sometimes be inappropriately applied. In addition to the possibility of applying inappropriate statistical tests, opportunities to employ better methods can sometimes be overlooked without professional guidance. *icipe* currently has just one biometrician on staff. *icipe* should consider strengthening this capability to ensure best practice from experimental design through to data analysis and interpretation.

f. Science and development priority positions and skills

icipe has an impressive range of staff and skills delivering into all Themes. However, the review team identified the need for more strategic science or development expertise and four areas of skills that are required to implement the recommendations on adoption of technology, One Health concept and data management.

icipe has a track record of building its capability by offering placements to some of its best PhD graduates from its CBID Programme. This has been a successful practice with several examples of current senior researchers having progressed under this scheme and as such this practice should be continued. It is especially important for *icipe* given the challenges it sometimes faces in attracting some of the best researchers to move to Nairobi.

Attracting high profile scientists to take up science leadership senior positions at *icipe* has proven especially challenging. This is understandable given that many potential appointees already have tenured positions in internationally renowned universities and other institutes. *icipe* has in part tackled this through long-term partnership agreements whereby some key partners including the Institut de Recherche pour le Development (IRD), Centre de Cooperation Internationale en Recherche Agronomique pour le Development (CIRAD), the University of New Zealand, the University of Glasgow and the CIM Programme of Germany base a number of their scientists at *icipe* where they are fully integrated within *icipe*'s various programs and work on *icipe*'s priority research areas. Management is currently preparing to introduce a Program for Adjunct Scientists positions. *icipe* should also consider introducing a Fellowship program that enables international scientists to take up a position in *icipe* for about 2 years. This would enable *icipe* to benefit from the intellectual input from the Fellows and at the same time, bypass the issue of Fellows having to resign from their tenured positions. Of course, such a program would need to be supported by the Fellows employer (by offering long term absence) but given the number and depth of the *icipe* Partnerships with many aligned universities and other institutes around the world, such a proposition might be achievable.

Given the expanding boundaries of *icipe*'s work, the new developments in scientific research, and the potential in moving into areas such as invasives, there is a continuing demand for new capacities in the Centre both to operationalize the one health framework and to balance its work in both research and development. At the same time adding new capacities is difficult given the resource requirements that at least initially must come from core resources, noting the already large demands on those resources (see section IV). Such new capacities must have a significant probability of generating a return in terms of improved synergies in the research portfolio but also in terms of being able to generate fundable projects. The review team's suggestions for new capacities below must be assessed in this light and will primarily depend on the directions taken in the new strategy. These are thus a set of suggestions based on the existing research programs and strategies.

icipe is committed to taking as many of their research outputs to adoption in Africa as possible, while at the same time recognizing that as a research focused international centre, it must support the scale-out process via partners who are better placed to undertake that role. A key function of the TT Unit is to identify these key partners and their potential roles in the path to impact. However, *icipe* recognises that the combination of its developed practices and technologies under the 4-H Themes and their targeted communities varies widely and that it must be more innovative in matching technologies, communities and impact pathways. Understanding these complexities and defining best options should be a priority for the SSIA Unit, working with the GI Unit. Currently however, that unit's skills are strongly focused on agricultural economics, impact evaluation and monitoring and evaluation. There are also increasing demands for capacity in both market and policy research. However, given the critical need of the TT Unit in the area of understanding the farmer adoption process and assessing the effectiveness of alternative methods for disseminating IPM and IVM techniques, appropriate skills in sociology or anthropology could support research and learning in this key area. Stronger capacity in these disciplines is considered essential if *icipe* is to strengthen its aim of greater adoption of its outstanding science outputs.

One of the core strategic objectives of *icipe* is to apply a stronger systems approach to its research through its One Health concept. As stated previously, there are numerous examples of cross-Theme research being undertaken but

none that could be described as fitting the One-Health concept which in *icipe*'s case, is more aspirational through its inclusion of Plant Health alongside the more normal One-Health concept of Human Health, Animal Health and Environmental Health. To be a leader in this domain, which it undoubtedly aims to be, *icipe* needs the capability to quantify the many systems relationships with sufficient robustness that will enable it to model the diversity of systems and have predictive capacity. For example, this would apply in developing a surveillance and response capacity for controlling invasive species. *icipe* has modelling capability now, especially in spatial modelling and for modelling the interactions within research Theme projects. However, it does not have sufficient modeling capability to underpin its objective of transitioning to a Centre with strong One Health capability. New skills are required to conceptualize, engineer and develop a modelling framework and capacity that will enable *icipe* to fully explore and benefit from the One Health concept.

Both the Human and Animal Health Themes are developing vector control methods to interrupt disease transmission. To help identify the most opportune methods to interrupt transmission, and to understand the trends post treatment application, inclusion of an epidemiologist with appropriate skill sets within these teams would be desirable. At the present time, this expertise is lacking at *icipe*.

Data analysis is a critical discipline in a research institute as large as *icipe*, with its range of disciplines, especially with its consistently large number of PhD students. The current Biometrics Unit is under-resourced, especially if meta-analysis of large datasets is to be undertaken. This can be considered a reputational risk to the Centre especially given that disease preventions in humans is a key area of research. Strengthening of the Biometrics Unit should be a priority.

IV. Managing the Resources to Achieve *icipe*'s Strategy

Governance and management are essential functions in an international centre that affects the efficiency of operations, strategic direction of the organization, international relations, reputation, and the ability to mobilize resources. Governance and management are a necessary cost in the operations of the centre, but with the intent that these costs are kept to a minimum that ensures that the above functions are effectively implemented. The IPER team finds that these functions have been significantly improved over the review period and *icipe* is governed and managed in a manner that enables effective use of the public resources provided to the centre. Moreover, *icipe* has plans to continue improvement in its systems to ensure both effective control and improved efficiency in the use of its financial resources. Noting that the IPER team does not include disciplinary expertise in the finance and management area-- although one member has board experience with a CGIAR center--, this review will focus on those areas where change is planned and make suggestions for further improvement.

IV.1. Generating the resources

a. Funding Flows 2012-2017

icipe depends on international public funds to conduct its research and maintain staff and infrastructure. It operates within a very competitive funding environment, competing particularly with the fifteen CGIAR Centres and eight other non-CGIAR Centres. Moreover, that funding environment is continually shifting in terms of funding priorities, aid budgets, and grant modalities. *icipe* operates very successfully in this funding environment, partly due to the particular niche that the Centre has carved out, partly due to the quality of its research, and partly to the increasing visibility of the Centre in African R&D. This is demonstrated by the healthy financial flows that were maintained over the review period (Table IV.1).

Table IV.1 Core and Restricted Funding received by *icipe*, 2013-2017

US\$ '000'	2013	2014	2015	2016	2017
Unrestricted Core Income	6,767	7,546	7,019	4,383	4,238
Restricted Projects Income	17,827	23,238	18,525	18,479	15,622
Centre Generated Income	2,372	1,660	1,726	1,576	2,488
Total	26,966	32,444	27,270	24,438	22,349
Core Income as % of Total	25	23	26	18	19

Funding for *icipe* peaked in 2014 at just over \$30 million. This also coincides with the peak in Windows 1 and 2 funding to the CGIAR in support of their CGIAR Research Programs (CRPs). The positive reversal in support to agriculture by international aid donors that started in 2008 plateaued in only five years.⁹ It is not due to any lack of confidence by donors in *icipe* that funding has declined somewhat over the review period (as evidenced that the 2018 budget is slightly more than 30 million), but rather to a much tighter funding environment-- and the effect due to completing several very large projects. It is noticeable that core funding has declined at a faster rate than grant funding, also a similar trend to that in the CGIAR. It is difficult to say what future trends in funding to agriculture will be over the next five years—only that any future spike in world food prices generally induces renewed funding to the sector.

In this highly competitive funding environment *icipe* tends to source two quite different funding sources for project grants. Those for pure science tend to be sourced through calls for proposals where there are varying probabilities that the proposal will be funded. For bilateral donors these calls are often tied to the participation, if not lead, of national institutions, often universities. In general, science funding is becoming ever more competitive, often involving two or even three rounds, and with an increasing number of conditions. This compares to grants proposals developed directly with the funder, most often a bilateral donor but also increasingly foundations. These grants

9 Official Development Assistance to agriculture started to plateau-- data only available to 2015-- in 2013 and the percent going to research peaked in 2007 and 2008 at 12.5% and declined to 5% by 2015. See FAO <http://www.fao.org/aid-monitor/analyse/sector/en/>.

are generally much larger in size and longer in duration. They build on *icipe*'s evolving relationship with the donor and are much more flexible in the project design. However, they increasingly involve a large component directed toward impact on development outcomes, which requires a well-developed operational, field capacity within *icipe* or in conjunction with relevant partners. In general, the larger the impact component, the larger the grant. For most international agricultural research centres this produces a dilemma in how far to move operations and capacity downstream towards scaling out technologies (see section III).

b. Donor Portfolio

In 2017 there were 4 core donors to *icipe* and 50 donor sources of project funds—amounting to 88 grant agreements-- for approximately a budget of US\$22 million for restricted grants and US\$ 5 million for core grants. The core donors are essentially European bilateral agencies, with some change over time, for example BMZ shifting to increased project funding and Sida slightly increasing. At the time of writing this report, Norway has joined as a donor in 2018 by providing program support. The Government of Kenya provides modest, but important, core support and this year the Government of Ethiopia has been added as a core donor, with no conditionality that the funds have to be spent in Ethiopia. Kenya and Ethiopia demonstrate their support for *icipe* from government budgets on which there are heavy demands. Maintaining a set of core donors is critical in giving the Centre the financial flexibility to manage volatility in restricted income flows and to allow for such important expenditures as capital investment and infrastructure maintenance, in which the Centre has invested wisely over the review period.

The average expenditure per project in 2017 was US\$165 thousand, which was down from the average size in 2016 (Table IV.2). However, there is a significant skewness in the distribution of donors and their contribution to *icipe*'s annual income. In 2017 five donors account for 55% of overall grant income and the top 10 donors account for 80% of overall (core and restricted) grant funding. The EU was the largest donor for restricted grants, followed by the Mastercard Foundation and the Biovision Foundation. Of the remaining top 10 donors, all had funds originating from governments in the North. The majority of the remaining, smaller donors provide funding for particular projects. Many are universities in the North through which *icipe* is sub-contracted on research projects. Examples of these smaller project-based donors include the National Institute of Health, National Academy of Sciences, Wellcome Trust, and the German Research Foundation.

Table IV.2 Average Expenditure (US\$'000's) per Project 2016-2018

	2016		2017		2018
	Actual	Budget	Actual	Budget	Budget
No. of Project Agreements	86	54	88	44	38
Restricted Expenditure	16,891	23,086	14,567	18,630	19,884
Average Cost/Project	196	428	166	423	523
Total Restricted Income	18,479	26,372	15,622	21,271	22,395
No. of Donors	54	31	50	27	25
Income/Donor	342	851	312	788	896

Note: difference in expenditure and income arise due to funds earmarked from core income to fund restricted projects.

icipe maintains the diversity of donors essential in reducing the risk of over reliance on any one donor and has a good track record in attracting grants. Although *icipe* largely confines its research portfolio to well-defined niches in which it has significant comparative advantage, competitive grants tightly aligned to research projects cannot fund the Centre at a size and scale essential to addressing emerging challenges and opportunities in Africa, especially in an environment where accountability is moving more strongly towards measurement of impact on development outcomes. As discussed in section III, this has moved *icipe* to defining how far downstream into the development arena it is prepared to venture and how it structures this component of its activities. What is essential

is that a significant research component is built into these larger, more impact-oriented projects and that *icipe* has the necessary skills based in the relevant disciplines.

Trends in funding are a strategic consideration influencing positioning in the R&D spectrum, geographic focus and location, and administrative efficiencies. In an era where budgets rely on project funding and the Centre must fundraise in a competitive environment, there is a practical tendency to expand the boundaries of the project envelop that *icipe* competes within, especially for large projects. This will be an issue to monitor, namely how far into the development sphere the Centre is prepared to venture, the research or operational scope of the project, and new capacities that the Centre must build to implement the project. These are not easy decisions but do influence the ongoing coherence of the research portfolio.

c. Resource Mobilization

Over the last decade international agricultural research centres including *icipe* have invested significantly in capacity to support resource mobilization. *icipe*'s Resource Mobilization Unit sits under the Director General. It has an intelligence function in identifying new funding possibilities, an interaction function with principal donors, a proposal development function with principal investigators, and a monitoring and tracking function on development of the project pipeline.

Senior management works closely with the unit and takes the lead role in relationships with those donors providing or potentially providing, core funding and with larger bilateral partnerships and projects. The unit coordinates the project proposal development process in response to calls from the wide range of donors and ensures that proposals going forward from the Centre meet the necessary criteria. The key steps the unit plays include asking the 4-H Themes to develop concept notes, arranging for these to be vetted by the Director of Research and Partnerships and the Science Committee, supporting the development of full proposals for those selected under the internal review process, and finally ensuring compliance with requirements of the call.

The 4-H Themes initiate most of the proposals. There is little direct funding to the research units with the majority of their support being through joint project development with one or more Theme; although research units can initiate funding proposals. For some units, joint proposal development has been more difficult because of budgetary ceilings put on calls, while for other units that provide both research support and could initiate their own research, such as the SSIA and GI Units, there is probably greater opportunity to develop independent projects. One unit where this may be more important in the future is the TT Unit, although there is still discussion of the extent to which the themes incorporate more downstream activities in their proposals, as opposed to devolving responsibility to the unit. The TT Unit however requires additional capacity if it is to play a role in supporting scaling-out of technologies across all Themes (see section III), while taking a path to more independent project proposal by units generally tends to be counter to *icipe*'s strategic intent of having stronger 4-H systems approach.

d. Centre Visibility and Positioning

Funding is closely tied to *icipe*'s reputation and visibility. The Centre is well regarded within the science disciplines in which it works, particularly within the entomology research community. Its reputation is reflected in the quality of its publications and its ability to compete effectively in competitive grant calls. Moreover, *icipe* has a solid footing with the European bilateral donors, including the EU and IFAD. However, these are the donors where aid policy has been shifting and support to agriculture declining. Moreover, IVM approaches to disease management lies outside the mainstream of approaches to vector borne human disease control. This argues for continuing efforts to diversify funding sources, but primarily to donors who have in all likelihood not heard of *icipe*, as for example the recent case of the Mastercard Foundation. This effort was led by the DG and the DG remains a central resource in being able to attract new donors.

icipe's mission and strategy is not straightforward to frame in terms of its potential impacts on the development agenda. Having an Africa focus and operational capacity is an advantage and the 4-H framework has potential

as an innovative approach, particularly if built around the idea of improved livelihoods, but it is difficult to market to funders whose programs tend to be divided along sectoral lines. For example, the Bill & Melinda Gates Foundation is in process of developing a “networked approach to surveil, diagnose, and respond to plant health challenges for smallholder farmers in sub Saharan Africa-- tentatively named the African Plant Health Initiative.”¹⁰ However, this initiative has no link to their large investments in human health. The more recent thinking of building 4-H around the more targeted area of invasive pests and diseases makes development outcomes more tangible, especially given the recurring introduction of new species, such as fall armyworm or maize lethal leaf necrosis or the experience with cassava mealybug. These introductions have devastating impacts on livelihoods and *icipe* is uniquely positioned to address these challenges. Moreover, there is an explicit target on invasive species under SDG 15 on ecosystem sustainability, namely “by 2020 introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.”

Broadening the visibility of *icipe*, particularly to international policy makers, involves the Centre’s participation in key international fora and over the past years, the DG, in particular, has led the way in raising the profile of *icipe* through participation in key events, such as AfDB’s launch of TAAT (Technologies for African Agricultural Transformation) at the World Food Prize Laureate Award Ceremony, the G20 Conference on One World - No Hunger, and the 2018 Aid and Development Africa Summit, among others. The DG also delivered seminars at the World Bank headquarters in Washington D.C. and the Bill & Melinda Gates Foundation headquarters in Seattle, USA. With the development of a new strategic plan in 2019, a well-crafted communications platform, and continuing participation in well targeted international fora, *icipe* should continue to increase its visibility across the research for development communities.

IV.2. Managing the resources

Effective management of the Centre is as important as quality science in the functioning of an international Centre. It is as important as the science in the reputation of the Centre and it is essential to maintenance of funding levels. Effective management sets the overall strategic direction of the Centre and is a prime determinant of staff morale. Possibly most importantly, it directly influences how efficiently resources are utilized, particularly the balance between administrative costs and resources directed at its core business of undertaking insect science. This section provides a very brief overview of management and administration.

a. Leadership in managing a research Centre

Central to management effectiveness is senior leadership. In the case of *icipe*, this is quite narrowly defined, consisting of the DG and two Directors for Research and Partnerships, and Finance and Administration. This narrow leadership team is probably commensurate with the size of the Centre but with all the functions carried out by the senior management team, it does put pressure on their time. At least one, and possibly two new senior executive officers’ positions to lead the implementation of senior leadership decisions would go some ways in releasing senior management to pursue its higher level functions and further improve the effectiveness of management and administration.

The current DG was recruited at the beginning of the review period and in just that short period, has led to significant improvement in many aspects of *icipe*’s internal and external environments. She has significantly raised the standing of *icipe* in the international agricultural research community and increasingly in the development community, as reflected in the accolade given her and *icipe*’s research mission by Bill Gates (Bill & Melinda Gates Foundation). Such standing significantly aids in resource mobilization, as reflected by the addition of three new major donors, the Mastercard Foundation, the Government of Norway and the World Bank, among others. However, the major achievement of the DG and her two Directors over the period has been to accomplish significant improvements of the management, financial and other accountability, transparency and human resources systems at *icipe*. These changes are embedded in the Centre by its commitment to a program of continuous improvement in all three components of the administration. Recognizing the need for such improvement is the mark of sound leadership

¹⁰ <https://eucalipkis.kumu.io/african-plant-health-initiative-design-convening-presentation>

but acting on that recognition has significantly improved the operational efficiency of the Centre, including a major ongoing improvement in Centre infrastructure.

b. Management structures and decision making

A number of committees ensure day to day management, decision making reflecting core constituencies within the Centre, and oversight and decisions on specialist areas that are key to the types of research carried out in *icipe*. The Senior Management Committee (SMC) is the leadership team reflecting and representing the organizational structure of the Centre. The committee is made up of the DG, the two Directors, and a leader of a Theme (Animal Health), a country office representative (Ethiopia), and a unit leader (Behavioural and Chemical Ecology). The committee reviews resource mobilization, financial status, project status, human resources, progress in infrastructure upgrades, and other issues that affect the ongoing operational status of the Centre.

Other committees include Science Committee, Intellectual Property, Institutional Biosafety, Health and Safety, and Environmental Management. These and other committees ensure management and decision making on key aspects that impinge on the operation of the Centre. Importantly, there is an *icipe* Staff Association which provides a pulse on emerging staff issues and overall morale and provides input and feedback to management.

Most of the research of the Centre is organized around the four Themes. The Theme leaders set the strategy for each Theme's program within the frame of the Centre-level strategy. To date this has been done somewhat independently of the other Theme strategies and is complicated at the moment with three of the four theme leaders in acting roles. There is potential for more interaction among Theme leaders, particularly around how and whether to move forward with the 4-H concept, synergies in external partnerships and allocation of skills and as well on the issue of focusing on the scaling out of technologies, within and across the Themes, mediated by the TT Unit. A more integrated, Centre wide approach to implementing its strategy appears to be a priority for *icipe*. That more integrated approach should be undertaken through the existing Science Committee, under the leadership of the Director of Research and Partnerships.

c. Finance and control systems

Over the review period *icipe* has significantly improved its finance and control systems. This was in part a response to core donor concerns in 2014 about the financial integrity of control systems in place. A position for an internal auditor who reports to the chair of the finance and audit committee of the Governing Council (GC) was created and this has greatly strengthened the audit function within the Centre. This complements the external audit by KPMG, which over the review period have provided unqualified opinions on the Centre's accounts.

As part of the appointment of *icipe* to manage its RSIF/PASET program, the World Bank at the end of 2017 undertook an assessment (not audit) of the Centre's finance and control systems. This included an assessment of accounting and budgeting, control systems (including internal audit), financial reporting, banking and funds flow, external audit, and asset management. The assessment found that internal processes and controls were adequate for the management of RSIF, although capacity in certain areas would have to be increased. RSIF, as the name implies, would be based on the management of an investment fund and this would require a fund manager. This was identified as the area of principal risk for the program. *icipe* is planning a significant upgrade in its systems to an Enterprise Resource Planning System (ERP system), which would integrate finance, grants management, human resources, and travel into an integrated, online system. Although such systems come at some risk in achieving such interoperability, the increased demands of the investment fund would justify the planned investment.

d. Results Based Management and M&E systems

In 2010 *icipe* began the development of a results based management (RBM) system with support from donors who contributed core resources. The design of the RBM was based on a “framework (that) will take into consideration existing good practice and lay out an approach that: (i) incorporates measuring results with widely recognised tools; (ii) assesses risk on an ongoing basis; and (iii) incorporates learning into strategies, projects and programs. The *icipe* RBM, adopted in 2011, is an operational framework that explicitly links the strategic objectives and priorities of the Centre to the various programs and projects that it finances so that collectively they help achieve the goals of *icipe*”.¹¹ Each theme developed its own results framework based on key performance objectives. These in turn were evaluated in terms of principal outputs that became the basis for generating strategic outcomes which became the basis of the results being monitored.

RBM systems are designed to provide the dual objectives of learning—that provides the basis for program adaptation—and accountability and thus reporting. There are often trade-offs in these two objectives in the design and implementation of an RBM. A recent evaluation of the practice of RBM within the CGIAR found that “CGIAR lacked a shared conceptual understanding of RBM. At System-level, CGIAR saw RBM mainly in relation to the SRF (the CGIAR level Strategy and Results Framework) and results-based reporting to donors; while Centres and CRPs sought to develop performance management systems for their own purposes, and for complex research programs. As a result, there has been confusion about the purpose of RBM for CGIAR. In addition, insufficient consideration was given to the fact that CGIAR is a research for development organization with a mandate to deliver research results”.¹²

A similar conceptual dissonance characterizes the application of RBM at *icipe*. The Themes use the RBM as a basis to track principal outputs which then provide the basis for reporting. For example, the first objective of the PH Theme is to “Increase horticultural and staple food production by at least 30% by 2020 by reducing pre- and post-harvest quantitative and qualitative losses due to pests”. The output to achieve this objective is defined as “Baseline information on pests’ status, farmer practices and their impacts on ecosystem and livelihoods assessed.” The expected outcome is “At least five ex ante study outcomes utilised by scientists, policy makers and other stakeholders by 2018”. The objective is more aspirational than realistic; the output limited in its ability to contribute to the objective; and the outcome not well defined in relation to the objective. The potential for learning and program adaptation in relation to this objective would be limited.

The RBM currently is used for reporting. It is managed in the Grants Management Unit and is updated through project reporting. It is one of three principal documents that are provided to core donors. This is a necessary function to ensure accountability, but it limits the learning and program adaptation function. Moreover, there is no M&E framework that would provide the necessary data that would link outputs to principal outcomes. As discussed in section II in the SSIA Unit, the focus on developing such an M&E framework should provide the basis for a more detailed RBM system where outputs and outcomes can provide a basis for program learning.

e. Human Resources

Progress in Human Resources management has lagged behind the improvement in other administrative areas until the recent hiring of a Manager of the Unit, who is now leading the development of improved systems in this critical function. Several major challenges are being dealt with simultaneously. The first is to appoint three Theme leaders to fill the positions currently being held in acting capacities. *icipe* Theme leadership requires a relatively unique set of skills, *viz.* setting the strategic direction of the Theme, providing scientific oversight of the Theme’s research portfolio, mobilizing financial resources and managing and mentoring of staff. Academic experience alone does not provide the skill set needed for these positions. Attracting senior scientific positions has been a continuing challenge for *icipe*, although the Center has been successful in recruiting from CGIAR centers. The contract period has recently been extended from 2 to 3 years, which may provide further incentives for senior scientists. Finding a

¹¹ *icipe*’s Results Based Management Framework 2014–2020 (2016). Nairobi, Kenya: *icipe*.

¹² CGIAR-IEA. 2017. Evaluation of Results-Based Management in CGIAR, Final Report. Rome, Italy: Independent Evaluation Arrangement (IEA) of CGIAR.

successful match will take time and an extensive search process. However, the continued success of the Centre depends on adequately filling these positions.

The other initiatives focus on improving employment conditions to make *icipe* a more conducive place to work. Contract period extension from two to three years is being implemented, and for new principal scientists, the creation of an “innovation” fund that supports new scientists in commencing their research without depending initially on sourcing new grants. A review of job classification is also underway. This review is considering options for reducing the administrative burden of scientists, clarity on the roles and responsibilities of positions, and equity in rewards. This is a large task and revolves around how work, responsibilities and remuneration at *icipe* is structured. A key consideration of the review is whether there should be one staff classification, potentially dissolving the current distinction between international and national recruited staff, which by its very being, creates a sense of inequity. At the same time there is a focus on growing staff in the organization. *icipe* has one of the better formulated staff development pipelines as it applies to researchers. Depending on talent and commitment, it is possible for participants in the PhD/ARPPIS program to progress to postdoctoral and visiting scientist programs, and even eventually to senior positions. The difficulty is that maintaining the pipeline of talented young scientists depends on a reliable and continuing funding stream. At this stage *icipe* does not have a strong parallel program to enable outstanding non-research staff to progress through to positions that match their ability. This should be a priority for *icipe* in the coming 5 years.

icipe is making progress in improving gender balance in professional staff. The Centre has a gender policy but its coverage is limited to how gender is integrated or mainstreamed into the R&D carried out by scientific staff. At the moment, it does not cover gender balance in the Centre itself, although there are implicit goals in place on that issue.

One additional note is that human resource management in country offices is managed through a host institution under which *icipe* legally operates in the country; e.g. the MOU between *icipe* and ILRI as it relates to the hosting of the *icipe*-Ethiopia office. This to date is a reasonable model and reduces the necessity of *icipe* having to develop country specific legal arrangements in the operation of its country offices. Should the Centre expand its country offices in Africa in the future, the pros and cons of this model (partnering with a CGIAR Centre) and alternative models will need to be considered.

IV.3. Allocating the resources

In the current environment the allocation of Centre income to R&D priorities is principally determined by donor decisions on grant proposals and the associated budgets. Grant income largely determines the allocation across themes, to partners, and for staff salaries. *icipe* is fortunate in still having a sizable core funding, which besides funding indirect costs of the Centre, allows flexibility in maintaining research programs which have gaps in their funding continuity, and ensuring continuity of staffing. This system introduces both constraints and complexity in planning of longer term research, which is reviewed below.

a. Budgeting

Initial resource allocation is decided through the budgeting process with the budget approved by the GC in their annual meeting in October or November of each year. The budget is adjusted on the basis of additional or reduced grant and core funding over the course of the fiscal year. The budgeting process itself starts in August in which the principal parameters for the budget are defined. The income is based on confirmed grants and core funding. No probabilities are assigned to proposals in the pipeline with a view to including high probability projects into the budget process. Each Theme and Unit head then estimates two budgets for the upcoming year, one based only on existing grants and the other based on existing grants and requests for core funding. These then go into a consolidation process in which the DG and the two Directors balance core requests with availability of core, after setting aside needed expenditures for indirect costs and planned capital expenditures. This consolidation process, which can also have implications on staff retention and appointments, is done within a three year budgeting

framework. Behind this budgeting of core resources is an implicit set of priorities and an assessment in stability in Theme and Unit research programs.

It is noted, at least for the 2016 and 2017 budgets, that there has been a tendency for large differences between the original budget and actual income and expenditure, with the budget being significantly over estimated. It is true that income is not fully known at the finalization of the budget, but it can be argued that an underestimation of income would reflect a more conservative approach to budgeting. Greater accuracy in the budgeting process would allow more effective GC oversight, particularly an understanding of the reason for the discrepancy between budget and actuals.

Overall Centre institutional costs in 2017 were 22% of overall expenditure—excluding overheads recovered (see Table IV.3). This fluctuated between 20% and 23% over the review period. Overhead recovery in 2017, however, amounted to 6% of overall expenditure, which was a slight increase over previous years. This recovery rate compares to an overhead target rate of 15% set by the Centre. This does indicate that overhead recovery lags behind the established overhead rate but is indicative of the Centre’s funding mix as discussed below.

Table IV.3: Principal Areas of Expenditure (US\$ '000's) 2013-2017

	2013	2014	2015	2016	2017
EXPENDITURE					
Research	18,846	25,773	20,460	20,261	18,202
Institutional costs					
Centre Management	1,011	1,299	1,479	1,591	1,508
Administration and Finance	1,295	1,331	1,459	1,074	1,117
Corporate	669	2,795	4,200	746	143
Facilities and Maintenance	1,343	522	767	858	1,061
Field Stations	937	851	849	823	879
Service Units	39	70	73	54	134
Overhead Recovery	-1,000	-1,057	-1,293	-1,022	-1,126
Total	4,294	5,811	7,534	4,124	3,717
Total Expenses	23,141	31,584	27,994	24,385	21,920
Surplus / (Loss)	3,825	860	-724	53	429

Notes - corporate costs include 3,700 reversal of accrued core income in year 2015 and an exchange loss of 1,947 in year 2014

Income and expenditure devoted just to research are presented in Tables IV.4 and IV.5. Partnerships are directly financed out of restricted grant funding and transfers cover the three year period for which data are available. The percentage of the research budget going to partners declined from 17% in 2015 and 2016 to just 10% in 2017. The disbursement to partners had been high in 2015 and 2016 due to two large EU funded projects (EU Bee health and Milk Value Chain) which had greater proportion of piloting and scaling activities and thus required larger inputs from partners. Partnerships in more upstream research are sometimes associated with *icipe* acting as sub-contracted partner to other agencies. However, a number of the new 24 donors funding various projects are now funding upstream research with *icipe* scientists leading-, including NIH, the Swiss National Science Foundation and a number of others. Notwithstanding its dependence on year-to-year variation in project funding, it would be informative and strategically useful to have a target for funding national and regional partners as a measure of downstream scaling and the balance between partner and Centre in implementing such work.

Two other major trends are suggested in Table IV.4. The first is that funding of the support units derives primarily, although not exclusively, from core resources. This is due to the challenge many research units have in aligning and committing relevant skills to Theme-led externally funded research projects, or to develop project ideas of their

own that proceed to funded-projects that would be led by the unit (with or without participation from other parts of *icipe*). How to most appropriately fund the research units into the future will be dependent on the trends in core funding if the current dependence on those sources is to be maintained. This would seem to be a particularly risky approach, and current trends suggest some units are developing their own or taking a lead on projects. The issue is on maintaining flexibility but at the same time achieving cohesiveness and coherence of Themes and Units working together to apply their combined skills and innovation.

The other trend, albeit linked to the previous, is the increasing dependence of research expenditure overall on core funding. In an environment in which core funding was increasing, this would not be an issue, and would be more palatable to core donors who prefer to fund research. However, core funding has been trending downwards while recovery of overhead rates are still very low. The implications of these issues are discussed in more detail below.

Table IV.4: Principal Sources and Allocation of the Research Expenditure (US\$ '000's) 2013-2017

Year	2013	2014	2015	2016	2017
Restricted Research	14,425	18,709	13,704	12,331	12,185
Partner Expenses	n/a	n/a	2,997	2,677	1,514
Overheads	1,000	1,057	1,293	1,022	1,126
Sub-Total	15,425	19,766	17,994	16,030	14,825
Core Support to Research					
Direct Research	736	1,498	1,222	911	1,855
Research Support Units	283	1,037	718	871	725
Sub-Total	1,020	2,535	1,940	1,783	2,580
Total Research Cost	16,445	22,301	19,934	17,812	17,405
Infrastructure	2,401	3,472	531	2,450	798
Total	18,846	25,773	20,465	20,262	18,203

As shown in Table IV.5 there are significant differences in the funding across themes. Plant Health Theme has consistently maintained the highest level of funding. There could be several reasons for this, including the evolution of push-pull to impact on an increasing number of constraints, the funding of *icipe* by donors with priorities for agricultural programs, and the relative importance of plant health in the African context. Environmental Health Theme has remained well funded over the period but has been dependent on one or two large donors. There is significant volatility in the funding to both animal and human health research and as a result continuity of research has depended in part on core funding.

Vector management is an important, but in many ways, complementary approach to the more main line focus on vaccines and drug treatment. Moreover, animal health is only one among several principal constraints on animal production systems. The Animal Health Theme's research portfolio has had a relatively narrow focus and presents opportunities to expand the application of its expertise to animal health challenges outside its current portfolio of disease, pests and geography. Maintaining sustainable Animal and Human Health Themes will depend on both Themes being alert to new opportunities and being willing to direct their considerable resources accordingly. The recently completed review process of the Animal Health Theme and that being planned for Human Health should help bolster their strategic thinking around various research portfolios and partnership opportunities in responding to emerging issues.

Table IV.5: Expenditure of the Research Budget by Theme, 2013-2017

THEME: US\$'000'	2013	2014	2015	2016	2017
Animal Health	1,278	1,770	2,119	3,004	1,901
Plant Health	7,099	8,029	7,527	6,281	6,250
Human Health	2,778	3,027	2,746	1,588	1,529
Environmental Health	3,479	6,270	4,733	4,336	4,803
Capacity Building	1,529	1,814	1,961	1,309	1,369
Bio-Innovate	-	-	-	69	523
Research	16,162	20,909	19,086	16,587	16,375
RSU	283	1,392	848	1,224	1,031
Infrastructure	2,401	3,472	531	2,450	798
TOTAL	18,846	25,773	20,465	20,262	18,204

b. Implementing the *icipe* strategy through project-based funding

Like other similar research institutes, *icipe* requires a consistent supply of long-term funding. That is difficult to achieve with the Centre's large proportion of direct project funding in the total funding envelope. In the example of the high profile push-pull technology as it applied to maize cropping, the long-term research commitment and the outstanding impacts were achieved by attracting a succession of funders at different stages in its evolution and development. However, this sort of succession of different donors supporting the development of a single research pathway is usually difficult to achieve. *icipe* has been successful over the period in maintaining the integrity of its research programs with project based funding and for supporting occasional breaks in direct funding of larger scale research initiatives by the strategic use of core funding. This is likely to become more and more challenging as *icipe's* research direction or priorities respond to emerging issues, fluctuations in core funding continue to be the norm, and there is a move by *icipe* and by donors towards more impact oriented research. Maintaining its research programs is clearly a high priority for the Centre but to do so it must continue to both search for new sources of core and projects funding and manage allocation of core as strategically as possible.

Increasing demands on *icipe's* core funding that is at best, stable, highlights its critical function in research continuity. Any move to greater dependence on project based funding would require a move toward full cost accounting. The issue of full cost recovery was identified as a growing challenge in the 2016 annual meeting of the GC. There is an inbuilt "contribution" provided by core funding to those projects that do not cover all direct and indirect costs associated with that project. Achieving full cost recovery is made difficult by ceilings placed on the proportion of project funds that can be allocated against overheads by many, if not most donors. Some flexibility is required to balance donor ceilings on overheads and what items and resources are allocated as direct versus indirect costs. The Centre can only attribute costs allowable by donors, but there is usually scope for some negotiation and latitude in what constitutes direct costs. As discussed at the GC meeting, full cost accounting also requires a change in institutional culture. It particularly has implications for coverage of staff salaries and decisions on positions that do not have consistently high allocations to externally funded projects. The risk inherent in even a continuation of the current levels of core funding demand a new negotiated position on how donors fund *icipe's* programmes in order to enable improvement in overhead recovery and further implementation of full cost accounting. Implementation of full cost recovery has introduced a range of challenges and is being done in a step-wise approach using a well-planned implementation framework over the next 3-5 years. This is to avoid such changes suddenly being forced upon the Centre due to adverse financial circumstances.

c. Project development

The development of the portfolio of project grants brings together three principal dimensions; *viz*, the size of the projects, the degree of collaboration within *icipe* and with potential external partners as opposed to internal and external competition, and the balance of upstream research versus impact oriented R&D—the latter which has been discussed previously. Larger projects are more efficient in terms of the associated administrative costs, but small grants support fellowships and postdoctoral fellows, provide venture capital to test new ideas that are too risky to justify in larger investments, and support rapid research responses to new pests and diseases, e.g. stunt disease in Napier grass. Small grants have their roles especially in extending research boundaries, but they come at a cost and must be used strategically. Balancing the portfolio of projects, especially to ensure that *icipe* is not overwhelmed by small, high demand, low efficiency projects, is critical and is probably a key role of the internal Science Committee.

The Grants Management Unit performs a heroic task of managing 80 to 100 projects using rudimentary tools (Excel spreadsheets) although moving to ERP. The unit manages a range of aspects of every project from the signing off to scheduled reporting. Coordinating reporting from over-stretched principal investigators is a major challenge, especially when about 50 percent of all projects are small grants. While there is the potential for real improvements in efficiency with the planned development of the ERP system, most of those improvements will be related to financial reporting. Technical reporting will remain the task of principal investigators and other senior scientists.

The move to full cost accounting has the potential to increase competitiveness between themes and units as they strive to ensure that they have a high proportion of costs externally supported. The increased competitiveness may tend to lessen collaboration between themes and units which may impact such key Centre level issues as the need to incorporate research units in proposals, collaboration and systems research within the 4-H framework, and in the development and deployment of the TT Unit. Larger projects, however, provide a platform for such cooperation. Managing this balance in the context of competition for project funding and the imperative for collaborative research is in part a function of the openness and transparency within the culture of the Centre and an aspect of the culture which senior management should be monitoring.

d. Investing for the future

In many ways the most difficult challenge arising from full cost accounting is in building new capability. It is for this reason that the strategic use of core funding for new priority skills is so valuable. There are a range of disciplines which, if able to attract new appointments, would significantly strengthen *icipe*'s core skills and enable it to be more competitive in winning grants. A move into developing early warning and response systems for invasive species will require new capacities in epidemiology and modelling. If the TT Unit is to develop as an organizing locus for scaling IPM and IVM methods, it too will require the requisite new skills. The expansion of push-pull technology into southern and West Africa may also necessitate that *icipe* develop relevant country or regional offices where a viable field capacity would enable the Centre to compete much more effectively for projects in those regions and deliver impacts more strongly. An initiative for having *icipe*'s own staff based more widely would also be a positive response to most bilateral donors and foundations wanting to see country-specific outcomes in response to their R&D investment. An example would be the recent funding of a plant disease surveillance system in Nigeria by the Gates Foundation. Bringing on board new capability requires attracting the right personnel, possibly capital expenditures, and in most cases, initial research investment to establish credibility. These are significant investments and thus will require strategic use of core funds.

IV.4. Governance

The Governing Council (GC) is entrusted with the legal authority for *icipe* and undertakes the governance function for the Centre. This review of the GC is based on accepted good practice on board governance, an assessment of the rules of procedure of the GC, and a review of the minutes of the GC since 2014. The discussion below identifies areas where the GC might review its current practice to improve both efficiency and effective board practice.

a. GC membership and rotation

Membership in the GC is governed by the Charter which provided international legal status to *icipe*. According to the Charter the GC consists of 15 members plus the Director General as an ex-officio member. Membership in the GC is drawn as follows: (a) Two members drawn from the host country; (b) Eight members drawn from the Sponsoring Group of *icipe* (core donor countries); and (c) Five members drawn from Academies of Sciences as determined by the GC, bearing in mind the principle of equitable geographical representation of all the major regions of the world. This results in a representational board reflecting principal stakeholders, namely host country, donor countries, and the science establishment.

The Charter was ratified in 1970 and has not been amended since that time, primarily because there is no provision for amendment in the Charter. Many of the suggestions for improved GC function in this section would require an amendment to the Charter, which would in turn require a provision for amendment in said Charter. The IPER suggests that with appropriate legal advice, the GC consider adding such a provision on amendment to the Charter, where the power to amend is vested with the GC. For all international centers known to the IPER, this is normal practice. Such a change to the Charter can only be done by agreement with the original signatories to the Charter.

By CGIAR standards the GC with 15 members is a large board. In 1970 the board membership as set out in the Charter was a fair reflection of the four, original international Centres at that time. However, board membership in these centres has changed significantly since then, often requiring amendment to the Charter. For efficiency reasons the GC should consider both the number, representation, and skill sets that should constitute a governing board in the current era, with the understanding as noted above that this would require an amendment to the Charter.

Donors are represented on the GC principally through university scientists with strong links to particular donor agencies. This interpretation of the charter allows some flexibility in maintaining a balance of skills on the Council, but even more flexibility would be provided with some key change to the Charter. Global scientific representation does not appear necessary given *icipe*'s mandate is focused on Africa although such a change should not preclude drawing scientific talent from anywhere in the world. Talent in the area of audit and finance, the private sector, and resource mobilization come primarily from institutions outside the set in the Charter. It should be noted that the trend in other similar boards has been to always have two members with expertise in the audit and finance area. A further change should aim to expand the geographic representation on the board, i.e., having two members from Kenya in a reduced board size would seem excessive. A reduced size should make the board meetings more efficient as well as reducing cost. Eliminating categories would enhance flexibility in board selection, focus selection on skill sets need on the GC, and expand access to board talent.

To ensure that the GC renews itself and brings on new talent, at the same time as assessing the effectiveness of current GC members, tenure should be strictly limited to two terms and there should be an assessment of member effectiveness at the end of the first term which would determine whether the member is appointed for a second term. Several current members have served third and fourth terms and no member has not been nominated for a second term.

b. Conflict of interest

Ensuring that potential conflict of interest is effectively managed is essential in avoiding conflicted decision making by the GC. This is particularly important in the area of financial matters but also applies when GC members have links with other organizations that may have relationships with *icipe* or being paid for certain services offered to the Centre. The rules of procedure outline a very narrow definition of conflict of interest, focusing only on financial matters and such matters not well defined.¹³ GC members may have other interests, as for example, by serving on other boards, which may in certain issues present a conflict of interest. The key term here is “managed”,

¹³ The rules of procedure state that GC members “shall have no pecuniary or financial interest in any aspect of the *icipe*'s activities and stakeholders shall so declare in the first meeting of the year.” There is no definition of what constitutes a financial interest, as for example do donor representatives have a financial interest? In such case no financial interest might be too limiting.

namely in the Chair's management of potential conflict of interest in the GC's deliberations. However, there are no set processes for defining and declaring potential conflicts of interest that would enable the Chair to be more proactive in avoiding conflicted decision making. It is advised that a more formal conflict of interest procedure be implemented in the GC meetings.

c. Secretariat/Secretary

In governing board best practice, the board secretary serves an important role in taking responsibility for the minutes, the development of the agenda, the board papers, logistics, and support to the Chair in the management of the meeting. Most importantly, the secretary serves as a bridge between the Board Chair and the Director General. This can be a particularly important role when there are differences of view or opinion between the two. In such cases, the secretary can provide both a communications link and a mediating role. A board secretary should have a historical knowledge of the Centre, provide continuity in the succession of board chairs and provide an independent support to the Chair in the execution of the governance function.

However, in the particular case of the secretary to *icipe's* chair of the GC, this role is vested by the charter in the Director General. This provision in the charter obviously does not provide the necessary separation between the management function of the Director General and the governance function of the GC and thus generates a potential conflict of interest in the execution of the role of secretary to the GC. Given the very good working relationship between the DG and the GC, this arrangement has not presented any problems over the review period between management and the GC. However, in respect that this might not always be the case into the future, some consideration should be given by the GC to the position of secretary to the GC.

d. Finance and budgeting

In a review of the GC minutes over the review period, there is an apparent imbalance in GC capacity between programme and audit and finance, in large part due to the charter restrictions on GC membership. At the same time there is an over dependence on the audit function to fulfill fiduciary responsibility, without similar attention given to budget and finance. Moreover, good board practice argues for a separation of the finance and audit functions as two committees. Given the size of the GC this could be possible but would be constrained by the necessary expertise on the GC (see section IV.4.a above). Although not suggesting two committees, the IPER team would argue that a more structured approach to annual approval of the budget and response to budget would improve the effectiveness of the GC. This could include the relation between budget and impacts on programme or strategic investments, but particularly clearer oversight in years of a budget deficit and a potential drawing down of reserves, as occurred in 2015.

e. Oversight of science quality

Science quality is one of the more difficult areas to monitor in a manner that provides assurance across project, thematic and Centre levels. Oversight is vested in a Programme Committee of the GC for which all of the GC are members. This function of the GC is well designed and has a range of different levels of review and assessment. Each meeting of the GC has a Programme Committee session organized around presentation by the 4-H Themes each year. A relatively new science quality oversight initiative is to have an external review of the science of individual Themes undertaken by three experts from disciplines relevant to that theme. The first of these reviews was undertaken in 2017 and provided a rigorous assessment of the science in the Animal Health Theme. This is complemented by periodic development of strategies for disciplines and program thrusts which are considered by the Programme Committee to have come to a transition point, as was recently completed for Bee Health. All of this provides input to both senior management and the GC for the ongoing assessment of the science in the Centre. Moreover, it provides much of the basis for the science assessment of this IPER panel and for future panels. The structure and execution of GC oversight of the science at *icipe* is considered by this panel to be excellent and helps in maintaining the high standard of science in the Centre.

V. Recommendations

The review team is of the view that only a small number of what it considers the most critical recommendations should be highlighted in this section and that each of those recommendations need to be specific. Nevertheless, *icipe* should consider the “second-level” recommendations, which are not included below, but are stated throughout the document.

The review team has considered the issue of Centre programmatic structure but not made a particular recommendation as it does not meet the criteria of being “specific” and are of the view that the best timing of such a restructure is some years hence. Nevertheless, the review team considers the current structure of four Themes, Capacity Building and Institutional Development (CBID) Programme and the nine variously independent Units warrants consideration, particularly in terms of efficiency criteria and ability to integrate across so many organizational boundaries. The Themes operate independently, drawing on capacities in the research units as required or to the extent that project budgets allow. The Units, on the other hand, vary in their independence from Themes and/or the ability to support all themes or only some themes, their size, the degree of providing service functions vs developing their own research agenda, and their potential to independently attract external funding. The evolution of the research units was in many respects to avoid duplication in similar capacities in each of the Themes, as for example, is the case in the creation of the Technology Transfer (TT) Unit. The Themes in general integrate across units in project design but often excluding some units due to budget limitations and expertise required to accomplish specific tasks. Given the competition for funding, this leads to some units developing their own research projects and/or some units primarily providing support to a particular Theme. This is all manageable to some degree but is it optimal? It would appear that units that already provide or will provide “services” across multiple Themes in the future (e.g. TT Unit) might need to sit outside the Themes, perhaps as a new “Core Resource Theme” but others which are carrying out their own research agendas (and have greater degrees of independence) might be better placed within Theme structures provided such moves don’t blunt their performance as demonstrated hubs of innovation and new ideas. The review team considers that *icipe* should consider a revised structure over the next 5 years. This timeframe is suggested because, by then, the emerging and critical units, TT and SSIA, will be more mature and have better defined roles and capabilities, *icipe* will have made considerable progress towards a wider geographical role across SSA, and the goal of stronger one-health portfolio of research will be more advanced.

A second “less specific” issue, and one that is tied to organisational structure is that of management team membership. At present only one Theme Leader sits on the Senior Management Committee (SMC) (in this case that Theme Leader is the only one confirmed in a Theme Leader position, although rotational) but as the Theme Leaders collectively have critical strategic, operational and administrative roles in the Centre, there is a strong case that they should all be participants in the highest level of Centre management. Not having all Theme Leaders as members of the SMC reduces its value in deciding the future and supporting the Centre’s team building and communication efforts. This also would help to take some work pressure off of the three directors, who all carry heavy work responsibilities. This also could be ameliorated by the hiring of a senior administrator to take on some of the administrative duties. The review team is of the view that *icipe*’s Senior Management Committee membership should be considered in parallel with organisational structure and over a similar time frame.

The specific recommendations are:

1. One Health as an Integrating Paradigm

The aspiration by *icipe* to build a stronger One Health systems approach to its research is fully supported by this review as it was in the previous IPER. Since 2013 the *icipe* research portfolio has established several examples of projects which draw skills from across disciplines and aim to deliver benefits across multiple “health” themes but more needs to be done before *icipe* can be satisfied that the One Health paradigm is perceived as being fully established within the Centre. A problem framework that integrates across themes is needed to move this forward. There is experience outside *icipe* with zoonotic disease in integrating human, animal and environmental

health. The review suggests at several points the potential of invasive species as such a problem framework. As a way of furthering the establishment of the One Health paradigm within the Centre, *icipe* should put in place a range of processes/practices and incentives that encourage projects to take a stronger systems approach in their design. Those processes/practices might include strengthening the role of the Science Committee to initiate design of One Health systems projects which are more inclusive across the Themes, set targets for the number of One Health projects, deploy critical skills into such projects and progress towards one-health research by building internal modelling capability that supports design and analysis of system interactions. Globally, funding for the One Health concept remains a challenge as the donor communities continue to preferentially fund through individual sector programmes. The IPER team recognizes that this can be a major obstacle to fully realize the benefits of implementing the One Health systems approach while fully endorsing *icipe*'s commitment to system-wide research.

2. Strategic Capacity Needs within an Evolving *icipe*

icipe has an impressive management team and range of research and technical staff and skills delivering into all Themes and has made significant progress in attracting highly qualified professionals in science, management, administration and science service units over the past five years. These include: the Director General, Director of Finance and Administration, Director of Research and Partnerships, Head of Capacity Building and Institutional Development, Head of Human Resources, Head of Facilities and Asset Management, Head of Catering and Guest Houses, Head of Security, Resource Mobilization Coordinator, Head of Finance, Head of Social Science and Impact Assessment, Head of Technology Transfer, Head of Ethiopia Country Office, Procurement Manager, Internal Auditor, Station Management Coordinator at Mbita, Coordinator YESH project, BioInnovate Africa Program Manager, Bee Health Senior Scientist, Gender Specialist, Monitoring & Evaluation Specialists, various mid-career scientists, several seconded scientists and visiting scientists, and various technical and administration support staff among others.

In addition, *icipe* has made major efforts and progress in attracting visiting scientists and secondments with long-term agreements with Institut de Recherche pour le Development (IRD), Centre de Cooperation Internationale en Recherche Agronomique pour le Development (CIRAD), the University of New Zealand, the University of Glasgow, and CIM Program of Germany who base their scientists at *icipe* where they are fully integrated within *icipe*'s various programmes. *icipe* Management is also currently drafting agreements and terms of references for new Adjunct Scientist arrangements with key individuals globally.

However, some critical high-level positions remain vacant and there are a number of new science and administrative positions that should be prioritised. Appointments to the Plant Health, Human Health and Environmental Health theme leader positions to round out the full complement of senior leadership positions are considered to be most critical for both the strategic and operational effectiveness of the institute. (NB. an offer was made for the Plant Health Theme leader and the Environmental Health Theme positions in the months after the review).

As noted previously, the highest tier of leadership in *icipe* is quite narrowly defined, consisting of the DG and two Directors; Director of Research and Partnerships, and Director of Finance and Administration. This narrow leadership team is probably commensurate with the size of the Centre, but the breadth of functions carried out by this small team puts extreme pressure on their time. At least one, and possibly two new senior executive officers' positions to lead the implementation of senior leadership decisions would go some ways in releasing senior management to pursue its higher level functions and further improve the effectiveness of management and administration.

The review team identified three areas of science where priority appointments are necessary. While *icipe* already has modelling skills in the GI research unit and within its Themes, it would benefit from stronger modeling capability that would assist to conceptualize, engineer and develop a modelling framework to enable *icipe* to fully explore and benefit from the one-health concept. This will be particularly important in epidemiology and early warning systems.

The primary focus of the SSIA Unit since its establishment has, appropriately, been oriented towards agricultural

economics which supports the key areas of impact evaluation and Monitoring and Evaluation. The review team considers that expansion of the unit with new skills in sociology and/or anthropology would be timely to support *icipe* to develop its research on how best to piloting IPM and IVM programs, gain wider community adoption of its technologies, and scale management intensive technologies.

Data analysis is a critical discipline in a research institute as large as *icipe*, with its range of disciplines, especially with its consistently large number of PhD students and the associated wealth of data being generated each and every year. The current Biostatistics Unit is under-resourced, especially if meta-analysis of large datasets is to be undertaken. Lack of recognised professionals in this discipline might even represent a reputational risk to the Centre, especially given that human health and disease prevention is a key area of research. Strengthening of the biometrics function should be a priority, particularly as this will be a priority of the World Bank's RSIF fund.

3. Data Management

icipe has developed outstanding information management in terms of its journal, the digitization of its library, its institutional documents including partner agreements, its web page, and improvements in processing submitted papers to its journal. The Centre already complies with the growing requirements of many mainstream journals (e.g. PLOS family) that authors make their data available to other academic researchers who wish to replicate, re-analyse, or build upon the findings published in their journals. These data are often submitted as publicly accessible supplementary files, or a Data Availability Statement that indicates where data supporting the results published are available, with hyperlinks to relevant datasets. Where appropriate, clinical trials and Randomised Control Trials are archived in repositories such as Clinicaltrials.gov (*Pyronaridine plus artesunate for treating uncomplicated Plasmodium falciparum malaria* (<https://clinicaltrials.gov/ct2/show/NCT02411994>), and the trial register (Solaral: Solar energy for malaria elimination; <http://www.trialregister.nl/trialreg/admin/rctview.asp?TC=3496>). All researchers at *icipe* deposit sequence and genomic data in the central genome databases, most often via GenBank, and specialized databases such as VectorBase (vectorbase.org), the repository for genomic data for vectors of human disease.

These actions go some way in meeting the growing expectation from the wider research community and donors that data be securely held and over time moved into the public domain where it is available to other research teams. However, more needs to be done, especially in disciplines outside genetic, human health and the social sciences which have tended to lead the way in ensuring data retention and availability.

icipe is already working towards providing an appropriate centralized repository for all data collected and a draft Data Management Policy has been prepared. Such a policy is particularly important in a Centre such as *icipe* that has large numbers of Masters and PhD students and where, because of its research history, large datasets which have been assembled over long periods that are likely to prove of particular value in developing new research insights via meta-analysis.

Currently, normal practice at *icipe* is that data sets are kept by individual scientists, often in excel files, and when the scientist leaves—more so for PhD students—the data are transferred to supervisors. For a research Centre in the era of Big Data, it is essential that primary data are archived regularly and in a consistent manner across the Centre to prevent its loss for future research, particularly given the speed of global change. *icipe* should, as a matter of urgency, finalise and implement a Data Management Policy that will ensure mechanisms are put in place for centralized archiving and backup of data sets that are well labelled and described, that clear protocols under which those data sets might be accessed by other researchers are clearly defined, and that appropriate resources are assigned to implement the policy.

4. Pathways to Impact

icipe research and development agenda encompasses basic research orientated towards new knowledge, the development and testing of new products, innovative on-farm and community practices and policy to control disease and pests, through to activities that are focused on development and scaling out a range of technologies. It is important that *icipe* continue to deliver across the R&D spectrum and continue to do this through its impressive and diverse range of partners from the private and public sectors. *icipe* recognises that these partners are crucial to maintaining the quality of its science and to securing widespread adoption be it adoption of multi-faceted pest and disease management practices or its research and development programmes focussed on women and youth.

While recognizing *icipe*'s central role in scaling out its technologies, it should at the same time be striving to continually improve the balance of roles that *icipe* and its partners might play. This is particularly relevant in responding to the ever growing capability and capacity of its African partners: In response to this changing environment, *icipe* should:

- a. Ensure that it builds pathways to impact that specifically include building capacity of development partners. This will enable it to free up its research capability to address emerging constraints to agriculture, livestock, environment and human health. There is an evolving research agenda in the "science of scaling," which could be integrated into joint work between the SSIA and TT Units, and BioInnovate Africa Programme.
- b. Put even more emphasis on developing innovative impact pathways and, as much as possible, ensure that these pathways are well resourced in terms of *icipe* role, the role of relevant partners and funding. This greater emphasis will ensure that *icipe*'s three recent initiatives to overcome barriers to adoption, viz., the inclusion of a TT Unit, the Bioinnovate Africa Programme, and a growing SSIA Unit have a stronger framework for working together with research Themes to design and pilot the best options for impact.

5. Operational Modality to Cover the African Mandate Area

icipe's mandate area is sub Saharan Africa, which presents challenges in terms of the heterogeneity across the continent and opportunities given the demand for effective IPM and IVM control strategies. The Centre currently has activities in 40 African countries but the modality of cooperation varies significantly between East Africa and the rest of the continent. As might be expected in East Africa, there is a primary locus of activity in Kenya, where *icipe* has its headquarters and carries out most of its strategic and applied research. In addition, it has country offices in Uganda, Somalia, and most recently Ethiopia. Just about all donors currently have country priorities, and Ethiopia has been a focus for a significant number of donors. The Ethiopia country office has allowed *icipe* to integrate into both country level priorities of donors as well as into national ministries and agencies. The Ethiopia country office thus functions as more than an implementing capacity for projects developed at headquarters but rather as a multi task unit that gives the Centre operational field capacity, ability to interact within a complicated national institutional framework, and the intelligence on donor funding possibilities.

The operational modality in West and Southern Africa, on the other hand, relies on institutional partnerships, often through ties with former PhD students, in project implementation. Because of the project dependence, these are often relatively short term in nature and limit the visibility of *icipe* in the country. The Centre has a range of technologies and methods that would have potential for impact in these countries, a prime example being the current scaling of push-pull in both West and Southern Africa. The fall army worm offers another opportunity, where *icipe* could potentially lead the development of a surveillance and rapid response capability on this new challenge and other invasive species. However, the ability to take these roles would depend on longer term institutional ties, some operational capacity in the country or region, and the ability to mobilize resources, similar to those of Ethiopia country office. Much donor funding flows through donor country offices but to access those funds requires a visible operational presence in the country or region. The IPER team feels that *icipe* is now at the point that it would be advantageous to extend the operational modality of country, or more appropriately regional, offices in West and Southern Africa, potentially building on the experience with push-pull in those regions. To do so will require an upfront strategic investment from core resources.

6. Capacity Building, Institutional Development, and Expanded Outreach

icipe has a long and enviable record in Capacity Building with about 100 post-graduate students embedded in the research Themes and research Units at any one time. The quality of the students and the training they receive is evidenced by their publication record. There is an opportunity to use the success of the CBID Programme to support institutional development in an expanded outreach strategy into West and Southern Africa, as discussed in Recommendation 5. This would entail building capability in selected core centres in those regions, what has been termed centres of excellence. It is recommended that 15-25% of the postgraduate intake in each year be quarantined for students from those selected core partner institutes so that over time, these graduates will significantly build the capacity of the Partnering Institutes. This will require funding which targets capacity building in those regions-- often difficult given that donors have specific country priorities-- and may be linked to *icipe*'s involvement in the World Bank's PASET program.

7. Ensuring Financial Sustainability

As with any international organization, *icipe* is dependent on donor funding to finance its operations. The Centre is fortunate in having a financing model that combines strategic unrestricted funding with restricted project funding. Core funding has had an important positive impact on the Centre in its support of long term research and has provided a funding mix that supports sustainability and ability to deliver on its strategy. Core resources fund the direct overhead costs of the Centre, primarily administrative and maintenance costs, much of capital improvement, strategic investments in new capacity, and program budgets that do not have sufficient project funding. Over the review period the Centre has witnessed a plateauing and gradual decline in core funding, an inability to meet overhead rates from project funding, and an increasing demand on core resources from programs. It is too short a period to say whether these are structural trends, but forward planning is essential to ensure that these three areas remain in balance.

Three options suggest themselves to maintain this financial balance. The intention is to avoid the third option, which is to cut important program capacities that do not have sufficient project or core funding to support them (although the Centre should not hesitate to reduce those skills which are unlikely to be required in the medium to long term). If the third option is the least preferable, then financial balance would then require some combination of increasing the number and quantum from core donors and improving cost recovery from the grant portfolio with the eventual objective of achieving full cost accounting. Both these preferred strategies have their own challenges but the IPER team's rather probabilistic assessment is that any medium-term growth in *icipe* will primarily come from restricted funding and that this would argue for further movement—acknowledging that the Centre already is moving in that direction— to increased cost recovery and eventually full cost accounting. To do the latter will require negotiation with donors and shifting from indirect to direct costs in budget development, as well as a significant internal shift in incentives and organizational culture.

VI. Conclusions

icipe is successfully playing crucial roles in tackling a wide range of human, animal, plant and environmental health challenges of SSA while at the same time, focusing some of its skill and innovation to provide opportunities for communities, especially women and youth, to establish small and medium enterprises on which they can build real change in livelihoods. *icipe*'s Capacity Building and Institutional Development Programme is arguably unmatched in Africa in terms of the numbers of scientists trained and the quality of the training they receive. *icipe*'s management is sound, its team of the Director General and two Directors outstanding and over the last 5 years there has been significant improvements in administrative processes, financial management, communication and visibility.

Nevertheless, there are a number of major challenges to *icipe*'s future. Attracting financial support for research is a major challenge for most national and international institutes and *icipe* is no different. However, the review team considers that addressing some other issues are urgent and that resolving these will go a long way towards underpinning financial stability and growth. As outlined throughout the review report, the reviewers consider the most important challenges are reinforcing the leadership team with high quality appointments to the vacant Theme Leaders positions, broadening its geographic influence, building on its record of delivering on-the-ground impact and continuing its program of improvement of administrative processes.

Annex 1

IPER Background and Terms of Reference



2018 External Review of *icipe's* R & D, Capacity Building and Management Programs Background and Terms of Reference

Background

Established in 1970, the International Centre of Insect Physiology and Ecology (*icipe*) is an intergovernmental, not-for profit research organization, with a mission to alleviate poverty by ensuring food security, improving health, protecting the environment and building the capacity of researchers and communities across the developing world, through the application of insect sciences. Employing more than 500 staff, *icipe* is headquartered in Nairobi (Duduville campus), Kenya with outposts in Ethiopia, Uganda and on the shores of Lake Victoria in western Kenya (*icipe*-Thomas Odhiambo Campus-ITOC). *icipe* has a proud reputation and history of delivering world-quality science that has made crucial contributions to African food and health policies, delivered development outcomes to rural communities, and has been at the forefront of building Africa's biophysical and socioeconomic research capacity. The Centre's research activities span the African continent with partnerships linking research organisations, universities, the private sector, national programs, NGOs and government organizations not only across Africa, but around the globe. *icipe's* programmes are delivered via four research themes – Animal Health, Human Health, Environment Health, Plant Health as well as a Capacity Building and Institutional Development unit and several other technical units.

icipe considers the regular external and internal monitoring and evaluation of its performance an important activity to regulate both the quality of its research and development and continued relevance to ensure compliance to its mandate and mission. Thus, the Centre undergoes numerous reviews to assess its institutional performance and output. This includes (i) research projects, which have their own mechanisms of review and planning, based on agreements with funding partners, and with close participation of the stakeholders, (ii) through its Sustainable Research Evaluation Systems (SRES) instituted by the Governing Council (GC) it assesses the scientific quality, translation of results into impact, human resources, partnerships, infrastructure, and capacity development of all scientific units to ensure that the scientific level of research remains at an internationally acceptable level and (iii) *icipe* Periodic External Review (IPER) that broadly evaluates institutional mandate and programmatic activities to ensure it meets the development needs of *icipe's* beneficiary constituency by reducing poverty, improving health, food security and their wellbeing. These reviews are not independent of each other and at the higher-level bullets (i) and (ii) can feed into bullet (iii). Through these periodic monitoring and evaluation exercises, *icipe's* activities and operations are prioritized and refocused to meet the needs of the beneficiary communities as well as the larger constituency.

From an institutional standpoint, both the GC and the Sponsoring Group of *icipe* (SGI – an *icipe* Charter based group of representatives of the subscribers of the Charter with a supportive responsibility for financing the Centre) have important roles to play in this vital exercise.

I. Historical Perspective and Modus Operandi to the Review

Since 1983, the GC commissioned with the support of the SGI the IPER, as an instrument to undertake the review of scientific programmes and the administrative and financial management of the centre. The reviews are carried out every 5 or 6 years - the last one covering 2008-2012 was undertaken in January/February 2013, the final report of which is available at www.icipe.org. Prior to this, the review covering 2002-2007 was conducted during the first half of 2007. The 2008-2012 review was a Centre-wide assessment, including R4D, capacity and institutional development, management, internal organisation, administration, policies and partnerships of the Centre. However, the 2007 review focussed exclusively on the programmatic and strategic issues, in particular, research and capacity building agenda.

The Management develops, the Executive Board approves and the GC endorses the terms of reference of the review, the review team and the review process. The review team is composed of a multidisciplinary group of experts knowledgeable not only in their respective disciplines, but also in the global research agenda on agriculture, human health and the environment and are also conversant with general developmental issues including management and resource mobilization.

The reviewers undertake a study of relevant documentation, and carry out an assessment of on-going R&D activities and programmes and visit of *icipe*'s field sites and stations. The review mission also consults with partners and collaborators. The review period varies from two to three weeks culminating in the preparation of a detailed report and key recommendations. The senior management team of *icipe* is usually given the opportunity to comment on the report and recommendations prior to submission to the GC. The outcome of these reviews also covers recommendations on policy guidelines that facilitate the development of vision and strategic documents as well as mid-term plans with clear-cut schedules for implementation.

II. Terms of Reference for the Institutional Review

a) **Why an Institutional Review?**

icipe's vision and strategy 2013-2020 outlines steps to be taken to provide, through insect science and capacity building, the much-needed solutions for food and nutrition security, good health, improved livelihoods, and sustainable use of natural resources for the people of tropical Africa. The strategy is based on the Centre's '4-H' themes of Human, Animal, Plant and Environmental Health, using a variety of scientific tools, approaches and disciplines, in collaboration with R&D partners as well as institutions of higher learning.

The vision and strategy is conscious of the very dynamic global environment that *icipe* operates in. The strategy recognises that *icipe* has made crucial contributions to African food and health policy by delivering development outcomes to rural economies and remain at the fore-front of building research capacity in insect science. Recent external reviews recognised the quality of *icipe* research, innovations and excellent capacity building credentials. The vision and strategy document also highlights various challenges and opportunities and how the Centre will respond and simultaneously deliver on-the-ground impact including developing solutions that are both systemic and sustainable by integrating key research components among the themes towards the concept of one health, improving and expanding adoption of technologies from its flagships projects, establish new programmatic areas (e.g. insect for food and feed, endosymbiotic research), and units (social science and impact assessment, technology transfer), and creating new partnerships with a broader set of respected and like-minded research institutes to ensure its science remain competitive.

A review of the institution's programmatic and institutional agenda is therefore timely to evaluate how *icipe* is re-positioning itself to meet the new challenges and opportunities. Most importantly, IPER should be able to establish how programme agenda is in tune with the institutional mandate and to what extent it meets the development needs of its beneficiary constituency through the co-creation of knowledge-based solutions, building capacity of individual researchers and institutions in Africa, contributing to policy development and ultimately, reducing the impact of arthropod pests and vectors and enhancing the role of beneficial insects, both of which have direct bearing on poverty, health, food security and well-being. The review will also serve as the benchmarking function, taking stock of what has been achieved during the reporting period and enabling a more realistic realignment of programme priorities and implementation plans for the next 5-7 years.

The programme and institutional review will be conducted three Reviewers. Much of the Review will be completed as a desk exercise, with essential team meetings for: the allocation of responsibilities; visits to *icipe* headquarters and selected *icipe* field sites; discussions with *icipe* stakeholders, partners and beneficiaries; and in the writing of the final report.

b) **Strategic and institutional issues to be considered by the review:**

Based on material provided by the Centre, the team will review impact of *icipe*'s research and capacity building programmes. Then, following consultation with the Centre's stakeholders, and recognising the fundamental comparative advantage of an international centre in being able to work across country borders, and at the same time acknowledging the constraint of resources, the team will examine the trade-offs across strategic dimensions and offer recommendations for the future research planning of its programmes as well as the institutional requirements for doing so. An important consideration in the analysis will be to show how effective *icipe*'s historical perspective and unique evolution as an African institution and its institutional commitment in pursuing a development agenda for the benefit of Africa's poor has been useful in driving and sustaining its research agenda.

The following are the key pointers to the review:

Vision, strategy and priorities

- i. Success in operationalizing the Vision and Strategy 2013-2020 and the continuing relevance of the proposed challenges and opportunities in the light of emerging global issues since the previous review (i.e. the period 2007-2012)
- ii. Policies, strategic direction and priorities of the Centre and coherence with its mandate
- iii. Creation of new strategic partnerships and linkages and their role in the implementation of Centre's vision and strategy

Accomplishment, quality, relevance and impact

- iv. Recent accomplishments of the Centre in its R4D and training of its constituency
- v. Impact of the Centre's work in meeting national and regional development priorities of its African constituency since the last external review (i.e. the period 2007-2012)
- vi. Innovative programme design, planning, priority setting, science quality management (e.g. peer review, committees) and strengthening research infrastructure to deliver on the institutional mandate
- vii. Rising to the challenges of emerging opportunities and threats

Effectiveness and efficiency of management

- viii. Assessing the present and future capabilities of the Centre's Management and Administration structure, and policies in support of the growth in R&D and capacity building
- ix. Assessing the adequacy of resources (financial, human, physical, information) available and the effectiveness and efficiency in their management
- x. Assessing the effectiveness and efficiency of the Centre's partnership arrangement and relationships with relevant stakeholders

III. Schedule of the Review

Date	Activities
Apr - May 2017	Internal consultations and identification of potential review team.
May 2017	Draft ToR and nominated review team names shared with <i>icipe</i> ExBo members for comment.
June / July 2017	ToR and nominated list of review team sent to the GC's Executive Board for comment and approval.
Until October 2017	ExBo approval of review ToR and review team. Review team members invited and confirm their participation.
October - November 2017	Internal <i>icipe</i> meeting to agree on documentation and review program.
November 2017 – January 2018	DG's Office liaises with scientists and prepares the desk review information including preparing responses to 2007 – 2012 review recommendations.
Late November 2017	GC is informed about the planning status of the IPER and endorses the process. Review team representative participates in annual GC meeting to discuss forthcoming review with GC, <i>icipe</i> senior management and scientists.
End January 2018	Desk study materials shared with review team.
Early February 2018	Reading of review materials.
February 2018	Review mission – field and project sites
March - May 2018	Finalization of review report in consultation with <i>icipe</i> senior management.
Early June 2018	Submission of review report to <i>icipe</i> GC.

Annex 2

IPER Panel Profiles

Dr. John Lynam



Dr. John Lynam is an American citizen and his expertise is in smallholder-led agricultural development in the tropics.

Dr. Lynam has over 30 years' experience in tropical agricultural research in Latin America, sub-Saharan Africa and Asia. Much of his work has focused on agricultural research in both national and international systems, working within commodity, farming system, and NRM programmes.

An independent consultant since mid-2000, Dr Lynam has worked with international development organizations such as The World Bank, FAO, ILRI, the World Fish Centre, the Bill & Melinda Gates Foundation, the World Vegetable Centre and the CGIAR. His previous employment has been with, among others, Kilimo Trust in Uganda; the Food Security Division of the Rockefeller Foundation in Kenya; the Cassava Program of Centro Internacional de Agricultura Tropical (CIAT) in Colombia, and visiting research fellow at the Institute for Development Studies, University of Nairobi, Kenya.

Dr. Lynam has authored or co-authored over 42 publications on agricultural research in the developing world. Among these, he has co-authored two major monographs relating to African agriculture and development.

Dr. Lynam currently serves as chair of the Board of Trustees of the World Agroforestry Centre, and is on the Board of CIFOR. He has served on the program oversight panel of Aquatic Agricultural Systems and the independent science advisory panel of Drylands CRP.

Dr. Bruce Pengelly



Dr. Bruce Pengelly is an Australian citizen and his expertise is in plant genetic diversity and the role of forages in tropical systems, mixed crop-livestock systems in Australia, SE Asia and sub-Saharan Africa.

His initial appointment was to CSIRO in Townsville in tropical Australia where he worked predominantly on *Stylosanthes* diversity and adaptation and the use of pattern analysis to describe the morphological and agronomic diversity of germplasm collections. In 1982 he moved to Brisbane and was curator of the Australian Tropical Forages Genetic Resources Centre (ATFGRC) for almost 20 years during which time he characterised and published on the diversity of some major tropical forage germplasm collections including *Alysicarpus*, *Aeschynomene*, *Bothriochloa*, *Cenchrus*, *Desmanthus*, *Lablab*, *Macroptilium*, *Rhynchosia*, *Teramnus* and *Vigna*.

Macroptilium, Rhynchosia, Teramnus and Vigna.

From 1995, Dr. Pengelly led a series of projects in Australia, southern Africa and Indonesia on crop-livestock systems including the role of forages in such systems and the options for growing and using tropical forages within these complex mixed systems.

Dr. Pengelly held senior management positions in CSIRO, leading a large agricultural systems research program of over 100 research staff from 2003 to 2008, and later as Assistant Chief of the CSIRO Division of Sustainable Ecosystems from 2008 to 2010. From 2009 to 2013, Dr. Pengelly was the Partnership Leader of the CSIRO research for development partnerships with BecA (Bioscience for East and Central Africa), and with CORAF/WECARD.

Dr. Pengelly retired from CSIRO in July 2013 and currently works as an Agricultural Consultant. He has published widely on the diversity and forage potential of more than 10 major tropical forage genera and species. He has reviewed a number of programs and projects globally and written the *icipe* strategy 2013-2020.

Prof Serap Aksoy



Prof. Aksoy has been a Full Professor of Epidemiology at Yale School of Public Health since 2002. In that capacity she teaches and oversees an active research laboratory and mentors graduate students and post-doctoral researchers.

She is a world leader in infectious-disease epidemiology with a focus on insect-transmitted diseases. Her research focuses on African trypanosomiasis – a devastating and highly neglected zoonotic fatal disease of humans and livestock in Africa. Her research of over 27 years has helped develop interdisciplinary approaches to understand critical determinants of disease transmission ranging from research on tsetse and trypanosome biology; to population genetics of tsetse, symbionts, and trypanosomes; to disease epidemiology and ecology in Africa.

Her classic molecular and biological studies provided seminal information on tsetse physiology and tsetse's obligate symbiosis with microbes, and collectively identified multiple molecular targets to reduce tsetse populations. Her population genetics studies on tsetse and trypanosomes have elucidated vector dynamics and disease transmission epidemiology and factors fueling disease emergence, and collectively provided critical information to develop sustainable strategies for disease control in Africa. Many of the methodologies and the new concepts they pioneered in the tsetse fly system are of broad relevance for vector borne diseases and have been applied for the control of other insect transmitted agents.

She collaborates extensively with African scientists on her research projects, leading several collaborative research programs in Kenya and Uganda funded through the National Institutes of Health in the USA. She has also been involved heavily in efforts to build regional research and control capacity for vector-borne diseases in disease endemic countries in Africa – also funded through the National Institutes of Health in the USA. Through these programs, they have mentored and supported the research of 12 PhD students in Kenya and Uganda along with over a dozen of junior scientists in various academic institutions. She also has led large collaborative programs set in China and Turkey.

She has worked with many national and global funding agencies helping them shape their research portfolios and priorities as well as in their peer-review process. She has been an Editor-in-Chief of a prominent journal, PLOS Neglected Tropical Diseases. As EIC of PLOS NTDs, she leads efforts to build global research and publication capacity for all neglected tropical diseases of animals and humans. She has provided advise to many government agencies as well as private foundations on vector-borne diseases, including acting as the Chair of the NIAID Vector Biology Study Section and the Innovative Entomology program at WHO/TDRU. She has been an advocate of Global Health, a dedicated mentor to junior students and scientists in the USA and abroad and a passionate supporter of women scientists globally.

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A Stockholm Convention Regional Centre