icipe's Results Based Management Framework

Rolling 2014–2020

May 2020

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INTRODUCTION

Members of the CGIAR Consortium of International Agricultural Research Centres, national and international development aid agencies (including UN organisations), as well as international research organisations, have reformed their performance management systems and measurement approaches, and *icipe* is no exception. It is essential to establish an effective performance measurement system, to deal with analytical issues of attributing impacts and aggregating results, ensure a distinct yet complementary role for evaluation, and establish organisational incentives and processes that will stimulate the use of performance information in management decision-making.

Results-based management (RBM) is a life-cycle approach to management that integrates strategy, people, resources, processes, and measurements to improve decision-making, transparency, and accountability. RBM is essential for *icipe*'s senior management to exercise sound stewardship in compliance with acceptable performance and accountability standards. The approach focuses on achieving outcomes, implementing performance measurement, learning, and adapting, as well as reporting performance.

icipe adopted RBM as a project planning and monitoring tool in 2011. RBM is first a management system and second, a progress reporting system. *icipe* focuses on results to ensure that it employs management practices that optimise value for money and the prudent use of its human and financial resources. This RBM policy is the underpinning of sound corporate, programme, and project planning, implementation, monitoring and evaluation, as well as the Centre's reporting to donors on its research and development achievements. *icipe* implements RBM on an iterative basis, refining approaches as it learns from experience, and adapting realistically to circumstances (including necessary capacity building in its programmes). *icipe* supports its staff in implementing RBM by providing appropriate guidelines and training, which is updated regularly based on lessons learned. The Centre identifies expected results, performance indicators (quantitative and qualitative), baselines and targets for its programmes and projects. It develops cost-effective means to monitor and measure results and learn from the best practices of the international community. *icipe,* in collaboration with its partners, identifies its respective roles and obligations. The Centre shares the responsibility for achieving results at the programme and project levels with its national and international partners. *icipe*'s implementation of RBM leads to better reporting on more clearly identified development results to the international donor community as this is the technique they use to assess programme effectiveness.

The RBM framework provides guidance to programmes and is intended to help establish organisation-wide standards regarding four main pillars:

1. The definition of strategic goals which provide a focus for action;
2. The specification of expected project results which contribute to these goals and align programmes, processes and resources behind them;
3. On-going monitoring and assessment of progress and integrating lessons learned into future planning; and
4. Improved accountability and continuous feedback on progress.

Applying RBM is the beginning of an ongoing process to better define the specific goals

of *icipe* and to design mechanisms to ensure the measurement of progress towards those goals. At this stage, *icipe* tracks specific performance measures at an institutional level on an annual basis. Projects implemented by *icipe* are the basis of its RBM framework. As such, tracking results begins from a project vantage point. At project level, results are tracked during implementation and evaluated upon project completion. While the tracking tools are utilised during implementation it is important that the three major phases in a project's evolution are linked to: (a) project design; (b) implementation; and (c) impact assessment. Breaking down the project cycle into these three phases, highlights the learning and management aspect of *icipe*'s RBM framework and facilitates in attributing outcomes and impacts to a specific project or programme.

RBM is indeed a strategic management approach that will ensure *icipe*'s R&D activities are implemented in collaboration with our partners to contribute to a logical chain of results that mobilises scientific and technical expertise from academia, civil society, and the private sector in support of sustainable development problem solving at local, national, and global scales aligned to the United Nations sustainable development solutions network – http://unsdsn.org/ (SDSN). *icipe*'s R&D contributes to the millennium development goals - http://www.un.org/millenniumgoals/ (MDGs) related priorities and provides knowledge-based solutions aimed at equipping the communities in Africa to survive and live within a rapidly changing global environment.

RESULTS BASED MANAGEMENT OVERVIEW

1. Institutional focus of the Results Based Management Framework

The **vision** of *icipe* is reiterated in its new *Vision and Strategy 2013 – 2020* paper. It is "*Pioneering global science in entomology to improve the well being and resilience of people and the environment to the challenges of a changing world, through innovative and applied research, alongside deep exploratory study, impact assessment, evaluation and sustainable capacity building….” (Vision and Strategy 2013 – 2020: Addressing Africa's Challenges and Opportunities)*

The **mandate** of the Centre as stated in its Charter of 1986 stipulates that "…*the primary mandate of* icipe *shall be research in integrated control methodologies for crop and livestock insect pests and other related arthropods, and insect vectors of tropical diseases and the strengthening of scientific and technological capacities of the developing countries in insect science and its application through training and collaborative work.”*

The four principal **objectives** are to: (1) do research on harmful and useful insects and other arthropods and to apply this knowledge to integrated pest and vector management as well as on the beneficial use of insects, (2) establish training in research methods and techniques in insects covering the breadth from scientists to practitioners, (3) establish cooperation with key international centres throughout the world, and with national programmes throughout Africa and other countries in the tropics to facilitate research and application of pest control strategies, and (4) provide an international forum for the exchange of knowledge in insect science and management for tropical regions.

Established in 1970, the vision, mandate and objectives formulated above are the

guiding principles within the scope of *icipe*'s subjects in research and capacity building, despite the fact that the question of subject matter scope—arthropods or beyond—was addressed repeatedly with good arguments for both, to limit the scope to arthropods, i.e. respecting the Charter's original mandate, or to widen the scope to related subjects such as disease and weed management, soil conservation and research in plant–plant interactions. The dilemma is obvious and was addressed in several documents including the latest external reviews of 2002, 2007 and 2013.

2. Success in implementing *icipe's* vision and strategy

The 2013 review externally commissioned by *icipe's* Governing Council highly commended *icipe* for creating a superb portfolio of innovative research and development. The reviewers considered the research of high to highest quality, a fact supported by the large number of peer-reviewed articles published throughout the review period (449 manuscripts) from 2007 - 2012. Furthermore, they noted that the research was undertaken in a reasonably cost effective manner, the production of one peer-reviewed article costing ca. 250,000 USD, which compares favourably with e.g. 239,000 USD (average for 2008 to 2012) for a paper produced at SLU – the Swedish University of Agricultural Sciences, Sweden (The 2009 OECD-HERD average is 180,000 USD per paper). The evaluation was a learning process for the three members in the review panel and it gave them fantastic insights. They stated that *icipe* had performed excellently, typified by a strong involvement with national, public and private partners.

The reviewers strongly recommended that *icipe* maintain the mix of strategic and applied research but should also consider more direct interventions, perhaps with the aid of carefully selected development partners. They also strongly endorsed that *icipe* focuses its activities as far as possible on the whole of Africa. With the Martin Lüscher Emerging Infectious Diseases Laboratory (opened in 2011) and the African Reference Laboratory for Bee Health (supported by four bee health satellite stations in Burkina Faso, Cameroon, Ethiopia and Liberia), funded by the European Union, *icipe* is well equipped to serve on a pan African basis.

Although the engagement of *icipe* with communities and the academic systems through capacity building is excellent, the review panel indicated that stakeholders have expressed a wish for a stronger engagement with the national agricultural research systems (NARS). Most would like to contribute to *icipe*'s strategy development. NARS, in particular, expressed a desire to be included in the initial project planning stages. Despite this expression, *icipe* should maintain and strengthen high quality research in modern arthropod science that makes the Centre unique and distinct from other African research centres. They noted that, overall the impact on development is well recognised but remains fairly limited in the fields of e.g. human and animal health.

3. Core values that pillar *icipe's* strategic interventions

Having the unique advantage of being an African institution, based in Africa, and mandated to address pest problems at the foundation of poverty, especially in terms of food security and health, *icipe* designs interventions based on a pro-poor set of values that contribute to the achievement of the millennium development goals. These include:

1. Consultative engagement with communities as equal partners in the development of scientifically sound, simple and sustainable technologies;

2. Offering solutions for improving the quality of life of the people now and in the future, based on informed understanding of the complex interactions of the behaviour, ecology, biological diversity and the environment of pest and beneficial arthropods;
3. Targeting worldwide concerns such as deforestation and conservation in global biodiversity hotspots;
4. Promoting the commercialisation of research results through creation of new products, thereby creating employment in manufacturing and processing, and thus raising incomes and fighting poverty in a sustainable way;
5. Addressing institutional capacity gaps that limit technology uptake, adoption and sustainability;
6. Building the much-needed human expertise for research leadership and policy advocacy, as well as skill empowerment through networking with African institutions such as universities.

4. Programme implementation through strategic pan-African and international alliances

The 2013 panel of reviewers was satisfied that *icipe*'s new "*Vision and Strategy 2013–2020*" document provides a sound analysis of the current challenges of agriculture and health in Africa and refers to current integrated concepts like 'one health' or 'ecosystem health'. The panel, however, indicated that the theoretical basis of these concepts should be better reflected to understand the *icipe* scientists' interpretation as a basis for integrated vector control approaches in social-ecological systems. The reviewers also recommended that a reflection on theory of human–environment systems or social-ecological systems should be incorporated.

They observed that *icipe* uses the term '4-Hs' and would like to adhere to the "global one health philosophy" to address the interlinked problems of poverty, low agricultural productivity, poor health and the degradation of the environment. However, the strategy document does not make reference to the vast literature on ecosystem health and an increasing body of knowledge on 'one health'. The review panel advised that this should also be captured. The review team noted that it would greatly help the reader if the strategy document would refer to the literature and clarify its interpretation of concept terms, i.e. 'one health' should be seen as the added value of closer cooperation of human and animal health.

The Centre strongly engages with the public, private, academic and non-academic actors. This is highly appreciated and recognised. But is it done efficiently? The review team missed to locate any references to theoretical frameworks in such publications as the *Handbook of Transdisciplinary Research* or *The Social Ecology of Resilience: A Handbook of Theory and Practic***e**. Most of the community engagement is done well by natural scientists but rather intuitively. In that regard, the reviewers endorsed that a social scientist oversees the public engagement activities of *icipe* to set standards and procedures, and to capitalise on the excellent experiences.

icipe contributes very well to the building of capacity, i.e. through the African Regional Postgraduate Programme in Insect Science (ARPPIS), and does it much better than many other international institutions. The reviewers encouraged strengthening these efforts even more, considering the postdoctoral career plans of *icipe* alumni. Young scientists often have great difficulties building up their own research group at an African

university. This is recognised by the Wellcome Trust-funded *THRiVE* project, for which *icipe* should actively seek a phase II involvement.

Specifically, the reviewers welcomed *icipe*'s intention to strengthen vector control of leishmaniasis and IPM for cotton. The 2013 panel also agreed that farmer unions require more training in beekeeping and a better way of communication of research results that should not be in the 'research dialect' and similarly advised that AU-IBAR perceives that livestock issues are not paid enough attention. The panel of reviewers welcomed *icipe*'s focus on the relatively recent (2011) appearance of maize lethal necrosis disease (MLND) in farmers' fields. If not tackled successfully, this serious disease could negate a lot of the gains being made, e.g. by the push–pull technology.

Having previously aligned *icipe*'s work to the Millennium Development Goals (MDGs), the reviewers recommended that it may be a sound tactical move for *icipe* to join the emerging Sustainable Development Solutions Network (http://unsdsn.org/), particularly their Thematic Groups 7 & 8, on Sustainable Agriculture and Food Systems (that explores how to provide healthy diets to a growing world population while reducing the environmental impact of agriculture), and Forests, Oceans, Biodiversity and Ecosystem Services (that seeks integrative solutions for securing biodiversity and improving the management of ecosystem services), respectively.

In 2012, *icipe* joined in the formation of the Association of International Research and Development Centres for Agriculture (AIRCA, www.airca.org), which was stimulated by the need for integrated action to deliver sustainable agricultural intensification at the landscape scale. Other member organisations are the World Vegetable Center (AVRDC), CAB International (CABI), the Tropical Agricultural Research and Higher Education Center (CATIE), Crops for the Future (CFF), the International Center for Biosaline Agriculture (ICBA), the International Centre for Integrated Mountain Development (ICIMOD), the International Fertilizer Development Center (IFDC) and the International Network for Bamboo and Rattan (INBAR). AIRCA's mission is to "put research into use by strengthening capacities for sustainable improvements to incomes, food and nutrition security in healthy landscapes". AIRCA's activities are coordinated by a secretariat that was set up in 2014 and is hosted by *icipe* on its Duduville campus.

Established in 2013 and hosted at *icipe* is the Innovation Transfer into Agriculture – Adaptation to Climate Change (ITAACC) - http://www.icipe.org/itaacc/. ITAACC supports various innovation transfer projects and closely integrates agricultural scientists and practitioners in Africa. The projects are designed in collaboration with international agricultural research centres and realised in conjunction with various partners, including private sector and non-governmental organisations. The focus areas within *icipe* are:

A. Establishment of a knowledge transfer platform:
   i. Promoting the regular exchange between main actors from science and practice;
   ii. Establishing and managing a knowledge transfer platform (webpage, physical and virtual events, active marketing) based on broad partnerships (IARCs, CAADP, farmer organisations, the private sector, German International Cooperation, donors); and
B. Assessment of the demand–supply match for agricultural innovations:
   i. Developing jointly a method for auditing research results relevant for the market;
   ii. Applying the method, that is testing the innovation supply by IARCs regarding the potential for dissemination and market acceptance, in pilot studies.

5. Institutional responsibility, organisational capability and administrative efficiency

icipe has made tremendous scientific progress and consolidated its management and financial situation in the recent years. Programmatically it has also responded to the recommendations in the preceding review of 2007 to strengthen the socio-economic aspects, i.e. by developing an economic analysis for every intervention. *icipe*'s outreach in building up the East African regional and African research capacity is impressive. It appears that almost all entomologists in Africa have, or have had, some involvement with *icipe*. Kenyan universities particularly recognise this. In this way *icipe* also plays an important pan-African networking role in insect expertise.

The 2013 panel of reviewers clearly recommended action in three prominent areas:

Social economic analytical capacity: Overall the reviewers indicated that the impact of *icipe* technologies on development is well recognised but remains poorly documented and emerging evidence of the sustainable *icipe* interventions in all of the Centre's flagship programmes (the push–pull, fruit flies and tsetse interventions) should be analysed for their cost-effectiveness.

In this regard, *icipe* will embark on strengthening its impact assessment team to conduct cost–benefit analyses of the majority of its projects and programmes. For example, *icipe* has long recognised that the quest for effective and sustainable pest and disease vector control technologies will remain futile unless socio-economic, cultural, and environmental considerations are adequately addressed. The success of the development and implementation of integrated control technologies rests on sound longitudinal socio-economic and environmental impact studies. These will, therefore, be central to the progress of its work.

Integration of *icipe* technologies: *icipe*, as similar institutes worldwide, has all the components for demonstrating the added value of its holistic approaches, but these need to be put together effectively and analysed for their social, ecological and economic dimensions. The 2013 review envisages the strongest potential for *icipe* to be the move away from the understanding of system components in human, animal and plant health into progressively integrated approaches for all of them. This is well expressed in the new strategy document; however, a clear methodological outline of future research work that would integrate plant, animal and human health, and demonstrate the added value and profitability of such integrated approaches, is missing. In some instances, the reviewers felt that some Units concentrated on their own research rather than seeking cross-Unit activities and the panel recommended that there be room for more inter-cluster activities.

icipe sees great potential for integration, particularly of its mature technologies (e.g. push–pull, fruit fly control, some of the classical biological control programmes such as Diamond backmoth (DBM) and so on). One example could be smallholder-led growth and sustainable intensification of cereal–dairy production systems in East Africa through integration of animal and human health with push–pull. The Centre also recognises that there are tremendous opportunities to achieve these goals through strategic partnerships with organisations like AFAAS. This recommendation will be

institutionalised and form a prime foundation for the strategic outlook of *icipe*'s R&D agenda.

***icipe* Policy Research:** The review team noted that in its institutional goal(s) as stated in the "old" *Vision and Strategy 2007–2012* document, *icipe* aspires to "develop, introduce and adapt new tools and strategies for arthropod management that are environmentally safe, affordable, appropriate, socially acceptable and applicable by the target end-users, with full community participation. Eventually, the outputs of *icipe*'s research work will contribute to policy development in areas that are relevant to the Centre's mandate". In almost all areas the review team considered that *icipe* had indeed gone a long way to fulfilling these aspirations. However, more could be done.

***icipe*'s unique evolution** as one of Africa's leading scientific institutions with an institutional commitment to pursue the development agenda for the benefit of Africa's poor, has meant that the Centre has had to develop an institutional mechanism to respond to them. At the heart of *icipe*'s strategic response to this critical agenda is the forging of new and the realignment of existing multidisciplinary partnerships with national, sub-regional and international institutions, organisations and governments. Presently, *icipe* is hosting the Partnership for Economic Policy (PEP), a network of institutions, researchers and experts in economic policy analysis on its Duduville campus in Nairobi. PEP has extensive experience in development-oriented policy research and is a major partner of *icipe* in this area.

Further, *icipe* will continue with its efforts to strengthen and expand its activities to other African regions such as Central and West Africa, to better comply with its mandate and in fulfilling recommendations of the strategic reviews for 2002, 2007 and 2013. The Centre's strategy to develop integrated pest management, integrated vector and disease management and adaptation to climate change and ecosystem services packages and partnering for holistic approaches for problem solving is fully compatible with its mandate and represents one of the programme strengths if adequate linkages with the right partners are established across Africa. This will ensure that the Centre's output is appropriate, acceptable and affordable for the peoples of the tropical developing world, especially in Africa. *icipe*'s R&D partnership linkages are with universities, national research and extension systems (NARES) and governments, regional organisations, international research organisations (e.g. CGIAR and AIRCA centres), specialised networks, NGOs and CBOs, as well as with the private sector.

6. Background to development of *icipe's* Results Based Management Framework

In early 2010, *icipe*'s Governing Council (GC) and Management, in consultation with core donors, agreed to develop a results-based management (RBM) framework to support the Centre's strategic priorities, policies and guidelines of insect science research and development. The operational guidelines specifically state that the framework 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 programmes. The *icipe* RBM adopted in 2011, is an operational framework that explicitly links the strategic objectives and priorities of the Centre to the various programmes and projects that it finances so that collectively they help achieve the goals of *icipe.*

The RBM helps to promote efficient management techniques. The systematic approach of gathering and assessing data and results on progress towards objectives is a cost-effective way to diagnose early weaknesses in implementation plans. Periodic and targeted information helps the GC and the *icipe* Management recognise those activities that generate the highest pay-offs in terms of results, or those, which appear to need more support to deliver results aligned with strategic priorities. The Centre is then able to track and measure progress towards objectives, and makes targeted decisions to improve performance on an on-going basis. Process monitoring takes place on a continuous basis to track whether portfolios are being implemented as intended, standards are being met, and resources are being used efficiently.

Each of *icipe*'s core activity areas has an RBM Framework, which constitutes this document. All projects entail knowledge management and learning, which are the main components for any organisation dealing with adaptation to climate change like *icipe.* The 4-Hs and Capacity Building and most recently BioInnovate Africa programme (in 2017) and the Regional Scholarship and Innovation Fund (RSIF), a flagship initiative of the Partnership for skills in Applied Sciences, Engineering and Technology (PASET) (in 2018) frameworks encompass a cycle of planning, periodic performance assessment and organisational learning—all of which are supportive of knowledge creation and sharing. Learning from the R&D activities influences strategy development and programme/project design, and the lessons are fed back into programme/project implementation. The learning component is also critical for identifying and managing risks while bearing in mind the expected results and resource levels. This involves increasing knowledge by learning, knowledge dissemination and feedback into decision making, project design and strategy development.

As earlier mentioned, each of *icipe*'s core activity areas developed their RBM Framework and the reporting that follows is specific to the R&D Thematic Clusters (i.e. 4-Hs paradigm), Capacity Building, BioInnovate Africa programme and the PASET RSIF frameworks. We are pleased to report that, in line with *icipe*'s Vision and Strategy focus, its operative 4-H paradigm - addressing Human, Animal, Plant and Environmental Health—and the many integrated pest and vector management (IPVM) and insect-based income-generating technologies developed by the Centre over the years as the Capacity Building and Institutional Development Programme; BioInnovate Africa programme and PASET RSIF, are all of immediate relevance to future strategies for contributing to solutions for food insecurity and malnutrition, disease, poverty and environmental degradation. *icipe* is about much more than insects.

RESULTS BASED MANAGEMENT FRAMEWORK 2014–2020

PLANT HEALTH at *icipe*

a. Overview of activities

The activities in plant health contribute to improving sustainable food security and environmental health through development of biointensive IPM options for pre- and post-harvest pests, and for parasitic weeds (such as *Striga*) using predators, parasitoids, microbial insecticides and habitat management strategies. All technology development involves farmer participation to ensure farmers' needs are met. The agenda for plant health research covers four domains: **Staple Food Crop Pests**, which is covered by the *Habitat Management (HM)* and *Biological Control (BC) programmes for Cereal Pests* and *IPM of grain legume pests*; **Horticultural Crop Pests**, which includes *IPM programmes for vegetable* and *fruit pests*; **Commercial Farming Crop Pests,** which covers *IPM programmes for pests and diseases of coffee, cotton, cashew, sugarcane and cocoa*; and **Post-Harvest Pests and Mycotoxins** that includes *programmes focused on developing post-harvest pest and disease management technologies for staple, horticultural and commercial crops.*

Wherever possible, priority is given to solutions that minimise the impact on environmental and human health, such as BC (classical and augmentative, and microbial control), use of semiochemicals, baiting stations, and cultural and habitat management strategies. *icipe* is the only international institution in Africa that has an internationally accredited quarantine facility. This enables the Centre to import and maintain exotic natural enemies after regulatory requirements of the Kenyan phytosanitary organisations are satisfied and importation approved. For more intractable problems, we aim to undertake in-depth evaluation of the interactions between soil, plants, pests and natural enemies in their cultivated and natural habitats at multi-trophic level to develop novel pest management technologies.

Plant Health also participates in technology transfer activities in partnership with national agricultural research organisations (NARS) through Training of Trainers (ToTs) and farmer training programmes, among others. Further, the *ex-ante* and *ex-post* assessments of economic impact of introduced technologies and good agricultural practices developed in *icipe*'s plant health programmes are analysed. Factors associated with the success and failure of technologies are assessed and outcomes utilised for fine-tuning the technology for enhanced adoption.

b. Goal and Broader Objectives

The aim is to stabilise staple food, horticultural and commercial crop production by reducing quantitative and qualitative pre- and post-harvest yield losses, due to insect pests, mites, weeds and mycotoxin-producing fungi. This is achieved through the development of economically viable production systems that are less reliant on external inputs, in particular synthetic pesticides, and thus are environmentally friendly and sustainable. The focus is to quantify economic crop losses due to pests, undertake research leading to sustainable and economically viable IPM solutions, and provide support for their implementation. Through collaborative activities, national, regional and

private sector capacity and capability is built to carry out these tasks independently and disseminate and commercialise the produced technologies.

c. Strategic Outlook (up to 2020)

Staple Food Crop Pests

Biological Control (BC) of Cereal Pests: In Africa, noctuid stemborer abundance and their economic importance in graminaceous plants vary greatly between regions and with agroecozones within a region. The main focus will be on the biodiversity, distribution and abundance of the pests and their natural enemies (mostly larval endoparasitoids, *Cotesia* spp.) in wild and cultivated habitats in Africa. Simultaneously, the mechanisms underlying the host recognition and acceptance by the stemborers and their parasitoids will be analysed (with a special reference to *Busseola fusca* and *Cotesia* spp.). The recent outbreak and rapid spread of a serious maize disease termed as maize (=corn) lethal necrosis (MLN/CLN) and caused by a co-infection of maize by *Maize chlorotic mottle virus* (MCMV) and *Sugarcane mosaic virus* (SCMV), has threatened food security in the eastern Africa region. In the US, where MLN/CLN has been reported, corn thrips, chrysomelid beetles and corn rootworms transmit MCMV while cereal aphids such as *Rhopalosiphum maidis* transmit SCMV. However, the identity and distribution of potential vectors of MCMV and SCMV is not known in East Africa. In this regard, *icipe* plans to collaborate with national, regional and international partners to identify sustainable management technologies for the disease and its vectors. The focus will be to develop sustainable seed treatment strategies and further develop biointensive IPM tools that are less reliant on pesticides, targeting vectors like thrips and aphids.

Habitat management (HM) and push–pull: The push–pull strategy is a novel HM technique developed by scientists at *icipe* in Kenya and Rothamsted Research in the United Kingdom, in collaboration with Kenyan national partners, which simultaneously combats stemborers and parasitic *Striga* weed in cereal crops. This strategy involves repelling ovipositing stemborer moths away from the cereal crop by intercropping with *Desmodium* spp. (push), while trapping them on wild host plants such as Napier grass (*Pennisetum purpureum*) (pull). The *Desmodium* intercrop also induces abortive germination of *Striga* seeds, improves soil fertility through fixing atmospheric nitrogen and enhances moisture retention. Although the technology is effective under varied agroecological conditions, it has not been extended to drier areas due to sensitivity of companion plants to heat and moisture stress. Hence, to adapt the technology to drier areas and harsh climatic conditions, there is a need to develop drought-tolerant companion plants with similar semio- and allelochemical based pest management traits to achieve associated economic and environmental benefits. Supporting the process of developing a ‘climate-smart’ push–pull technology will be selection of plants that have ‘smart’ inducible defence systems by pest oviposition (early herbivory) and by ‘stress’ volatile organic compounds emitted by neighbouring plants (plant signalling). *icipe* will further elucidate the full chemistry of *Striga* inhibitory molecules of *Desmodium*, the genes involved in their synthesis, and also explore, together with partners, the possibility of transferring these properties to edible food legumes through heterologous gene expression. We are creating and/or strengthening institutional partnerships with the public, private and civil society sectors to expand the dissemination of both the conventional and climate-adapted push–pull technologies in sub-Saharan Africa (SSA).

Grain legumes: Strategic focus of research on thrips management in grain legumes will be to adapt and disseminate the management technologies developed on vegetables.

Innovative researchable areas (such as identification of semiochemical-based attractants for bean flower thrips, aggregation pheromone and novel biopesticide application strategies using autodissemination and spot spray techniques) will be pursued and outcomes used to further refine each management technology. In partnership with CIRAD, “push, pull and kill” strategies using botanical based repellents on the crop and coloured insecticide treated nets/sheets will also be assessed for thrips management on grain legumes. Investigations on damage to beans caused by the bean stem maggot, also called the bean fly (*Ophiomyia* spp., Diptera: Agromyzidae), in plants under stress due to soil infertility or drought will be carried out and appropriate IPM package developed and made available to growers.

Horticultural Crop Pests

The Centre has built a team of specialists in horticultural crop protection research. Expertise of this team covers entomology, acarology, plant and insect pathology, biological control, biopesticides, IPM research planning and implementation, design and performance of participatory training and learning, postgraduate training of local researchers and socio-economics.

Fruit pest management: Adoption of fruit fly IPM technologies is directly increasing producer income and wages and generating new livelihood opportunities. Success of the technology is providing the basis for diversification especially in rural economies. In the coming years, we shall elucidate fruit fly responses to kairomones from host plants and industrial by-products recently developed for attracting fruit flies. One of the most notable changes in the structure of agricultural research in recent years is the growing importance of the private sector. Building on recent successes between *icipe* and the private sector, especially with Real IPM Ltd., which is a Kenya-based pan-African producer of biopesticides, *icipe* will explore the possibility of similar arrangement with other private sector companies in moving locally developed fruit fly attractants to commercial paths. We envisage characterising the demography of recent invasion by *Bactrocera zonata* in North Africa to identify the source, pathways and origin of invasion and assess the genetic mechanisms involved in polyphagy, reproductive potential and other traits peculiar to invasions. Molecular markers will be developed for key parasitoids of the invasive species to measure if populations are genetically distinct and thus identifiable following release.

The citrus industry in East Africa is seriously threatened by biotic constraints. Chief among them is greening disease induced by a fastidious phloem-limited bacterium (*Candidatus Liberibacter africanus*) vectored by the African psyllid *Trioza erytreae*. In Kenya, this disease has led to a near collapse of the citrus industry. In March 2015, *icipe* initiated a project to tackle the vector of this disease by understanding its bioecology and management in addition to other important citrus pests, such as false codling moth and citrus rust mite.

Vegetable crop pest management: icipe will elucidate the chemical communication involved between parasitoids, leafminer flies (LMF) and host plants, to improve parasitoid response and increase LMF trapping while reducing to the bare minimum the attraction of parasitoids to traps. Studies will be carried out to understand the mechanism of action of endophytic entomopathogenic fungal isolates identified against LMF and field-test their potential in partnership with the private sector. We shall also identify the best crop rotation and associated crop schemes to reduce LMF effect on cultivated

vegetables in various horticultural production systems. *icipe* will also carry out large-scale validation of thrips and thrips-transmitted tospoviruses IPM technologies based on crop resistance, intercropping, use of semiochemical-based attractants and biopesticides, on high value crops such as onions, tomatoes and French beans. Strategic focus will be on researchable areas of interest such as development of novel application strategies for entomopathogenic fungi (EPF), interaction between EPF and tospoviruses and impact on transmission competence, and plant endophytes and their impact on thrips and thrips-transmitted tospoviruses. Lessons learned from the eastern, southern and Central African diamondback moth management will be scaled-up in other parts of SSA where crucifer vegetables are produced and BC-based IPM in smallholder systems remains unknown.

The ecology of two important aphid species of crucifers (*Brevicoryne brassicae* and *Lipaphis pseudobrassicae*) and okra (*Aphis gossypii*) will be studied and the role of natural enemies on the dynamics of the pest elucidated. Biorational insecticides (biopesticides, botanicals, oils, soaps) will be tested and promising management tools field tested, validated and recommended to growers. The bioecology of the newly introduced pest from South America, tomato leaf miner, *Tuta absoluta,* will be studied and the risk of its spread and establishment under a climate change scenario assessed. *icipe* will also focus on exploration for promising natural enemies in the pest's aboriginal home of Peru and later introduce them into Africa. Additionally, the implementation of proven IPM technologies will be validated and promoted. *icipe* is implementing a project aimed at understanding the biology and ecology of major pests and diseases of African indigenous vegetables (AIVs) and developing appropriate IPM strategies targeting them in different areas in Africa. In partnership with CIRAD, Michigan State University and African institutions, *icipe* is studying the effect of insect netting technology adapted to smallholder farmers for protecting vegetables against pests and the interaction with biological control methods and repellent plants. The impact of netting technology on natural enemies, on plant physiology and microclimate modification, is also being carried out.

Commercial Farming Crop Pests

Coffee production ***systems constrained by*** *diseases and insect pests:* The coffee berry borer (*Hypothenemus hampei*), and three major fungal pathogens, i.e. *Hemileia vastatrix*, *Colletotrichum kahawae* and *Gibberella xylarioides*,) that cause coffee leaf rust (CLR), coffee berry disease (CBD) and coffee wilt disease (CWD), respectively, constitute the major threats to coffee production in Africa. We will characterise and model the epidemiology of coffee diseases according to environmental heterogeneity (based on crop density, structure, type, climate and so on), to identify agroecosystems linked to lower levels of disease expression. We will also characterise coffee–parasite interactions to identify resistance mechanisms in coffee to diseases, which will enable selection of resistant germplasm for inclusion in coffee breeding programmes in East Africa. Research will also focus on effect of climate and other environmental changes on the coffee pests, chemical ecology, neuroethology and genetic diversity of the coffee berry borer, and basic biology and ecology of other emerging economically important pests due to global and local environmental changes. We shall further elucidate the communication system between the coffee berry borer and its two main hosts, *Coffea arabica* and *C. canephora,* for developing a better field trapping system for this pest. We shall also evaluate the coffee agroecosystem services and trade-offs in different systems

across East Africa, and carry out basic studies on the biology, ecology and role of antestia bugs (*Antestiopsis* spp.).

Smallholder cotton production constrained by insect pests
In partnership with EMBRAPA, *icipe* is developing a push–pull IPM strategy for smallholder cotton farms constrained by insect pests in Kenya and northeast Brazil. The habitat management strategy will be based on suitable attractive trap plants and repellent intercrops for cotton bollworm complex in Kenya and cotton boll weevil in northeast Brazil. The chemical ecology of the tritrophic interactions will be investigated while exploiting the innate inducible defence systems through recruitment of effective local natural enemies.

Cashew production constrained by *diseases and insect pests*
icipe, in collaboration with CIRAD and NARS in East Africa, has packaged the basic knowledge of insect pests and diseases in Benin and Tanzania, which is a prerequisite for developing and implementing a biologically-based IPM of cashew. Quantitative and qualitative knowledge of the major cashew pests and diseases (and their natural enemies) in Benin and Tanzania is now available as well as solid data on their biology and ecology. Results also showed the importance of pollinators on fruit formation and cashew yield in southern Tanzania; therefore, the need for their preservation and maintenance. *icipe* and its partners will also develop similar IPM programmes against cocoa and sugarcane pests.

Postharvest Pests and Mycotoxins
Postharvest losses are a major cause for food insecurity in Africa. These losses, which occur all along the supply chain from production to consumption, have direct links to food availability and prices, and also a bearing on the environment as a result of input inefficiency. *icipe*'s main focus is on research and development of IPM programmes to combat storage pests and moulds with emphasis on the invasive *Prostephanus truncatus* (larger grain borer) and mycotoxin-producing fungi.

Mycotoxins: Fungi, such as *Aspergillus flavus* and *Fusarium verticillioides,* produce toxic substances (e.g. mycotoxins) that are carcinogenic and that have other undesirable health effects on human and animal populations. *Aspergillus* fungi produce the mycotoxin aflatoxin, which is a natural carcinogen, and which also generates by-products with immunotoxic properties that are capable of causing disease and death. In farm animals, ingestion of contaminated feed can cause reduced growth rates, illness and death. The toxin contaminates the products produced by affected animals, which can then affect consumers of the foods. We shall identify the factors impacting the risk of fungal growth and aflatoxin contamination in maize grain to help design IPM intervention strategies to contain and limit exposure to this dangerous naturally occurring mould toxin in East and southern Africa.

Larger grain borer (LGB): We shall test the Purdue Improved Crop Storage (PICS) triple bagging method against various maize and legume storage insects. In addition, strains of the exotic LGB predator *Teretrius nigrescens,* adapted to different climates, will be released in several LGB-affected countries in SSA.

Postharvest treatments to ensure quarantine security: In spite of the adoption of IPM technologies in the field, postharvest treatments to ensure quarantine security against invasive pests is essential in order to access highly quarantine pest sensitive markets.

In this regard, scientific studies to establish postharvest quarantine treatment parameters are focused on mango as well as export vegetables (such as French beans).

Crosscutting areas

Entomopathogenic fungi (EPF): Considering the increasing interest in the development of EPF-based biopesticides, *icipe* will continue its partnership with the private sector in developing new products with potential markets. Application strategies through dissemination of EPF in the crops are being investigated by identifying powerful arthropod attractants (semiochemicals) that are compatible with the microbes. It has been recently discovered that many EPF play additional roles in nature, such as endophytes, antagonists of plant pathogens, and even plant growth promoting agents. *icipe* will explore the role of fungal endophytes in plant defence against arthropod pests to develop novel biological control agents and elucidate the underlying mechanism by which EPF interact with insect hosts and plant pathogens. There is ample evidence those plant hormones like salicylic acid (SA), jasmonic acid (JA), and ethylene (ET) pathways cross-communicate, allowing the plant to finely tune its defence response depending on the invader encountered and the natural enemies that are on the plant. We intend to investigate such interactions in key endophytes and anticipate results that will lead to promising prospects. To monitor the fate of biopesticides released in the field, and to protect the intellectual property of *icipe*'s fungal isolates, molecular probes will be developed for specific detection of the fungal isolates.

Climate change: Low-latitude regions in SSA are more vulnerable to the negative impact of climate change, especially global warming, than mid- and high latitude regions. Climate change could affect distribution and relationships between crop pests and their natural enemies, and lead to unexpected species interactions, and outbreaks of secondary pests. We shall use predictive experimental models to determine possible effects of climate change on key and occasional pests of selected target crops, as well as characterising and quantifying insects' responses to changes in climate, to develop adaptive responses. We are also embarking on investigating the climate and land cover change impacts on ecosystem services and food security, building capacity and developing adaptation strategies.

The role of agronomy and soil science in IPM: Most IPM techniques are based on agronomy and measures that improve soil fertility and thereby plant health. Recent studies by *icipe* have shown that soil fertility not only affects plant growth and vigour, but also affects pest infestation and damage, as well as the performance of natural enemies. Furthermore, the ever-dwindling soil fertility is a major constraint of agricultural production in SSA. Thus, closer linkages with institutes possessing the necessary expertise in agronomy and soil science will be sought.

Economic impact analyses related to plant and environmental health: The *ex-ante* and *ex-post* assessments of economic impact of introduced technologies and good agricultural practices developed in *icipe*'s plant health programmes will be analysed to inform policy makers and solicit a wider adoption of IPM practices for improved food safety and security, and market access. Research will also be conducted on the economics of pest management through IPM strategies, BC as well as pesticides, and the interactions with human and environmental health. Economic valuation of ecosystem services and their interaction with human activities will be another area of research.

Technology transfer: *icipe* is identifying the most effective dissemination pathways for further expansion of technologies among NARS and farmers, for strengthening emergency response against new invasive pests and their containment and management capabilities, and thus reduce farmers' dependence on synthetic pesticides.

Plant Health Results Based Management (RBM) Rolling Framework

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
Objective 1: 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 in *icipe*'s target areas.					
1. Baseline information on pests' status, farmer practices and their impacts on ecosystem and livelihoods assessed.	• At least five *ex ante* study outcomes utilised by scientists, policy makers and other stakeholders by 2018.	• Pest status of at least five key pests determined by 2017.	• Publications. • Survey records. • Web resources.	• Surveys. • Growers' interviews. • Secondary data collection.	• Political commitment exists. • Social attitude and willingness of stakeholders to cooperate. • Availability of funds.
Specific Objective: Development and implementation of a sustainable IPM and surveillance programme for the invasive tomato leafminer, *Tuta absoluta* (Meyrick), in North and sub-Saharan Africa by 2020.					
1. Natural enemies of *T. absoluta* identified and tested through explorations in Peru, and if feasible, introduced into Africa.	• Co-evolved parasitoid(s) identified tested and if feasible introduced to Africa by mid-2015. • Colonies of at least two species of the most promising natural enemies established by end of 2014. • One parasitoid species introduced into at least one of the target countries by end of 2019.	• Number of co-evolved parasitoid introduced to Africa by mid 2015. • Number of vibrant colonies established. • Number of parasitoids introduced to Africa by end of 2015.	• Research data. • Reports. • Student theses. • Publications.	• Field surveys. • Laboratory bioassays.	• Healthy colonies target pest and natural enemies in culture. • International and national regulations continue to allow insect collection and shipment. • Export and importation permits for natural enemies granted by the relevant government authorities of the target countries. • Parasitoids and the host are adaptable to rearing.
Specific Objective: Develop and implement integrated pre- and postharvest pest management approaches for thrips and tospoviruses infesting vegetables and grain legume crops in East Africa in collaboration with international and national partners by 2020.					
1. Biopesticide for thrips IPM developed and commercialised.	• Thrips and tospovirus management strategies for French	• At least one tospovirus-resistant cultivar of onion	• Publications. • Project reports, theses.	• Laboratory records. • Field experiments and data collection.	• No crop failures. • Grower acceptance and cooperation.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
2. Bean Flower thrips pheromone blend optimised. 3. Thrips IPM strategies based on intercropping, use of biopesticides, semiochemicals and botanical pesticides developed.	bean, onions, tomato and grain legumes encompassing at least two IPM components formulated by 2020.	and tomato identified by 2017. • Reduction in use of synthetic pesticides by at least 20% by 2020. • Number of peer reviewed publications.	• Private-public partnership agreements. • Pesticide use statistics. • Residue level statistics.	• Secondary data collection.	
4. Field efficacy and use of bean flower thrips pheromone standardised. 5. Field demonstration of thrips IPM strategies based on intercropping, use of biopesticides, semiochemicals undertaken. 6. IPM technology adapted and validated with grain legume farmers. 7. Ex-ante and ex-post assessment of the introduced management strategies.	• Awareness on thrips, tospovirus monitoring and management strategies created among agricultural extension officers/plant quarantine inspectors. • French bean, tomato, onion and grain legume farming enhanced by 2015.	• Awareness among at least 200 agricultural extension officers/plant quarantine inspectors enhanced on thrips and tospovirus monitoring/ management by 2015. • Awareness among at least 1,000 French bean, tomato, onion and grain legume farmers enhanced for adoption of the thrips and tospovirus management strategies by 2015. • French bean, onion, tomato and grain legume yields increased by at least 15%. • Rejection of French beans reduced by at least 10% in local, urban and export markets by 2015 • Number of training reports. • Popular articles, mass media reports.	• Training manuals and materials. • Survey reports. • Training registers. • Impact assessment reports. • Crop yield statistics. • Domestic and export agro-statistics.	• Pre- and post-assessment of awareness among course participants. • Surveys. • Impact assessment studies. • Field data. • Farmer interviews.	• Stakeholders are willing to participate in the training.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• Number of peer reviewed publications.			
Specific Objective: Development of sustainable management strategies for insect vectors of maize lethal necrosis disease (MLND) in East Africa by 2018.					
1. To identify and understand ecology of potential vectors responsible for transmission and spread of viruses causing MLN in East Africa. 2. To develop novel, effective and sustainable seed treatment strategies for the management of MLN. 3. To develop innovative and effective crop diversification strategies that influence both vector ecology and virus epidemiology.	• Integrated pest management strategies for key vectors of viruses causing MLN developed, through seed treatment, use of biopesticides and crop diversification techniques by December 2015.	• At least one key vector of Maize chlorotic mottle virus (MCMV) /Sugarcane mosaic virus (SCMV) identified by September 2014. • Number of distribution maps of key vectors established by December 2014. • Seasonality and alternate hosts of key vector in MLN hotspot areas studied by June 2015. • Competence of key vectors to transmit viruses causing MLN published by November 2015. • At least two sustainable seed treatment strategies against MLN identified by December 2014. • Levels of systemic insecticide residues in corn, tassels and silk estimated and safety to honeybees assessed by December 2015. • At least two intercrops that reduce the incidence of key vectors and thereby MLN identified by December 2014.	• Publications. • Project reports, theses. • Training reports. • Distribution maps.	• Laboratory and field experiments. • Surveys. • Secondary data collection.	• No crop failures. • Grower acceptance and cooperation.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• Impact of crop rotations on vector population and thereby the MLN identified by December 2015.			
Specific Objective: Develop and implement integrated pest management strategies for production of important indigenous vegetables in Kenya and Tanzania by 2018.					
1. Biology and ecology of major arthropod and nematode pests of amaranth, leafy cowpea and nightshades determined. 2. Effective management tools for target pests on amaranth, leafy cowpea and nightshade developed and implemented. 3. Available germplasms of amaranth varieties screened to identify source of resistance against key pests.	• African Indigenous Vegetables (AIV) IPM strategies that encompass at least three IPM components formulated by 2016.	• The key insect pests of at least one indigenous vegetable produced in Kenya and Tanzania identified by 2015. • The key nematode pests of at least one indigenous vegetable produced in Kenya and Tanzania identified by 2015. • The distribution, abundance and dynamics of at least one major pest of amaranth and nightshade determined in Kenya and Tanzania by 2015. • The pheromone biosynthesis activating neuropeptide (PBAN) and its correlation to variability in sex pheromone analysed in at least one AIV insect pest by 2017. • Variation in pheromone binding protein (PBP) and odorant binding protein (OBP) characterised in at least one AIV insect pest by 2017.	• Pest population data. • Reports. • Theses. • Questionnaires. • Publications. • Pesticide use statistics. • Residue level statistics.	• Laboratory records. • Field experiments and data collection. • Farmer interviews. • Surveys.	• Growers' acceptance and cooperation. • Political situation is favorable. • No extreme weather conditions (e.g. drought, flood). • No crop failure. • Security situation in target areas does not prevent or interrupt project implementation. • NARS cooperate in the project implementation.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• The role of indigenous natural enemies against at least one AIV insect pest determined by 2017. • Classical biological control agents explored for at least one AIV insect pest by 2016. • Diversity, distribution and molecular characterisation of at least one species of nematode pest assessed on nightshade in Kenya by 2015. • Attract-and-kill strategy developed and tested against at least one AIV major insect pest by 2017. • The role of seed dressing assessed against at least one insect pest of AIV by 2018. • The effect of nematophagous fungi, agro-industrial waste and intercropping on the management of at least one nematode species assessed on nightshade by 2018. • Amaranth germplasm and commercial lines assessed against at least one major amaranth insect pest by 2018.			

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
4. Socio-economic constraints and opportunities for value addition of amaranth, leafy cowpea and nightshades production and protection assessed.	• Awareness on AIV IPM strategies created among agricultural extension officers, plant quarantine inspectors and farmers by 2018.	• Baseline information on current growers' knowledge, attitude and practices (KAP) with regard to IPM and other AIVs production measures collected by 2014. • The effect of growers training on growers KAP evaluated by 2018. • Constraints and opportunities for AIVs' production and marketing evaluated by 2016. • Impact of AIV IPM technologies assessed by 2018.	• Publications. • Theses.	• Farmer interviews. • Surveys.	• Growers willingness to cooperate and be interviewed. • Political situation is favorable.
5. Capacity building and technology transfer initiated with national agricultural research partners and growers.	• Capacity built with national agricultural research partners and growers.	• Awareness created among at least 100 agricultural extension officers and plant quarantine inspectors by 2018. • Awareness created among AIV farmers by 2018. • Number of training reports. • Popular articles, mass media reports. • Number of publications and theses.	• Training manuals and materials. • Project reports. • Training registers. • Crop yield statistics. • Domestic and export agro-statistics.	• Farmer field days. • Training of trainers.	• Stakeholders willing to participate in trainings. • No extreme weather conditions (e.g. drought, flood). • No crop failure. • Security situation in target areas does not prevent or interrupt project implementation. • NARS cooperate in the project implementation.
Specific Objective: African nightshade for capturing nematodes – using 'dead end trap crop' technology for tackling a new pest in East African potato production undertaken by 2019.					

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
1. PCN (potato cyst nematodes) characterised - characterisation of PCN species and pathotypes.	• PCN (*Globodera* spp.) identified to species level. • PCN populations from different regions established. • Pure populations of *Globodera* species established. • At least one pathotype identified.	• Number of PCN species identified. • Number of PCN populations established. • Number of resistant potato varieties selected.	• Publications. • Recommendations.	• Field survey of PCN in potato growing areas. • Interviews with farmers. • Laboratory experiments. • Pot experiments.	
2. Dead-end trap crop identified - potential trap crops among indigenous solanaceous vegetables in Africa identified and tested.	• At least 5 trap crops identified for trapping PCN. • At least 2 trap crop species evaluated under field conditions.	• Number of trap crops selected for further evaluation. • Number of farmers involved in field testing using the selected trap crops.	• Publications. • Recommendations for PCN management.	• Field trials. • Pot trials.	
3. Roots and exudates analysed - susceptible/ resistance factors in selected trap crop roots and their exudates elucidated.	• Mechanisms and composition of root exudates analysed for at least 5 trap crops.	• Number of trap crops and their root exudates analysed and evaluated on PCN hatching and behaviour.	• Publications.	• Laboratory experiments and analysis.	
4. Biopesticides selected – potent biopesticides for PCN controlled screened and identified.	• Selected biocontrol fungi comprising at least 2 different species evaluated against PCN under natural conditions. • Naturally occurring parasitic fungi in field populations of PCN identified.	• Number of biocontrol fungi selected as effective suppressors of PCN. • Novel species of fungi identified from Kenyan populations of PCN.	• Publications.	• Pot trials. • Laboratory experiments and characterisation of new fungal isolates.	
5. Farmers trained - capacity building and technology transfer initiated with national	• Partnerships with NARS established.	• Number of students trained/graduated. • Number of meetings held.	• PCN training manuals. • MSc thesis.	• Stakeholder meetings. • Workshops and trainings.	

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
agricultural research partners and potato growers.	• Joint stakeholder meetings conducted. • Students trained and graduated. • Farmers in main potato growing areas have obtained basic knowledge on PCN.	• Number of farmers reached.	• BSc project reports.	• Joint field trials.	
Specific Objective: Develop an agroecological farming system for horticultural crops profitable and adapted to smallholder famers with low environmental impact based on a netting technology adapted to tropical climate conditions combined with biological control technics, semiochemicals use and plant association by 2020.					
1. Implementation of a nethouse in 30 farms in 6 sites.	• Calculation of the return on investment (ROI) in relationship to the crops grown and the demographic of the potential adopters (e.g., largescale and smallholder farmers), including the cost-effectiveness of combining proven biological control agents (bio-pesticides) with net technology.	• Number of complete interviews on 30 farms.	• Publications. • Survey records. • Web resources.	• Field surveys. • Growers' interviews.	
2. Development of a business plans through collaborations with partners in sales/marketing evaluation.	• Identification of the barriers to sustained adoption of the technology by the target audience, including (a) broad awareness of the technology's potential impact as well as availability, and (b) grower access to innovative low-interest	• Number of interviewed farmers and stakeholder actors. • Number of partners involved in the evaluation.	• Web resources. • Survey records.	• Growers' interviews. • Stakeholders actors' interviews.	

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	loans or savings schemes that provide the investment capital needed to purchase the technology; and identification of solutions of where possible.				
3. Improve financial access for smallholder farmers to netting technology.	• A practical and sustainable financial loan scheme that provides funds at an acceptably low interest rate and appropriate repayment terms.	• Number of designed business plans.	• Web resources. • Survey records.	• Survey records.	
4. Creation of long-term commitment and investment by the prime partnering manufacturer to provide the EFNs/agronets and in addressing future designs improvements (wear and tear, bulk roll dimensions, row-cover and support frames, etc.).	• Manufacturing, distribution and sales of agronets, and the design of support structures.	• Number of nethouse kits sold.	• Publications. • Survey records. • Web resources.	• Nethouse kits. • Survey records.	
5. 4 training sessions on agroecological horticultural farming system based on netting technology in 7 sites.	• 926 farmers trained on agroecological horticultural farming system based on netting technology. • 54 stakeholder actors trained on agroecological horticultural farming system based on netting technology.	• Number of trained farmers and stakeholder actors.	• Publications. • Survey records. • Web resources.	• Farmers feedback. • Stakeholder actors feedback.	

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
6. Study of the distance and contact host plant search and selection strategy in order to identify push and pull stimuli.	• *Tuta absoluta,* whitefly, *Nesidiocoris tenuis, Encarsia formosa* rearing. • Identification of volatiles emitted by healthy, leafminer- or whitefly-infested tomato of 4 varieties. • Identification of repellent and attractant volatile blend for leafminer and whitefly. • Identification of compound emitted by healthy, leafminer- or whitefly-infested tomato trichomes of 4 varieties. • Identification of repellent and attractant trichome compound blend for leafminer and whitefly. • Identification of companion plant.	• Number of colonies. • Number of semiochemicals blend. • Number of identified companion plant.	• Survey records. • Student theses. • Reports. • Publications. • Web resources	• Insect colonies. • Laboratory data. • Student theses. • Reports. • Publications.	
7. Promotion of biological control.	• Identification of natural enemies of leafminer and whitefly in Kenya. • Study of the effectiveness of the use of 1 predator and 1 parasitoid.	• List of identified natural enemies.	• Survey records. • Student theses. • Reports.	• Field survey. • Laboratory data. • Student theses.	

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	• Identification of attractant semio-chemicals for natural enemies from tomato. • Identification of attractant semio-chemicals for natural enemies from the prey/host. • Identification of companion plant to attract natural enemies.				
8. Optimizing netting to enhance its effectiveness in terms of microclimate conditions and crop protection.	• Models of micro-climate under netting, pest and beneficial insect population dynamics. • Study of the effectiveness of semio-chemical-treated nets. • Study of the impact of push-pull companion plant arrangements for pest management in the field.	• Number of models. • List of interesting semio-chemicals for net treatment. • Design of the best push-pull companion plant arrangement for pest management in the field.	• Survey records. • Student theses. • Reports. • Publications. • Web resources	• Field survey. • Laboratory data. • Student theses. • Reports. • Publications.	• Climate conditions.
9. Environmental economic and social assessment of the crop protection strategy.	• Cost-benefit analysis of the system. • LCA of the farming system. • Socio-technical analysis of the tomato production in Kenya to facilitate the scaling up of this new	• CBA of at least 10 farms. • LCA of at leat the 4 modalities in the experimental station. • STA of at least 100 farms.	• Survey records. • Student theses. • Reports. • Publications. • Web resources.	• Field survey. • Farmers and stakeholder actors interviews. • Student theses. • Reports. • Publications.	• Willingness of farmers and stakeholder actors to be interviewed. • Climate conditions.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	agroecological tomato farming system.				
10. Crop rotation program for netting technology with high value crops and indigenous vegetables.	• Crop protection program for African nightshade. • Crop protection program for amaranth. • Communication tools.	• Field trial covering one crop cycle.	• Field survey. • Student report. • Video clip. • Educational sheet.	• Field trial. • Publications.	• Climate conditions.
Specific Objective: Develop ant-based repellent semio-chemicals as new IPM tools for fruit fly management.					
1. Identification of an ant-based repellent volatile	• Insect rearing program. • Identification of the gland synthetizing the repellent. • Identification of the bioactive compound.	• Number of colonies. • Bioassays. • Number of biological models tested. • Number of bioactive compounds tested.	• Publications. • Database. • Student report.	• Laboratory bioassays.	• Scientific risk: identification of a semio-chemical involved in predator detection by prey has never been identified before.
2. Assessment of ant-based semio-chemicals on parasitoids.	• Assessment of negative impact of repellent semio-chemicals on parasitoids. • Combination of repellent semio-chemicals with parasitoids in IPM program.	• Bioassays. • Number of biological models tested.	• Publications. • Database. • Student report.	• Laboratory bioassays.	• Lack of discovery of an ant-based repellent semio-chemical.
Specific Objective: Dissemination and promotion of mango fruit fly integrated pest management (IPM) technologies by 2020.					
1. Proven fruit fly IPM technologies disseminated and promoted among smallholder mango growers.	• Establish partnerships with NARS, NGOs, private sectors, farmers and farmer groups relevant for the implementation of the	• At least 5 partnerships established with national institutions and research partners relevant for implementation of fruit fly activities.	• Partnership agreements. • *icipe* project reports. • Field data. • Laboratory data.	• Fruit fly monitoring data. • Inventories of fruit flies. • Field climate data. • Surveys data. • Laboratory data. • Growers' testimonies.	• Research partners are committed and have capacity to contribute to research, dissemination and adoption of the fruit fly IPM technologies. • Political stability in the partner countries. • Partners willing to cooperate in testing and dissemination of the technology.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	fruit fly management activities. • Assess the fruit fly composition, abundance and damage at selected project action sites. • Evaluate, adapt and validate attractants and biopesticide usage at project action sites. • Conduct community-based dissemination and promotion of IPM technologies.	• The composition and abundance of damaging fruit fly species to mango established in at least 5 project action sites. • At least 2 food attractants and 1 biopesticides identified and adopted for use under local condition at action sites. • IPM package for fruit fly suppression disseminated and promoted to at least 10,000 growers at action sites. • Growers adopt at least 2-3 components of the IPM technologies. • Growers reduce fruit fly infestation by 70%; fruit damage reduced by 15%.	• Peer-reviewed publications.	• Impact assessment studies. • Lists of participating growers. • Socio-economic reports.	• Favourable weather conditions for field trials. • Growers willing to adopt the technology.
2. Efficient fruit fly parasitoids introduced, mass produced and released in the field, and their impact on invasive fruit fly species assessed.	• Process and obtain import permit for introduction of exotic natural enemies into Ethiopia. • Conduct baseline assessment to establish alternative wild and cultivated host fruit species for fruit flies and native natural enemies at the project action sites. • Study trophic interactions between	• Import permit for at least one parasitoid species granted by Ethiopian government. • At least 3 baseline assessment studies conducted in the project action sites to establish the host range of at least 2 fruit flies species. • Establish the native natural enemies for two fruit flies in at least 2 project action sites.	• Import permit. • Research data. • Field data. • Laboratory data. • Reports. • Peer-reviewed publications.	• Inventories of natural enemies. • Established and thriving parasitoid colonies. • Parasitism rate/impact. • Establishment date.	• Parasitoids amenable to rearing. • Partners have expertise and skills to rear the parasitoids. • Permission granted by country government for parastoid importation. • Growers and NARS willing to cooperate. • Growers and communities at large willing to integrate parasitoids in the ecosystems. • Favorable weather conditions. • Political stability. • No crop failure.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	native and exotic natural enemies, pest and selected host fruits. • Large-scale augmentative releases of *F. arisanus* and *D. longicaudata*. • Follow-up on establishment, colonisation/dispersal of released parasitoid species and assessment of their impact on invasive fruit fly populations on cultivated and wild host-plants.	• At least 2 trophic interaction studies for at least one natural enemy, one pest and one host fruit conducted. • At least one parasitoid colony established in each of the project benchmark sites with at least 250,000 wasps in place for mass releases. • At least 2 augmentative releases of one parasitoid species in the project action sites conducted. • At least one study on establishment and dispersal of one parasitoid species conducted in each project action site. • At least one impact study of one parasitoid species conducted on one cultivated and one wild fruit type in at least two project action sites.			
3. New cheap female-biased fruit fly attractants and parameters for postharvest treatment developed, and scientific mechanisms underpinning biopesticide efficacy resolved.	• Develop blends and formulations of new female-biased attractants from compounds of host fruit volatiles. • Identification of host marking pheromones. • Field testing and optimisation of host	• At least two formulations of female-biased attractants from host fruit volatiles developed. • At least two host marking pheromones identified. • At least one attractant field-tested and optimised for fruit fly monitoring and	• Laboratory bioassays. • Field data. • Reports. • Peer-reviewed publications.	• Availability of the formulations. • Availability of the host marking pheromones. • Inventories of endosymbionts. • Established hot water parameters.	• Newly developed attractants effective for fruit flies monitoring and suppression. • Identified pheromones effective for fruit flies host marking. • Permission granted by NARS. • Growers and NARS willing to cooperate • Political stability. • Favourable weather conditions. • No crop failure.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	fruit odours and host marking pheromones for fruit fly monitoring, mass trapping and suppression. • Development of food baits from yeast-based products and field testing for monitoring and suppression. • Assess defensive interactions between facultative endosymbionts and fruit fly biopesticide. • Establish and disseminate parameters for postharvest treatment based on hot water treatment of mango against fruit flies.	suppression in at least two project action sites. • At least one host marking pheromone field-tested and optimised for monitoring and suppression in at least two project action sites. • At least one yeast-based food baits developed and field-tested at the project action sites. • Endosymbionts screened and characterised in at least one fruit fly species; defensive interactions between facultative endosymbionts and the most potent fruit fly biopesticide established. • Postharvest treatments based on hot water treatment established for at least three mango export cultivars.			
4. Socio-economic impact of the introduced fruit fly IPM and classical biological control technologies assessed.	• Develop baseline of knowledge, attitudes and practices (KAP) related to mango production and IPM technologies using complementary methods including focus group discussions and household surveys	• Baseline on KAP related to mango production and IPM technologies developed in at least two project action sites. • At least one ex-ante study undertaken in at least two project action sites; income of growers increased by at least 20% in at least two project	• Socio-economic reports. • *icipe* project reports. • M&E reports. • Peer-reviewed publications.	• Established learning sites. • Established farmer groups. • Training materials.	• Growers and NARS willing to cooperate. • Political stability. • Favourable weather conditions. • No crop failure.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	with data disaggregated by sex and age. • Undertake an ex-ante impact assessment to assess economic impact of IPM implementation. • Conduct a follow-up ex-post impact assessment of IPM upscaling on smallholder farms with data disaggregated by sex and age.	action sites; mango rejection reduced by at least 25% in at least two project action sites; reduction of insecticide use by at least 30% in at least two project action sites. • At least one ex-post impact assessment study undertaken in at least two project action sites; income of growers increased by at least 20% in at least two project action sites; mango rejection reduced by at least 25% in at least two project action sites; reduction of insecticide use by at least 30% in at least two project action sites.			
5. Capacity of NARS and other partners in the transfer of fruit fly IPM and classical biological control technologies strengthened.	• Train NARS (training of trainers) on preharvest management packages. • Conduct farmer field school (FFS)/IPM technology learning hands-on training. • Carry out public awareness to facilitate large-scale adoption.	• At least 40 agricultural personnel and extension/ quarantine officers identified and recruited for project implementation • At least three ToT workshops for training of NARS conducted in the project action sites • At least 40 agricultural personnel and extension/ quarantine officers trained on preharvest	• Research data. • Reports. • Theses. • Peer-reviewed publications.	• Training materials. • List of trained NARS. • Model farmer contacts. • Demonstration sites. • Awareness campaign CDs. • List of graduate students. • List of farmers.	• Stakeholders willing to participate in trainings. • Political stability. • Effective linkages with universities exist.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	• Advanced level training.	management packages in each project action site. • At least one model farmer identified in each project action sites • At least one IPM learning site identified and used for dissemination of the fruit fly IPM package in each project action site • At least 6 farmer field days conducted in the project action sites. • At least 60,000 fruit fly training materials (manuals, flyers, posters) distributed to NARS and growers in the project action sites • At least one awareness campaigns conducted through different media (e.g. on local radio stations, TV, farmers' magazines, etc.) • At least one farmers' listening group formed in each project action site • At least 200 CD recorded/ magazines on awareness campaigns distributed to farmers' listening groups. • At least two PhD students trained in the project lifespan on fruit flies and management.			

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
Specific Objective: Alien invasive fruit flies in Southern Africa: implementation of a sustainable IPM programme to combat their menaces.					
1. Sustainability of the mango production for food and nutrition security through the adaptation, dissemination and scale up of proven fruit fly IPM technologies enhanced.	• Enhanced Mango yield. • Use of synthetic chemical insecticide significantly reduced.	• Mango yield increased by at least 25% by 2022. • Reduction in chemical insecticide use by 50% by 2022. • 40 demonstration and learning sites for scaling up proven IPM technologies established in Zambia, Zimbabwe, Malawi and Mozambique by 2019. • At least one working paper on landscape level land use and land cover characterisation to guide the implementation of the IPM technologies by 2021. • Maps and a working paper elucidating suitable areas for parasitoid establishment to guide their release by 2021.	• Field data. • Laboratory data. • Peer-reviewed publications. • *icipe* and project .partners' annual report.	• Fruit fly monitoring data. • Growers' testimonies. • Lists of participating growers. • Socio-economic reports.	• Political stability in the project countries. • Partners' willingness to cooperate in testing and dissemination of the technology. • Growers willingness to adopt the technology. • Research partners' willingness and capacity to contribute to research, dissemination and adoption of the fruit fly IPM technologies. • Favourable weather conditions.
2. The role of biocontrol agents (*F. arisanus* and *D. longicaudata*) in suppression of the alien invasive *Bactrocera dorsalis* enhanced.	• Institutional and personnel capacity on application of biological enhanced. • Native and invasive fruit flies significantly supressed. • National laboratories for parasitoid rearing upgraded.	• Mass rearing of introduced parasitoids by 2019. • Upgrading national laboratories for parasitoid rearing by 2020. • Obtain import permit for the introduction and releases of parasitoids in the target countries by 2019.	• Report. • Publication. • Theses.	• Laboratory assessments. • Country report. • Dossier for parasitoid import permit. • Field trials.	• Stakeholders and policy makers provide a conducive environment for promotion and use of biocontrol agents. • Import permit of biocontrol agents obtained in time. • Conducive environment exists for mass rearing of parasitoids. • Partners have capacity to effectively rear biological agents • Insects are amendable for rearing. • Local capacity available to upgrade labs and upgrading completed on time.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• Introduction and large-scale augmentative releases of *F. arisanus* and *D. longicaudata* by 2020. • Assessment of establishment, colonisation/ dispersal of released parasitoid species, and assessment of their effectiveness on *B. dorsalis* populations by 2022.			• Local governments' regulatory bodies and partners are proactive to facilitate granting parasitoid import permit in time. • Political stability.
3. Socio-economic and gender impact of the IPM interventions in the mango production and value chain assessed.	• Differential impact of socio-economic status and gender on fruit flies IPM interventions in the mango production and value chain elucidated and documented.	• At least one ex-ante study undertaken by 2019. • At least 100 researchers, policymakers, farmers, extension officers and donors who are aware and who recognise the economic, social, environmental and human health impacts of interventions by 2022. • The socio-economic and gender impact of the IPM interventions in the mango production and value chain assessed by 2020. • Barriers and success factors for promoting, scaling up IPM technologies and increasing women and youth participation in the	• Report. • Publication. • Theses.	• Questionnaires. • Household survey. • Focus group discussion.	• Analytical capacity of national partners and their timely engagement in data analysis. • Participating farmers and other actors will cooperate in providing the necessary information through in-person surveys. • Political and security conditions will allow collection of household surveys in all countries. • Data of sufficient quality available on time, gender-disaggregation of key variables possible. • Capacity of national country teams for timely completion of surveys. • Timely availability of survey data and complementary on-farm trial data (available at *icipe* and partner institutions) • Proactive participation of partners in developing the M&E framework.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		mango value chain understood by 2020. • Cost-benefit analysis of the existing management practices and the proposed IPM technologies conducted by 2022.			
4. Human and institutional capacity for research and development for sustainable mango production in the target countries and beyond enhanced.	• Capacity of the beneficiaries in the target countries for sustainable mango production improved. • National and regional networks for implementation of area-wide fruit fly management initiated and fostered. • Agricultural innovation platforms (AIPs) to enhance stakeholder interaction and capacity for effective information sharing, and market linkages strengthened.	• At least 12 ToT workshops carried out by 2022. • At least 10 AIPs established by 2022. • 10,000 school students (disaggregated by gender) receive education on and become aware about IPM fruit fly management by 2022. • 20,000 extension training materials produced by 2022. • One million resource-poor farmers and policy makers are aware of fruit fly IPM by 2022. • Three post graduate scholars graduated by 2022.	• Training workshops. • Famer field days. • Student awareness campaigns. • Distribution of extension materials • Postgraduate students' enrollment.	• Reports on human and institutional capacity building. • Number of AIPs established. • Lists of trained personnel. • Number of postgraduate students trained. • Thesis.	• Proactive participation of partners in trainings. • Willingness for and active participation of partners to create the network. • Schools collaborate to sensitise students on fruit fly and IPM.
Specific Objective: Upscaling and institutionalizing of fruit fly IPM technology among smallholder fruit growers in East Africa by 2021.					
1. To establish the baseline damage caused by different fruit fly species on mangoes and intensify dissemination of fruit fly IPM approaches in the	• Regular and systematic fruit sampling of mango in the new target locations to ascertain	• Quantification of damage and composition of fruit flies. • Knowledge on host range of the main fruit flies.	• Baseline reports. • Data on fruit damage.	• Baseline survey. • Questionnaire. • Inventories of major fruit flies host range. • Inventories of pests.	• Favorable weather conditions. • Security situation does not prevent or interrupt activities. • NARS partners cooperate.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
new project action sites in Kenya, Ethiopia and Tanzania.	the damage, abundance and fruit fly composition. • Catalogue and establish the host range of major fruit-infesting fruit flies in the locations and establish seasonality of major mango-infesting fruit flies in the target locations. • Catalogue and assess the level of parasitism by native natural enemies attacking major fruit fly species in various locations in Zanzibar. • Identify suitable and easily accessible sites in consultation with NARS, growers and farming communities in the new project benchmark sites and establish IPM learning sites. • Participatory demonstration activities carried out that encompass various IPM management options and assess the impact	• Knowledge on seasonality of major fruit flies in target locations. • Availability of inventory of native enemies of fruit flies attacking key fruits and their parasitism levels in the project benchmark sites of Zanzibar, Tanzania. • Number of IPM technology sites established. • Number of model farms with display panels. • Number of demonstration sessions on the available fruit fly IPM technologies to growers with NARS. • Number of impact assessments undertaken by NARS. • Condition of *icipe* cultures of the two parasitoid species. • Number of mass releases carried out. • Availability of parasitism levels of the two parasitoid species.	• Project workplan. • Field reports. • Publications.	• Inventory of natural enemies.	• Growers cooperate and allow access to and sampling from their orchards.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	jointly with NARS and growers. • Boost colonies of the two parasitoid species (*F. arisanus* and *D. longicaudata*) at *icipe* for introduction and mass releases in the project benchmark sites.				
2. To develop capacity on IPM and good agricultural practices for NARS and growers to support up-scaling of fruit fly IPM technologies in the project target countries.	• ToT workshop on fruit fly biological control and IPM technologies conducted for extension officers and community extension service providers in the project benchmark sites. • Awareness campaigns and sensitisation on availability of fruit fly IPM in project benchmark sites in Kenya, Ethiopia and Tanzania conducted for farmers, farmer groups and the community at large. • ToT workshop on parasitoid rearing at *icipe* carried out for NARS partners on natural enemy production, releases	• Number of NARS and CESPs trained. • Number of training materials handed out. • Number of awareness campaigns. • Number of growers reached. • Number of NARs trained on parasitoid rearing.	• Training reports. • Photos of on-farm demonstration session in all project countries. • Demonstration sites with display panels.	• Established learning sites. • Model farmer contacts. • Lists of model farmers. • Lists of trainers trained. • Testimonies from trained personnel. • Training certificates.	• Favorable weather conditions. • Security situation does not prevent or interrupt activities. • NARS partners cooperate. • Potential members of CESPs are identified and cooperate. • Local authorities cooperate and participate. • Growers and NARS cooperate.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	and assessment of impact.				
3. To create linkages and partnerships for enhanced transfer and upscaling of fruit fly IPM technologies and strengthening of the mango value chain in Kenya, Ethiopia and Tanzania.	• Approval by county governments to open outlets to supply fruit fly IPM technologies at the grassroot level for growers' accessibility. • Database of mango growers in the project countries created. • Linkages between suppliers and growers/growers' association have been created to increase demand/supply of the fruit fly IPM technologies at the grassroot level and enhance scaling up and uptake of the technologies. • Innovative market information exchange apps (interactive platforms) for fruit fly IPM technologies developed that link the growers (vegetables and fruits) and the suppliers. • Contract and engage NARS partners and growers in resource mobilisation at local	• Numbers of stakeholder meetings taken place. • Number of approvals by county governments. • Number of databases of mango growers reached from previous project phases and the proposed phase. • Accessibility of database. • Awareness of private sector. • Number of private sector partners supplying the technologies to the growers. • Number of interactive platforms. • Number of committees formed. • Number of meetings with NARS on resource mobilisation for IPM technologies sustainability.	• Meeting minutes. • Meeting and project reports. • Written conversation with county governments. • Written conversation with private sector partners. • Project report. • Testimonies from recipients.	• Meeting attendant lists. • Published database. • Stakeholder testimonies. • Functional interactive platform of growers and private sector partners. • Meeting reports. • List of NARS and farmer groups. • List of resource mobilisation committee members.	• Favourable weather conditions. • All stakeholders willing to cooperate. • Political stability. • Producers have access to phones and internet. • Suppliers are interested in using the platform. • Local authorities cooperate and participate. • Growers, NARS and CESPs cooperate.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	and regional levels to enable them undertake field testing and continued sharing of the fruit fly IPM technologies in the communities.				
Specific Objective: Develop IPM tools and strategies for major coffee pests in East Africa based on a better knowledge of their bioecology by 2020					
1. Thermal requirements characterisation for major coffee pests in East Africa.	• Thermal thresholds determined for *Hypothenemus hampei*, *Monochamus leuconotus* and *Antestiopsis thunbergii* through life table study at constant temperatures and phenological modelling.	• 3 publications. • Thermal requirements of 3 major pests of coffee in East Africa. • Set of models available for further demographic simulations for 3 major pests of coffee.	• Published data. • Published papers. • Project reports. • PhD thesis.	• Scientific journals.	• Quality of data adequate for the purpose.
2. Distribution mapping for major coffee pests in East Africa, in the current climate situation and in different scenarios of climate warming.	• Demographic parameters simulated from phenological models for *Hypothenemus hampei*, *Monochamus leuconotus* and *Antestiopsis thunbergii.* • A set of risk maps for the 3 pests on coffee in the current climatic situation and in different scenarios of climate warming.	• Sets of risk maps published in scientific journals. • Sets of risk maps available as a component of an IPM program for major coffee pests, targeting stakeholders of the coffee industry.	• Maps and models. • Project reports. • PhD thesis.	• Scientific journals. • Databases.	• Quality of data adequate for the purpose.
3. Characterisation of major coffee pest population	• Networks of smallholding coffee	• Data sets available for modelling work.	• Maps and models.	• Scientific journals. • Databases.	• Stable security situation prevails to collect data.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
dynamics in coffee farms and of agroecological factors impacting the dynamics.	farms implemented for observation in different locations. • Data sets for monthly monitoring of *Hypothenemus hampei*, *Monochamus leuconotus* and *Antestiopsis thunbergii* populations and damage in different locations of East Africa. • Main agroecological factors characterised for coffee farms, including microclimate, shade, coffee fruiting cycle, farmer practices. • Models describing the impact of main agroecological factors on major coffee pest dynamics. • IPM recommendations developed based on these models.	• Models describing the impact of agroecological factors on major coffee pest dynamics published in scientific journals. • Sets of IPM recommendations for shade management and other best practices available for major coffee pests, targeting stakeholders of coffee industry.	• Project reports. • PhD thesis.		• Quality of data adequate for the purpose.
4. Identification and utilisation of semio-chemicals in the management of *Antestiopsis thunbergii*.	• Promising bioactive volatiles isolated from coffee berries or conspecifics.	• A set of bioactive compounds available for field assessment. • 1 publication for promising kairomones for the control of *A. thunbergii.*	• Research data. • Reports. • Publications. • PhD thesis	• Laboratory bioassay data. • Field trials data. • Research publication.	• Semiochemicals and sex pheromones can be identified.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• 1 publication for promising pheromones for the control of *A. thunbergii*.			
Specific Objective: Promote adoption of push-pull technology for effective management of striga, stemborers, fall armyworms infestation and aflatoxin contamination of cereals through collaboration with international and national partners by 2020.					
1. Push-pull technology implemented by over 120,000 farm households, and indirectly benefit over 720,000 people in East Africa.	• Food sufficiency and household incomes of 120,000 push-pull farmers increased by at least 50% by 2019 through higher and sustained crop, fodder and milk yields.	• Acreage of farmland under push-pull. • Household income levels attributable to push-pull. • Number of households having food sufficiency. • Number of farmers having improved dairy animals. • Number of push-pull farmers utilising fodder from push-pull in their dairy production. • Number of dissemination channels optimised and employed. • Cereal and fodder yields and milk production levels among target farmers. • Number of partnerships formed. • Number of stakeholders trained.	• Baseline data, maps and reports. • Ex-ante and ex-post impact assessment reports on household food security, nutrition and incomes. • Project reports. • Country and county sub-programme. • Reports by development partners.	• Baseline surveys. • Ex-ante and ex-post surveys. • PM&E.	• Commitment and cooperation of national institutions, extension networks and participating NGOs, CBOs, farmers and their support groups assured. • Technical expertise is available for developing new technological innovations and a backstopping framework. • Conducive weather conditions.
2. An integrated management approach for Napier stunt disease.	• Improved incomes and livelihoods of at least 5000 Napier farmers in Western Kenya by at least 50% through adoption of an integrated Napier stunt disease	• Quantity of Napier grass and milk produced. • Number of alternative fodder grasses in use. • Number of farmers using the integrated disease management approach.	• Published data. • Published papers. • Project reports.	• Field and laboratory data sheets. • M&E instruments. • Surveys.	• No overwhelming confounding factors (e.g. unusual weather, political instability) affect interpretation of the results. • Good cooperation and communication between stakeholders. • Farmers willing to adopt the cultivars. • Screened Napier cultivars remain resistant to NSD.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	management strategy, characterised by increased fodder and milk production by 2019.	• Number of partnerships formed. • Number of stakeholders trained on integrated disease management. • Number of peer-reviewed publications.			
3. Stemborer and fall armyworm management approach developed by exploiting early herbivory traits and plant signalling	• Staple food sufficiency achieved by at least 20,000 farmers in Western Kenya by 2020 though grain yield increases by 30%. • Novel scientific knowledge on early herbivory and plant signalling generated and applied in crop protection by scientists, extension agents and policy makers by 2020.	• Number of 'smart' maize varieties with early herbivory traits identified. • Number of farmers adopting the use of 'smart' maize varieties. • Increase in grain yields. • Number of food sufficient households as a result of use of 'smart' maize varieties. • Number of peer-reviewed publications on early herbivory and plant signalling. • Number of stakeholders trained on stemborer and fall armyworm control by exploiting inherent plant defence traits.	• Project reports • Scientific papers. • M&E reports.	• Field and laboratory data sheets. • Scientific journals. • M&E instruments. • Surveys.	• Partners remain supportive. • Farmers willing to adopt the cultivars. • Conducive weather conditions.
4. Fall armyworm management approach developed by understanding the mechanism by which push-pull controls the pest by 2020.	• Scientific knowledge generated and included in integrated management of fall armyworm in Africa by scientists, extension agents and policy makers by 2020.	• Percentage change in fall armyworm infestation in push-pull cereal fields. • Number of farmers adopting the use of push-pull integrated fall armyworm management approaches.	• Project reports. • Scientific papers. • M&E reports.	• Field and laboratory data sheets. • Scientific journals. • M&E instruments. • Field surveys.	• Partners in the integrated management of fall armyworm remain committed and supportive. • Farmers willing to adopt push-pull in integrated management of fall armyworm. • Integrated management of fall armyworm, including push-pull, is mainstreamed in country policy frameworks.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• Number of peer-reviewed publications on integrated management of fall armyworm using push-pull technology. • Number of stakeholders trained on FAW control by using the Push-pull strategy.			
5. An integrated management approach developed and implemented for *Striga* control in maize in Western and Southern Africa.	• Food sufficiency and livelihoods of at least 30,000 smallholder farmers improved by at least 50% by 2018 through efficient control of *Striga* resulting in increases in maize yields by at least 50%.	• Number of farmers practising integrated *Striga* control methods. • Acreage under integrated *Striga* control methods. • Grain yield increases attributable to integrated *Striga* control. • Number of stakeholders trained on integrated *Striga* control. • Number of publications. • Number of partnerships formed. • Number of partners' joint field days conducted.	• Reports and published papers on integrated *Striga* control. • Project reports. • Scientific papers. • M&E reports.	• M&E surveys. • Project reports.	• No overwhelming confounding factors (e.g. unusual weather, political instability) affect interpretation of the results. • Good cooperation and communication between stakeholders.
6. Food and nutrition safety improved by controlling mycotoxin contamination in maize through push-pull technology by 2020.	• At least 10,000 farmers in western Kenya reduce aflatoxin and other mycotoxin contaminations of maize crop harvests by 30% by 2020.	• Number of farm households with reduced aflatoxin contamination in maize grown in push-pull farms.	• Reports and published papers on integrated *Striga* control. • Project reports. • Scientific papers. • M&E reports.	• M&E surveys. • Project reports.	• No overwhelming confounding factors (e.g. unusual weather, political instability) affect interpretation of the results. • Good cooperation and communication between stakeholders.
Specific Objective: Baseline information of plants - Lepidoptera stemborers – parasitoids interactions by 2020.					

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
1. Baseline information on host plant selection mechanisms by Lepidoptera stem borers (Noctuidae) and refugia of lepidopteran maize stemborers and associated parasitoids during non-cropping season.	• Description of herbivore- plant volatiles induction on oviposition within a community of maize Lepidoptera stem borers. • Study on the importance maize residues to ensure the carry-over of maize stemborers and their associated parasitoids during the non-cropping season as compared to surrounding wild habitat.	• Conspecific or heterospecific larvae-infested maize plants produce specific chemical signatures that female moths use as host cues. • Description of the importance of maize residues as compared to wild habitat to ensure the carry-over of maize stemborers and their associated parasitoids. This is valid in regions where the wild habitat is reduced.	• Identification of volatiles attracting female moths. • Comparisons of two techniques of volatiles collection. • PhD Student thesis. • Publications. • Reports.	• Laboratory data on volatiles analyses. • Surveys. • Laboratory bioassays.	• No extreme weather conditions (e.g. drought, floods). • Security situation in target areas does not prevent or interrupt project implementation. • Farmers cooperate. • Availability of the studied insects.
2. Impact of fall armyworm invasion on maize stemborers' communities and their associated parasitoids in maize field in a context of climate change (part of the FAW EU Project).	• Study on the effect of temperature on interactions between a community of lepidopteran maize stemborers and the fall armyworm under laboratory conditions. • Study on the effect of larval density and duration on the competition outcomes between lepidopteran maize stemborers community and the fall armyworm under laboratory conditions.	• Identification of the type of intraspecific interaction that characterises fall armyworm larvae resource utilisation and their interspecific interactions with maize stemborers communities including *B. fusca, S. calamistis* and *C. partellus*, and information on the effect of temperature on these interactions under laboratory conditions. • Evidence that the introduction of *Spodoptera frugiperda* had changed	• PhD student thesis. • Publications. • Reports.	• Surveys. • Laboratory bioassays.	• No extreme weather conditions (e.g. drought, floods). • Security situation in target areas does not prevent or interrupt project implementation. • Farmers cooperate. • Availability of the studied insects.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	• Study on the Influence of the recent introduction of the fall armyworm, Spodoptera frugiperda (Lepidoptera: Noctuidae), on maize stemborers and their associated parasitoids composition in maize fields in Kenya. • Study on host acceptance by the stemborer's parasitoids, *Cotesia flavipes* and *C. sesamiae* towards *Spodoptera frugiperdae* larvae.	the equilibrium of maize stemborer communities and showed to be able to co-habit with stemborer species as additional pest in maize fields across the cropping seasons in different agro-ecosystems. • Identification of the effect of larval density and duration on the competition outcomes between lepidopteran maize stemborers community and fall armyworm. • Confirmation if *C. flavipes* and *C. sesamiae* are able or not to parasitise *S. frugiperda*.			
3. Genome sequencing of *Busseola fusca*.	• To understand the biology of *Busseola fusca*, we sequenced, assembled and annotated the genome and transcriptome of this important maize pest.	• Genome and transcriptome of *B. fusca* sequenced, assembled and annotated. .	• Research data. • Publication. • Databases of the sequenced DNA and RNA.	• Extensive bioinformatics.	• Constant international collaborations. • Insects availability.
4. Baseline information on host selection mechanisms by *Cotesia* spp. parasitoids (Braconidae) of Lepidoptera stemborers.	• Determination of the candidate genes involved in host acceptance by *Cotesia sesamiae*.	• Genetic studies that involve use of two *Cotesia sesamiae* populations (differing in *B. fusca* acceptance) could be useful in the identification the candidate genes involved in host acceptance	• Research data. • Reports.	• Laboratory bioassay data and extensive behavioral experiments.	• Insect availability. • Healthy insects.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		by this parasitoid species. This study is geared towards the determination of the candidate genes involved in host acceptance through cross-mating the two C. sesamiae populations in the laboratory to provide a proof for the heritability of host acceptance in the resulting progenies.			
Specific objective: Exploration for biological control of the invasive Guineagrass in USA by 2019.					
1.Conduction of an Africa-wide collection of Guineagrass and analysis of DNA to determine molecular match between African Guineagrass and the invasive American Guineagrass.	• Collections of Guinea grass from 16 countries in Sub-Saharan countries (South Africa, Botswana, Zimbabwe, Mozambique, Zambia, Cameroon, Democratic Republic of Congo, Tanzania, Uganda, Ghana, Togo, Ivory Coast, Benin, Nigeria, Ethiopia and different regions of Kenya).	• Collections of Guinea grass from 5 African countries (South Africa, Botswana, Cameroon, Ghana and Tanzania) and all planned regions of Kenya.	• Project reports.	• Laboratory records. • Field collections. • Publication	• Presence of Guinea grass in the field. • Presence of good rainy seasons for Guinea grass collection.
Specific objective: Integrated pest management strategy to counter the threat of invasive fall armyworm to food security in Eastern Africa (FAW-IPM) by 2022					
1. Establishing an emergency community-based fall armyworm monitoring, forecasting, early warning and management system (CBFAMFEW) in Eastern Africa.	• Community-based fall armyworm monitoring, forecasting and early warning established in target regions of Uganda, Burundi and Rwanda that aid in	• Number of national/ county/sub-county fall armyworm officers/staff trained as ToT for community training. • Number of pheromone traps established, and	• Project reports. • Popular articles. • Online maps.	• Meeting participation list. • FAO website. • FAO data portal.	• Continued community willingness to participate in CBFAMFEW. • Mobile connectivity is stable for the purpose.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	timely interventions for fall armyworm management. • Enhanced awareness on CBFAMFEW among policy makers, extension agencies and growers in Uganda, Burundi and Rwanda.	mobile applications downloaded by community focal persons in Uganda, Rwanda and Burundi. • No. of districts, villages covered by the community-based fall armyworm network in Uganda, Rwanda and Burundi.			
2. Regional preparedness, early warning, information on available management options and capacity for timely response to fall armyworm infestation in Eastern Africa enhanced.	• Extension agencies and maize growers in Kenya, Tanzania, Ethiopia, Rwanda and Uganda have access to fall armyworm monitoring and surveillance tools. • Additional effective fall armyworm IPM options available. • Best-bet cultural practices for fall armyworm management promoted.	• At least 100 extension officers per target country have access to monitoring surveillance tools by 2022. • At least 100,000 men and women maize growers (of which 30% are women) in Kenya, 75,000 in Tanzania, 75,000 in Ethiopia, 20,000 in Rwanda and 20,000 in Uganda have access to monitoring surveillance tools by 2022. • By 2020, one additional effective fall armyworm IPM option registered and available for commercialisation. • At least 3 best-bet cultural practices identified and promoted by 2019.	• Project reports. • Training reports. • Dissemination data.	• Surveys. • M&E surveys. • Publications. • News articles. • FAO web portal.	• No extreme weather conditions (e.g. drought, floods). • Security situation in target areas does not prevent or interrupt project implementation. • Partners remain supportive. • Farmers willing to adopt the IPM practices.
3. Knowledge on the biology and ecology of fall armyworm enhanced.	• Enhanced understanding on the biology of fall	• At least 3 publications highlighting fall armyworm	• Project reports. • Publications.	• Laboratory and field experiments and demonstrations.	

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	armyworm in East Africa for development of fall armyworm IPM strategies.	bio-ecology completed by 2021.	• PhD and MSc theses.	• Journal websites. • University and ARPPIS web links.	
4. Effective natural enemies for fall armyworm identified, introduced, tested and released in target countries.	• Both indigenous and introduced natural enemies of fall armyworm effectively conserved for natural control of FAW in East Africa.	• At least 1 effective natural enemy released in 3 target countries by 2020. • At least 100,000 parasitoids released per country by 2022.	• Project reports. • Publications. • PhD and MSc theses.	• Laboratory and field experiments and demonstrations. • Journal websites. • University and ARPPIS web links.	
5. Novel and environmentally-friendly biocontrol technologies developed, tested and disseminated for fall armyworm management.	• Novel biopesticides and their application strategies available for fall armyworm management in East Africa.	• At least 2 biocontrol technologies developed by 2020. • At least 25,000 growers in 3 target countries directly benefitting from biocontrol technologies by 2022.	• Project reports. • Publications. • PhD and MSc theses.	• Laboratory and field experiments and demonstrations. • Journal websites. • University and ARPPIS web links.	•
6. Habitat management strategies for FAW control optimised and scaled out to smallholder maize growers.	• Habitat management and other cultural practices optimised and scaled out for fall armyworm management in East Africa.	• 25,000 maize growers using fall armyworm control push-pull by 2022.	• Project reports. • Publications. • PhD and MSc thesis.	• Laboratory and field experiments and demonstrations. • Journal websites. • University and ARPPIS web links.	
7. Locally adapted fall armyworm-resistant maize cultivars, hybrids and landraces in Africa identified.	• Fall armyworm-resistant maize cultivars available for maize growers.	• At least 1 fall armyworm-resistant cultivar availed and disseminated in partnering countries.	• Project reports. • Publications. • PhD and MSc thesis.	• Laboratory and field experiments and demonstrations. • Journal websites. • University and ARPPIS web links.	
8. Implementation of IPM strategy to counter fall armyworm infestation in Eastern Africa jointly with maize crop growers,	• Fall armyworm IPM strategy effectively implemented in partnership with maize growers, private	• At least 100,000 maize growers in Kenya, 75,000 in Tanzania, 75,000 in Ethiopia, 20,000 in Rwanda and 20,000 in	• Project reports. • Training reports. • Dissemination data. • News articles.	• Surveys. • M&E surveys. • Publications. • News articles. • FAO web portal.	• No extreme weather conditions (e.g. drought, floods). • Security situation in target areas does not prevent or interrupt project implementation. • Partners remain supportive.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
private sector, NARS, NGOs and growers enhanced.	sector, NARS, NGOs and growers and widely available for adoption.	Uganda reached with sustainable fall armyworm IPM technologies by 2021. • At least 40% of the maize production area affected by fall armyworm (341,262 ha) in the target project areas covered by at least 1 effective IPM option by 2022. • At least 3 technology demonstrations in each country in each year. • At least 1 TV program/Youtube video; 1 radio program and 1 news article per year developed and translated. • At least 5,000 booklets/ posters/ brochures on fall armyworm developed, printed and distributed each year. • At least one fall armyworm microsite developed and maintained.	• Field demonstration reports. • Website reports.		• Farmers willing to adopt the IPM practices.
9. Research capacity in Eastern Africa to develop and implement a sustainable IPM strategy for fall armyworm enhanced.	• Enhanced capacity for research among researchers and institutions for development and implementation of fall armyworm IPM strategies.	• At least 750 stakeholders trained through ToT events by 2022. • At least 3,000 lead maize growers in each project country participate in technology dissemination activities.	• Publications. • PhD and MSc theses. • ToT reports. • Dissemination reports. • Policy briefs.	• M&E surveys. • Publications. • Journal websites. • University and ARPPIS web links.	• Partners remain supportive. • University regulations are conducive for timely completion of research.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• At least one post-doc, 3 PhD and 5 MSc students trained on fall armyworm research by 2022. • At least one open day for policy makers and NARS partners in each year.			
10. Livelihood, environmental and gender impacts of fall armyworm along the maize value chain in Eastern Africa determined and utilised for decision making.	• Socio-economic, environmental and gender impacts of fall armyworm management facilitate promotion of fall armyworm IPM strategies.	• At least 150 high-level stakeholders reached per country with fall armyworm evidence note by 2022. • At least 50% of the maize growers to be included in the survey in the target areas aware of the socio-economic benefits of the sustainable fall armyworm IPM options.	• Publications. • PhD and MSc theses. • Policy briefs.	• M&E surveys. • Publications. • Journal websites. • University and ARPPIS web links.	• Partners remain supportive. • Stakeholders effectively participate in surveys.
Specific Objective: Strengthening citrus production systems through the introduction of IPM measures for pests and diseases in Kenya and Tanzania by 2018.					
1. Critical gaps in knowledge surrounding the distribution, population dynamics, damage and molecular ecology of targeted pest species and their associated natural enemies filled	• The distribution, abundance and dynamics of ACP (African citrus psyllid) and FCM (false codling moth) and their natural enemies established by 2017. • Develop predictive phenology models for ACP and FCM under varying climate change scenarios by 2016. • Study on molecular ecology of different	• The distribution, abundance and dynamics of ACP and FCM known by end of 2017. • The identity, species composition, and abundance of at least 70% of associated natural enemies known by end of 2017. • Role of biotic (predation, parasitism and disease) and abiotic factors (climate) affecting dynamics of ACP and FCM determined by 2016.	• Pest distribution maps. • Research data. • Student theses. • Reports. • Publications.	• ACP and FCM monitoring data. • Inventories of ACP and FCM natural enemies. • Field climate data. • Surveys data. • Laboratory data on molecular biology.	• Political situation is favourable. • No extreme weather conditions (e.g. drought, flood). • Security situation in target areas does not prevent or interrupt fieldwork. • NARS partners and farmers cooperate. • Insect amenable to rearing.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	populations of ACP and FCM conducted by mid 2017.	• Predictive phenology models for ACP and FCM under varying climate change scenarios made available by end of 2016. • Molecular ecology of varying populations of ACP and FCM established by mid 2017. • Vibrant colonies of ACP and FCM established by end of 2015.			
2. The incidence, severity and distribution of huanglongbing (HLB)/citrus greening determined; and pathogen-vector interaction assessed.	• Countrywide survey conducted and the incidence, severity and spatio-temporal patterns of distribution of HLB assessed using molecular tools by end of 2017. • The role of HLB infection on ACP vector competence, fitness parameters and dispersal capability assessed by quantitative real-time PCR assays by end of 2017. • Stochastic models developed to assess the patterns of spread of HLB disease by end of 2015. • HLB disease distribution and	• Incidence, severity and spatio- temporal patterns of HLB established and geo-referenced maps of their distribution in the two countries made available by end of 2017. • Role of HLB infection on ACP vector competence, fitness parameters (e.g. fecundity) and dispersal capability established using qRT-PCR by end of 2017. • Stochastic model to assess the patterns of disease spread developed by end of 2015. • Hyperspectral pattern of disease spread and regional distribution established using remote sensing tools by end of 2017.	• Research data. • Reports. • Student theses. • Publications.	• Survey data. • Laboratory data on molecular identification and qPCR. • Field climate data. • Maps.	• Political situation is favorable. • No extreme weather conditions (e.g. drought, flood). • Security situation in target areas does not prevent or interrupt fieldwork. • NARS partners and farmers cooperate.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	potential implications on citrus industry on a regional scale assessed using earth observation tools by end of 2017.				
3. Ecologically sustainable management methods for ACP and associated HLB disease, and FCM developed, tested and implemented.	• Behavioural evidence for kairomonal and female-produced sex attractants and repellents in ACP studied and tools for monitoring and suppression developed by end of 2017. • Potent fungal and viral-based biopesticides and natural products identified, tested and implemented for management of ACP and FCM by end of 2017. • An efficient attract-and-kill product that can be used in combination with biopesticides for management of both pests identified by end of 2017. • Citrus plant materials/root stock for HLB resistance	• At least two kairomonal and female-produced sex attractants and/or repellents of ACP identified by end of 2016. • Synthetic analogues of the identified semio-chemicals tested in wind tunnel and in field cages by end of 2017. • At least two isolates of EPF identified and their efficacy tested against ACP and FCM, and one virus product introduced and field tested against FCM by end of 2018. • An IPM measure that combines the use of one soft chemical and biopesticide tested for ACP by end of 2016. • At least one attract-and-kill product introduced into one country, field tested in combination with biopesticide against FCM by end of 2017. • At least 20 citrus genotypes screened for	• Research data. • Reports. • Student theses. • Publications.	• Laboratory bioassay data. • Field trials data.	• Semiochemicals and sex pheromones are identified. • Virulent entomopathogens and natural products are identified. • Clean citrus planting materials/ budwood and stock can be identified. • Geographically isolated locations can be identified to establish insect proof nurseries. • Willingness of farmers to adopt new technologies.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	screened by mid 2017 using a participatory on-farm approach ACP proof nurseries established in strategic locations for production of clean nursery stock and HLB free materials produced by mid 2017. • Best-bet IPM technology for controlling ACP and FCM among citrus growers at selected project action sites implemented by 2017.	tolerance/resistance to HLB by mid 2017. • At least two insect-proof nurseries established and 500 HLB-free clean stock, produced by mid 2018. • Best-bet technologies based on rotational application of biopesticide and soft chemical and clean planting materials for ACP and HLB management, and biopesticides and attract-and-kill for FCM implemented by 2017.			
4. Socio-economic assessment of the importance of the ACP and associated HLB disease, and FCM, and the impact of IPM on target biotic constraints established.	• Baseline data on farmers' knowledge, attitude and practices of ACP, HLB and FCM management collected by end of 2015. Economic impact of ACP, HLB and FCM on citrus production established by end of 2016. • Potential impact of IPM interventions evaluated by end of 2016. • Ex-post assessment of implemented IPM management options	• Baseline data on farmers' knowledge and management practices for ACP, HLB and FCM conducted and information on knowledge, attitude and practices collected in at least one action site by end of 2015. • Economic impact of ACP, HLB and FCM on citrus production assessed in at least one action site by end of 2016. • Potential impact of citrus IPM intervention assessed for at least one action site by end of 2016.	• Socio-economic questionnaires. • Research data. • Reports. • Publications. • Student theses.	• Farmers interviews. • Surveys data. • Impact assessment studies.	• Political stability. • Security situation in target areas does not prevent or interrupt socio-economic work. • Growers' willingness to respond to questionnaires. • Growers provide accurate economic data. • NARS cooperates.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	for target pests and disease conducted by end of 2017.	• At least one ex-post assessment of implemented IPM management interventions conducted by end of 2017.			
5. Knowledge integration, capacity building, and technology transfer with national public and private sector partners and growers established.	• Regular meetings/workshops focusing on trans-disciplinary knowledge integration and learning among partner institutions and stakeholders organised by end of 2016. • ToT workshops on citrus IPM conducted by end of 2017. • Citrus IPM technology learning sites established field days conducted, extension materials produced and disseminated by end of 2017. • Postgraduate training conducted by end of 2017.	• At least one workshop for knowledge integration and learning among partner institutions and stakeholders conducted in each country by end of 2016. • At least one ToT workshop conducted in each of the target countries by mid-2016; at least one technology learning site and one farmer field day conducted in each of the target countries by end of 2018. • At least 3 PhD and 3 MSc students trained on bioecology and management of the target pests by 2018.	• Record of workshops and farmer field days. • Attendance lists of trained personnel. • Reports. • Student theses. • Publications.	• Record of ToT workshops and farmer field days. • Attendance lists of ToT, farmers' field days. • List of students trained.	• Political stability. • Security situation in target areas does not prevent or interrupt trainings. • NARS and farmers' willingness to participate in the trainings.
Specific Objective: Promotion of post-harvest disinfestation of key horticultural crops in Kenya and Uganda by 2021.					
1. Infestation of the target crops in the project action site significantly reduced through use of the IPM technologies.	• Preharvest disinfestation treatment of the key target pests on the target crops applied on large scale; preharvest pest	• Preharvest infestation level by the key pest on the target crops reduced by at least 10-15% by end of 2018.	• Reports. • Publications.	• Grower interviews. • Pest abundance data. • Damage levels.	• Availability and accessibility of the IPM inputs. • Growers cooperate and apply the IPM technologies area-wide. • Political stability.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	infestation reduced by 10-15%.				
2. Postharvest disinfestation treatment of thrips on French bean and false codling moth on bell pepper established.	• Quality of vegetables improved through implementation of postharvest disinfestation treatment.	• Developmental duration for immature stages and the most heat-tolerant stage of false codling moth on bell pepper established by mid 2019. • Heat treatment parameters required to achieve Probit 99.9968% for false codling moth on bell pepper established by mid 2019. • Impact of treatment on vegetable nutritional quality established by end of 2019. • Medium scale postharvest disinfestation trials against thrips on French beans validated by end of 2019.	• Reports. • Heat treatment data. • Student theses, • Publications.	• Laboratory bioassays.	• Insect amenable to mass production. • Political stability.
3. Proven postharvest disinfestation treatment of mango and avocado against fruit flies validated.	• Quality of fruits improved through implementation of postharvest disinfestation treatment.	• Large-scale trials on avocado (cold treatment) validated by end of 2018. • Large-scale trials on mango (heat treatment) validated by end of 2018.	• Reports. • Student theses. • Publications.	• Large scale treatment trials. • Entrepreneur heat treatment facility(ies).	• Insect amenable to mass production. • Political stability. • Cooperation by NARS and other stakeholders in technology validation.
4. Awareness and capacity on the postharvest treatment of the target crop pests among various stakeholders, including policy makers, enhanced.	• Knowledge of the use of hot water disinfestation treatment among the partner entrepreneurs enhanced.	• At least two private entrepreneurs trained on postharvest treatment technologies by end of 2018.	• List of entrepreneurs trained. • List of policy makers and other	• Policy briefs. • Hand-on training for the partner entrepreneurs on postharvest disinfestation treatment	• Stakeholders willing to participate in training programs. • Cooperation by NARS growers and policy makers. • Political stability.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• At least 1,000 growers trained on preharvest IPM measures of fruits and vegetables as a prerequisite for successful implementation of postharvest disinfestation treatment as a prerequisite for successful implementation of post-harvest disinfestation treatment by end of 2018. • At least two policy briefs on the use of postharvest disinfestation treatments developed and circulated to policy makers and other stakeholders by end of 2019. • Policy makers and other stakeholders are aware of the availability of postharvest disinfestation treatments by end of 2019. • At least one PhD and one MSc student trained on various aspects of postharvest disinfestation treatments by end of 2020.	stakeholders informed on the technologies. • Student theses. • Publications.	of the target fruits and vegetables.	
5. Pilot postharvest disinfestation treatment plant for fruits and vegetables established and operationalised.	• Postharvest disinfestation treatment implemented by the partner entrepreneurs.	• At least one postharvest disinfestation plant established in the project countries by mid of 2019.	• Postharvest disinfestation facility. • Reports.	• Number of growers benefiting from the pilot postharvest disinfestation facility. • Questionnaires.	• Entrepreneur willingness to take up the available technologies. • Political stability.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• At least one postharvest disinfestation plant becomes operational by end 2019.	• Testimony from growers and other stakeholders.	• Interviews.	
6. Certification, standards of fruit and vegetable post-harvest treatment established.	• Rule and regulation governing the use of the postharvest hot water disinfestation treatment shared and harmonised among the partner entrepreneurs.	• At least one harmonised protocol developed by end of 2019.	• Reports. • Policy briefs. • List of partners. • Publications.	• Developed protocols and standards.	• Political stability. • Cooperation by NARS and other stakeholders in technique validation. • Endorsement by policy makers.
7. Access to lucrative export markets regionally and international for the target commodities facilitated.	• Zero infestation of the target crop by the target pest at points of export. • Access to lucrative export market regionally and international for the target commodities regained.	• At least two awareness campaigns among policy makers on the efficiency of the postharvest disinfestation treatments conducted by end of 2019. • The entrepreneurs are able to access at least one regional/ international export markets by 2020.	• List of participants. • Reports. • Volume of fruits and vegetables exported. • Export markets regained.	• Market surveys. • Records from Ministry of Trade.	• Favorable weather condition. • Political stability Endorsement by policy makers. • Willingness of trading partners to engage in negotiation and lift the trade ban.
Specific Objective: To enhance productivity of avocado and cucurbits among smallholder growers in East Africa through integrated pest and pollinators management (IPPM).					
1. Avocado-cucurbit- production systems in diverse agro-ecologies characterised for the role of pollinators and insect pests, and associated extrinsic and intrinsic factors.	• Avocado-cucurbit-production systems in diverse agro-ecologies assessed.	• Landscape dynamic for cucurbit-avocado production systems in 3 diverse agroecology characterised by 2019. • Species composition and genetic diversity of insect pests and pollinators and their abundance on target crops in 3 production systems assessed by 2018.	• Research data. • Landscape maps and GIS databases. • Project reports. • Student theses. • Research publications.	• Satellite imagery. • Ground truth data. • Field survey. • Laboratory bioassays.	• Relevant data made available from different sources. • No extreme weather conditions. (e.g. drought, floods). • Political stability.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• Pollination deficit in the target crops assessed in at least 3 landscapes by 2019. • Symbionts in key pests and pollinators of cucurbits and avocado characterised by 2019.			
2. Potential for integrating pollination and IPM services assessed at landscape level.	• Knowledge of integrating pollination and IPM of the target pests enhanced.	• Pest management practices and floral biology in the target crops characterised by 2019. • At least 4 existing (biopesticide, protein food bait, male attractants, sanitation) and 1 new IPM option for sustainable management of insect pests of cucurbits and avocado adapted for IPPM and implemented by 2019. • The nature and magnitude of interactions between the pollinators and IPM practices documented by 2020. • Impact of integrating pollination and IPM on key cucurbit and avocado pests and pollinators' health established by 2019.	• Research data. • Project reports. • Student theses. • Research publications.	• Laboratory bioassays. • Field trials.	• Minimal disruptions from biophysical and environmental catastrophes. • Socio-cultural environment in target areas conducive for uptake and adoption of IPM technologies and bee keeping.
3. Management interventions for target crops based on improved pollination services	• Increased production of quality avocado and cucurbit as a result of	• Pollination services intensified through their	• NARS and partners reports. • Research data.	• Avocado and cucurbit famers interviews.	• Minimal disruptions from biophysical and environmental catastrophes.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
and IPM practices adapted, validated and implemented	enhanced pollination and application of IPM of the target pest. • Income of avocado and cucurbit farmers enhanced.	conservation (managed and wild) by 2020. • Sustainable pollination and best-bet IPM options for cucurbits and avocado promoted by 2020. • Impact of enhanced pollination services and IPM on avocado-cucurbit system productivity established by 2020.	• Project Reports. • Student theses. • Research publications. • Partnership agreements for technology dissemination.		• Socio-cultural environment in target areas conducive for uptake and adoption of IPM technologies and beekeeping.
4. Impacts of integrating pollination and IPM services on farmers' livelihoods determined.	• Benefit and impact of integrating pollination services and IPM of the target pest on farmers' livelihoods documented.	• Knowledge, attitude and practices (KAP) towards IPPM documented by 2020. • Impacts of IPPM interventions on livelihoods of cucurbits and avocado producers documented by 2020. • Ex-ante adoption of IPM pollination services documented by 2020.	• Baseline report. • Impact assessment report. • Economic analysis report. • Research publications.	• Avocado and cucurbit farmer interviews.	• Willingness of end user/client to participate and respond to questionnaires and provide accurate data.
5. Strengthen capacity, transfer technology and create policy awareness on IPM-pollination integration	• Knowledge and skills of avocado and cucurbit farmers, growers, extension officers, policy makers and other stakeholders related to IPM-pollination integration enhanced. • A cohort of trained young scientists created.	• At least 3 training-of-trainer (ToT) and 4 farmer field days on integration of IPM and pollination services, targeting 6,100 beneficiaries, held by 2020. • At least 2 PPP agreements formed to enhance availability of IPPM products for end users.	• Record of workshops and farmer field days. • Attendance lists of trained personnel. • Training curricula/manuals. • Training reports. • Research publications.	• Training workshops. • Model farmer contacts. • Awareness campaigns. • List of graduate students.	• Mutual willingness of stakeholders to contribute to the successful implementation of project activities. • Expressed need for training.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• At least 3 awareness events targeting growers and policy makers held by 2020. • At least 3 PhD and 2 MSc students trained on bee symbionts, integration of IPM with pollination services and GIS/earth observation tools by end of 2020.	• Media reports. • Farmer/extension information materials. • Student theses.		
Specific Objective: To implement, disseminate and promote, a sustainable and eco-friendly integrated pest management (IPM) approach for reduction of tomato losses due to *T. absoluta* infestation leading to increased yield and quality of tomatoes in east Africa.					
1. Baseline socio-economic assessment prior to the *T. absoluta* IPM intervention undertaken.	• Baseline socio-economic assessment prior to the *T. absoluta* IPM intervention evaluated by 2021.	• Reference point data and information on *T. absoluta* socio-economic impact on tomato growers' livelihood prior to the intervention collated and documented by 2019. • Logistic forecast models and forecast data generated by 2019.	• Reports. • Publications.	• Tomato growers' interviews.	• Willingness by growers to participate in interviews and surveys. • Cooperation by growers, quarantine officers and extension officers to participate in interviews and avail relevant reports. • No drought/crop failure during the project lifespan. • Political stability.
2. Performance of introduced parasitoid *D. gelechiidivoris against T. absoluta* assessed and the use of the identified potent *M. anisopliae* fungal isolates under field conditions validated.	• Performance of introduced parasitoid *D. gelechiidivoris against T. absoluta* established. • Efficacy of identified potent fungal isolates validated under field conditions.	• Level of percent parasitism of *T. absoluta* by *D. gelechiidivoris* documented by 2019. • Reduction of *T. absoluta* population as a result of *M. anisopliae* application documented by 2021.	• Reports. • Theses. • Peer-reviewed publications.	• Laboratory bioassay data • Data from field trials.	• Healthy colonies of target pest and natural enemies in culture. • Cooperation by growers. • No drought/crop failure during the project lifespan. • Political stability.
3. Awareness on management of *T. absoluta* using IPM approach among various tomato value chain	• Knowledge and skill of the tomato growers, extension officers and other stakeholder on	• At least 3 ToT workshops for NARS conducted in the project action sites by 2021.	• Post training reports. • Trainee certificates.	• Training workshops. • Model farmer contacts. • Awareness campaigns.	• Willingness by extension and quarantine officers to be trained. • Cooperation by NARS and stakeholders to release and avail their staff for trainings.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
stakeholders created and capacity of various stakeholder on the intervention enhanced.	*T. absoluta* using IPM enhanced. • Cohort of trained young scientist on various aspect of *T. absoluta* created.	• At least 90 agricultural personnel and extension/ quarantine officers identified and recruited for project implementation by 2021. • At least 1 model farmer identified in each project action site by 2021. • At least 1 IPM learning site identified and used for dissemination of a *T. absoluta* IPM package in each project action site by 2021. • At least 6 farmer field days conducted in the project action sites by 2021. • At least 1 awareness campaign conducted through different media (e.g. on local radio stations, TV, farmer magazines, etc.) by 2021. • At least two PhD students trained in the project lifespan on fruit fly management 2021.	• Training materials. • Testimonies from trained personnel. • Thesis. • Reports. • Peer-reviewed publications.	• List of graduate students.	• Tomato farmers willing to be identified. • Lead farmers allowing their farms to be used as demonstration learning sites. • No drought/crop failure during the project lifespan. • Political stability.
4. Implementation of a proven integrated pest management (IPM) strategiy against *T. absoluta* upscaled in East Africa.	• Increased production of quality tomato and grower's income.	• At least 60% reduction in *T. absoluta* population in tomato greenhouses and open fields by 2021. • At least 50% reduction in infestation of tomatoes by *T. absoluta* by 2021.	• Reports.	• Grower interviews.	• No drought/crop failure during the project lifespan. • Climatic and physical landscape suitable for implementation and sustainability of proposed *T. absoluta* IPM package. • Political stability

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• At least 70% reduction in expenditure on broad spectrum synthetic pesticides targeting *T. absoluta* by 2021. • At least 50% increase in yield quantity and quality by 2021.			• Willingness by growers to adopt and implement *T. absoluta* IPM packages. • Willingness by Agro-dealers to avail traps, lures, etc. at affordable prices within the growers' locations.
Specific Objective: Promoting smallholder access to fungal biopesticides through Public and Private Partnerships in east Africa by 2021.					
1. Strengthen public-private partnerships (PPPs) for development, production and promotion of biopesticides in East Africa.	• PPPs for commercialisation of biopesticide expanded between partners, strengthened through mutual and better understanding of strengths, weakness, opportunities and threats.	• At least 3 PPP agreements signed by second quarter of 2018. • Business opportunities workshop organised by first quarter of 2018. • At least one market survey and SWOT reports accomplished by end of 2018.	• Technical and financial reports. • Partnership agreements. • Business opportunity workshop report. • Market survey. • SWOT analysis.	• Workshops, discussions forums. • Partner reports. • Publications.	• Favourable weather condition. • Political stability. • Effective participation of all stakeholders. • Endorsement by policymakers.
2. Develop improved biopesticide formulation and application strategies for enhanced efficacy of potent biopesticides products.	• Innovative biopesticide products, their formulation and application strategies adopted by private sector for commercialisation.	• At least 2 innovative formulation and application strategies of biopesticide developed and communicated by mid-2019. • Potent biopesticides for at least 2 new and emerging pest identified by end of 2019.	• Reports. • Student thesis. • Publications. • Sales record.	• Laboratory and field bioassays.	• Favourable weather condition. • Political stability.
3. Optimise biopesticide mass production and quality control methods at for various scales	• Enhanced production of biopesticide products by private sector partners, women and youth groups engaged in the	• At least one validation and training facility on small-scale biopesticide production established at *icipe* to train youth and women on biopesticides by end of 2018.	• Reports. • Evidence of available mass production facility. • Institutional newsletter.	• Laboratory bioassays. • Development of training materials. • Production & optimisation trials, • Facility installation.	• Favorable weather conditions. • Political stability. • The approvals of regulatory authorities to establish biopesticide production facility are received in-time.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	project for various pest targets.	• At least two small-scale production facility involving women and youth groups established and operationalised by end of 2020. • At least one industry scale pilot mass production facility for biopesticides established by mid 2020 with private sector partners.	• News articles. • Biopesticide production report.	• Assessment of quality control protocols	
4. Register and commercialise new biopesticide products in East Africa.	• New biopesticide product registered for use in integrated pest management of pests in the target countries.	• At least two PPP agreements signed for product commercialisation by mid of 2019. • Eco- and mammalian toxicity of at least two biopesticide products/formulation accomplished by first quarter of 2020. • At least 2 dossiers for product registration submitted to regulatory authorities by mid of 2020.	• PPP agreements. • Eco- and mammalian toxicity test reports. • Registration dossiers.	• Project reports. • Laboratory tests on test organisms. • Annual reports of Regulatory authorities. • Partner reports and websites.	• Sustained partnership with private sector. • Political stability. • Timely approval by regulatory authorities.
5. Transfer technology and build capacity on biopesticide research and use to multi-stakeholders.	• Enhanced awareness and capacity among various stakeholders on biopesticides, their efficacy, production technology and enabling policy leading to increased adoption of biopesticides.	• At least 10,000 smallholders made aware of the use of new biopesticides for management of target pests by end of 2019. • Small-scale biopesticide production established, optimised and operationalised by at least	• Reports. • Field demonstration reports. • Grower testimonies and video. • Brochures. • Posters and other	• Pre- and post training surveys. • Policy review, desk research. • Field demonstrations. • Field days. • Awareness campaign.	• Favourable weather conditions. • Political stability. • Effective participation of growers and extension officers. • Effective participation of women and youth entrepreneurs.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		two women/youth groups by end of 2019. • At least one sensitisation and awareness campaign for policy makers and other stakeholders with 25 participants on biopesticides in East Africa undertaken by end of 2020. • At least 2 MSc and 1 PhD student trained on biopesticide research by end of 2020.	dissemination materials.		
Specific Objective: Developing, commercializing and scaling of biopesticides for integrated fall armyworm (FAW) management to improve the livelihoods of smallholder farmers					
1. 1. Stakeholders involved in the biopesticide sector including policy makers and regulatory authorities sensitised on policy and regulatory needs and socioeconomic aspects related to use of biopesticides for FAW management.		• One sensitisation workshop for regulatory authorities and policy makers. • Policy review on regulatory procedures for biopesticides completed and documented. • One report on demand for and cost-effectiveness of biopesticides for FAW management. • Combination formulations developed and screened in the lab. • Field efficacy of combination products established in multi-country/locational trials. • Potential for "lure and infect" strategy for FAW in	• Policy paper on harmonisation of biopesticides registration and use. • Report/publication on demand for and ex-ante socioeconomic benefits of biopesticides.	• Policy review, desk research. • Field demonstrations. • Field days. • Awareness campaign.	• Policy and regulatory authorities' willingness to permit product introduction, field trials and registration of biopesticides in target countries.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		combination with commercial lures initiated. • Registration initiated for commercial biopesticides with proven record in target countries.			
2. 2. Label-extension procedures initiated for proven commercially available biopesticides and novel combination formulation product developed and validated in the field.		• Field-efficacy trials with Mazao Tickoff® and Mazao Achieve 78® and label extension procedures initiated and accomplished with private sector partners and regulatory authorities • Non-target effects of Tickoff® and Achieve® on FAW natural enemies assessed. • Commercial biopesticides with proven efficacy introduced in target countries.	• Registration dossiers . • Eco- and mammalian toxicity test reports. • Field efficacy permits.	• Registration dossiers. • Field efficacy permits.	• Regulatory authorities permit product introduction, field trials and registration of biopesticides in target countries • Favorable weather conditions. • Political stability. • Effective participation of growers and extension officers.
3. 3. Additional novel biopesticide products developed and commercialised through Public-Private Partnership for FAW management.		• At least 5 novel entomopathogens for FAW management identified and curated. • Protocols for pathogenicity and mass production of potent entomopathogens developed, optimised and communicated to private sector and community organisations. • Novel formulations of entomopathogens tested			• Private partners find PPPs for FAW management economically viable to invest in the opportunity

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		and shelf life and non-target studies initiated. • Eco- and mammalian toxicity for novel formulations generated. • Field efficacy of novel formulations of potent isolates established. • Registration of at least 2 novel biopesticide products initiated.			
4. 4. Capacity of partners strengthened for promoting and scaling the use of biopesticides as important components of FAW-IPM.		• Training and dissemination materials on biopesticide production and use and other FAW-IPM developed and distributed to reach at least 30,000 maize growers and extension officers in each target country. • Local entrepreneurs trained on biopesticides production through business incubation. • At least six participatory field demonstration sites established and awareness on efficacy of biopesticides created among at least 6,000 lead farmers. • Public-Private Partnerships established for biopesticide production in target countries and		• Field demonstrations. • Field days. • Awareness campaign. • Master student theses.	

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		commercialisation initiated. • Biopesticide use enhanced to contribute to reduction of synthetic pesticide use for FAW control.			
Specific Objective: To improve food and nutrition security, conserve environment, and to increase income and improve health of resource-poor farmers (including women farmers), by reducing crop losses and pesticide use through development and dissemination of effective pest management practices, especially IPM, in East Africa, along maize, rice and chickpea value chains by 2019.					
1. Production and productivity along maize, rice and chickpea value chains, by reducing crop losses through dissemination of effective IPM options increased.	• At least 30% reduction in crop losses (from the baseline) in target communities by 2019. • At least 30% increase in yield (from the baseline) in target communities by 2019. • At least 30% reduction in frequency pesticide applications by 2019. • At least 20% increase in household incomes from adoption of IPM practices by 2019. • At least 50% farmers apply IPM practices. • At least 70% farmers beneficiaries understand pest damage and behavior. • At least 25% reduction in the frequency of pesticide	• Number of beneficiaries engaged in IPM technology evaluation and adoption. • Percentage reduction in pesticide use in beneficiary communities. • Number of extension agents, farmers and graduate students trained. • Percent yield loss abated in beneficiary communities.	• End of project evaluation report. • Project research and progress reports. • Policy briefs. • Journal papers.	• Baseline and end line survey data. • Key informant interview. • On-station and on-farm experimental data collection.	• Stable socio-political environment in target countries. • Political will and support.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	application. • 6 PhD/MSc students trained. • Over 800 farmers and extension agents trained by 2019 (200 a year for 2016, 2017, 2018 and 2019).				
2. Key partners identified, IPM technologies developed and implementation strategies defined for sound sustainable intensification along the maize, rice and chickpea value chains.	• Identify key stakeholders and develop implementation strategy by mid 2016. • Problem identification and prioritisation by mid 2016. • Design and conduct on-farm and on-station IPM participatory trials for rice, maize and chickpea pests, diseases and weeds by early 2017. • Evaluation and assessment of IPM packages and implementation strategies by mid 2017. • Scaling up proven IPM technologies under sustainable intensification systems by end of 2019.	• Number of stakeholders participated. • Number of pest problems identified and prioritised per crop per country. • Number of respondents interviewed (baseline survey). • Number of on-farm trials conducted. • Number of farmers participated. • Number of demo trials. • Number of IPM packages evaluated. • Percent crop loss abated.	• Progress report. • Working document report. • Journal articles published.	• Project launching/planning meeting reports. • List of sub-awards. • List of farmers participated. • List of demo trails per country. • List of papers jointly published with local partners.	• Stakeholder are willing to cooperate. • Farmers are willing to host on-farm trials. • Stable socio-political environment in target countries. • IPM packages are available. • Stakeholder are interested to carry out evaluations. • Several institutions are interested to scale out. • Government is willing to mainstream IPM.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
3. Pragmatic pest diagnostic capacity developed.	• Identifying local diagnostics and national pest, diseases and weeds priority by mid 2016. • Developing and testing diagnostic kits by end of 2016. • Capacity building and in-depth training on high impact pest and disease diagnosis by end of 2018. • Communication and data-network systems with partners by end of 2019.	• Number of scientists/institutions engaged. • Number of pests, diseases and weeds identified and prioritised. • Types of diagnostics identified. • Number of kits developed and tested. • Number of institutions tested the kits. • Number of people trained (short-term and long- term trainings). • Number of pests, diseases and weds diagnosed. • Number of people accessing data.	• Progress report. • Journal articles published. • Working document report.	• National pest data base/reports. • Questionnaires. • Expert opinion. • Consultation workshops.	• National institutions are willing to collaborate in identifying problems and local diagnosis. • National institutions are willing to collaborate in developing and testing kits. • National institutions are willing to collaborate in capacity building. • National institutions are willing in data sharing.
4. Integrated pest management (IPM) communication and education improved.	• Develop tailor made communication strategy for IPM to address different stakeholders by mid 2016. • Create awareness and disseminate information on IPM to enhance responsiveness of the stakeholders from 2016-2019. • Develop promotional materials targeted to different stakeholders	• Communication strategy developed. • Number of audiences addressed. • Number of people aware of IPM practices. • Number of people applying IPM practices. • Number of targeted stakeholders reached through these awareness campaigns. • Number of promotional materials developed. • Number of promotional materials disseminated.	• Working document report. • Progress report. • Journal articles published.	• Surveys. • Group discussions. • Meetings.	• Stable socio-political environment in target countries. • National institutions are willing in data sharing. • National stakeholders are wiling collaborate in drafting the communication materials in local languages.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	to enhance up-take of the IPM technologies in 2016 and in 2018. • Establish network of key stakeholders in IPM through a web-based interface that allows stakeholders to continually access emerging policy messages from the project by mid 2017. • Conduct training need assessments and educate farmers and extensions agents by end of 2018.	• Number of people accessing the web-interface. • Number of documents downloaded. • Types of training needs assessed. • Number of farmers and extension workers trained.			
5. Information and capacity building to reform and strengthen policies that influence integrated pest management provided.	• Identification of incentives and disincentives, policy gaps and institutional arrangements for adoption of IPM by early 2017. • Conduct a cost-benefit analysis for IPM options for maize, rice and chickpea by early 2017. • Conduct evidence-based policy dialogue to improve adoption of IPM from mid 2017-2019.	• Number of institutions participated. • Policy gaps identified. • Internal rate of return. • Net present value. • Number of policy briefs. • Number of policy workshops.	• Progress report. • Journal articles. • Working document report. • Project research and progress reports. • Policy briefs.	• Baseline surveys. • Consultation workshops. • Review of national agricultural policies.	• Enabling socio-political environment in target countries. • Positive changes in stakeholders. • Government mainstream IPM policies.
Specific Objective: MUSA - Microbial Uptakes for Sustainable management of major banana pests and diseases evaluated by 2020					

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
1. Microbial collections (fungi) and other beneficial EBCAs (endophytes and biological control agents) for IPM in banana.	• At least 8 EBCAs discovered and identified. • Collected EBCAs cultured and deposited in *icipe* collection.	• Number of EBCAs discovered and identified. • Number EBCAs successfully in culture.	• PhD thesis. • Publications.	• Field surveys. • Laboratory isolation. • Morphological and molecular identification. • Bioassays.	
2. EBCAs host range assessment.	• A number of selected EBCAs active against at least 2 pests in banana (plant parasitic nematodes (PPN) and banana weevil (BW)).	• Number of EBCAs successful in control of at least 2 pests in banana.	• PhD thesis.	• Screenhouse pot trials.	
3. EBCAs biology in plants, pests and pathogen interactions.	• Data on biology and effectiveness of selected EBCAs obtained.	• Knowledge on biology and effectiveness of selected EBCAs.	• PhD thesis. • Publications.	• Laboratory experiments. • Pot experiments.	
4. Procedure for EBCAs mass production, storage and application.	• Methods for large scale cultivation of microbial EBCAs bio formulation and storage.	• Identification of the most appropriate EBCAs culturing methods. • Protocol drafts available for partners.	• PhD thesis. • Publications.	• Laboratory experiments.	
5. Field integration of EBCA-based IPM.	• Field data for integration of EBCA (fungi) based IPM against PPN and BW.	• Field trial data.	• PhD thesis	• Field trials.	
Objective 2: Minimise the vulnerabilities of horticulture and staple crops to climate change-induced pest problems by at least 10% by 2020.					
Specific Objective: To disseminate knowledge of climate change impacts on ecosystem services and food security in Eastern Afromontane Biodiversity Hotspots by 2018.					
1. Complementing, encapsulating and concretizing the research results of the climate change project Phase I (CHIESA) and to make them adoptable and adaptable to specific user	• Integration, synthesizing and reporting of results from different WPs and within WPs from CHIESA by mid 2016. • Integration of	• Effects of climate change on biodiversity and habitats disseminated. • Species distribution maps for pest insects for maize, crucifers, avocado and coffee imparted.	• Publications. • Workshop records. • Predictive models trainings.	• Surveys. • Voucher specimens. • Secondary data. • Monitoring station.	• Quality of existing data. • Willingness of stakeholders especially policy makers. • Security situation. • Extreme weather events.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
groups as well as to wider audiences.	scientific capacity at institutional level built to achieve overall objective of climate change adaptation by end of 2016. • Synthesised results targeting a supra-regional Eastern Africa Mountain Biodiversity Hotspot, which also increase knowledge on National level impacts with feed into ministerial policies by end 2017.		• Meteorological data dissemination reports. • Training maps.		
2. Strengthening the capacities of relevant professional partner organisations to be able to further communicate research results and related technology to the end users.	• Maintenance and utilisation of the GeoNetwork platform and weather monitoring infrastructure by mid 2017. • Strengthen capacity of providers of extension service by end of 2017. • Improved access to appropriate and affordable technologies by mid 2017. • Implementation of community adaptation plans, including linking	• GIS platform established for sharing geospatial datasets among at least 25 East African stakeholder organisations regularly utilised. • Number of participants at trainings that showcase the utility of geospatial products. • Number of new local and regional products derived. • Geospatial datasets in use. • Number of community training events.	• Satellite imagery and GIS databases. • Basic maps. (printed and digital) for training • Aerial photos. • Atlases. • Training reports and certificates. • GIS data portal accessible and products uploaded. • Data products (records).	• Remote sensing. • Aerial photography. • Secondary data collection. • Number of participants on list. • Data portal access numbers. • Publications.	• IT capacity of stakeholder institutions. • Local budget contribution available. • Retaining of trained project personnel. • Geospatial data is available and accessible through a geoportal.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	with the existing government planning processes by end of 2018.				
3. Effective and sustainable distribution and communication of CHIESA research results to specific user groups as well as to wider audiences.	• Appropriate information, training, and communication materials available by mid 2017. • Increased knowledge and information about climate, technology and markets by end of 2017. • Adequate use of information dissemination pathways by mid 2018. • Appropriate political support for communication and dissemination by end of 2018.	• Number of out research on household vulnerability and adaptation strategies to climate change done. • Project website to share information among partners and other stakeholders regularly used. • Number of community sensitisation on climate change effects and need for research events conducted.	• Training data, maps and reports. • Workshops. • Project reports. • Literature. • Reports. • Maps and models. • Action plans. • Databases. • Training material.	• Household surveys. • Interviews. • Focus group discussions. • Course reports. • Secondary data collection. • Fieldwork.	• Quality of data adequate for the purpose. • Security situation in target areas does not prevent or interrupt fieldwork.
Specific Objective: Adaptation for Ecosystem Resilience in Africa (AFERIA)-Maize component.					
1. Enhancement of the distribution and abundance of the parasitoids of maize Lepidopteran stemborers.	• Releases of *Cotesia flavipes* and *C. sesamiae* (inland population) in Kenya (Taita Hills, Murang'a and Makutano) and in Tanzania (Moshi). • Farmers sensitisation on the use of the parasitoids to control the maize Lepidoptera	• Number of parasitoids released in each target region. • Number of farmers sensitised in each target region. • Number of Kenyan and Tanzanian agricultural officers trained.	• Reports. • Training manuals and materials.	• Laboratory mass-rearing of the parasitoids and their respective hosts. • Field releases.	• No crop failures. • Good parasitoid production and their respective hosts in the laboratory. • NARS and farmers acceptance and cooperation. • No extreme weather conditions (e.g. drought, floods).

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	stemborers and ToTs training (i.e. agricultural officers).				
Specific Objective: Determine the contribution of organic agriculture to sustainable development in the tropics by 2018.					
1. Effect of organic and conventional farming systems on pest and disease incidence, severity and damage determined and documented by 2018 2. Effect of organic and conventional farming systems on soil biodiversity assessed, and documented, by 2018. 3. Effect of organic and conventional farming systems on soil fertility and safety evaluated, and documented, by 2018. 4. Yields and incomes generated through organic and conventional farming systems compared by 2018. 5. Participatory on-farm research (POR) conducted for wider result dissemination and adoption by 2018.	• Long-term organic and conventional farming systems compared and their effects on soil fertility, soil biodiversity, pests and diseases, yield and health determined and widely disseminated by 2018.	• At least one major pest and one major disease of maize assessed under the two different farming systems by 2018. • At least one major pest and one major disease of vegetables assessed under the two different systems by 2018. • The effect of both systems on at least one major plant nutrient (N, P or K) determined by 2018. • Effect of farming system on at least one soil physical characteristic assessed by 2018. • Pesticide and nutrient leaching compared for organic and conventional systems by 2018. • Comparative yields and incomes for at least 2 commodities documented by 2018. • Results tested on-farm in at least 3 different locations by 2018.	• Publications. • Project reports, theses. • Pesticide use statistics. • Residue level statistics.	• Laboratory records. • Field experiments and data collection. • Farmer interviews.	• No extreme weather conditions (e.g. drought, flood). • No crop failure. • Security situation in target areas does not prevent or interrupt project implementation. • NARS cooperate in the project implementation.
Specific Objective: Predicting climate change that induced vulnerability of African agricultural systems to major insect pests through advanced insect phenology modelling, and decision aid development for adaptation planning by 2016.					

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
1. Baseline information on pests' life table according to the temperatures along altitudinal gradients, soil and plant biophysical characters, farmer practices and their impacts on agro-ecosystem influencing the pest density and communities, competitions assessed.	• Climate change-induced vulnerability of African agricultural systems to major insect pests predicted through advanced insect phenology modelling, and decision aid developed for adaptation planning by 2015.	• Development of predicting models combining different parameters evaluated at least for three major insect pests by the group by 2015.	• Field collections, field and laboratory experiments.	• Morpho-taxonomy. • Biological experiments, physico-chemical analyses.	
Specific Objective: Enhancement of food security, resilience, and livelihoods of smallholder maize and tomato farmers through scaling of climate-smart integrated pest management (CSPM) practices and technologies to counter the effects of climate change on pest management by 2022.					
1. Improved knowledge and capacity of farmers, farmer organisations and extension services to implement and policy makers to advocate CSPM technologies to manage pests.	• Provide training to farmers, farmer organisations and extension services to implement and scale up climate-smart pest management (CSPM). • Engage NARES institutions and policy makers working on climate change and agriculture for scaling and advocating CSPM. • Provide support to private sector to create awareness and deliver CSPM technologies to end users.	• At least 2,100 model female and male farmers capacity built to train other farmers by 2022. • At least 100 farmer-based organisations participate in capacity development training to train farmers by 2022. • At least 500 female and male agricultural extension agents participate in training on CSPM technologies and their use to train farmers by 2022. • At least 20 private sector and civil societies capacity built through training by 2022. • 200 experts from NARES and institutions working on	• Training reports. • Project annual reports. • Feedback from project partners.	• Training data.	• Partners commit and adhere to the MOUs/ agreements. • Parasitoids adapt to local conditions. • CSPM technologies and practices are socially and economically acceptable. • Value chain actors are proactive to supply CSPM technologies and other inputs. • Farmers, farmer-based organisations and extension agents are willing to come and participate in trainings. • NARES and other institutions get permission and have time to participate in training and project implementation. • Policy makers will find time to be trained and sensitised about CSPM technologies and their impacts. • Private sector have access to technologies and deliver to farmers.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		climate change trained on CSPM technologies and mass rearing of parasitoids to support extension officers by 2022. • 100 policy makers engaged. • At least 20 private sector and civil societies capacity built, access technologies and participate in commercializing technologies by 2022.			
2. Climate-smart pest management technologies integrated, adapted and scaled in Ethiopia and Uganda.	• Strengthen/establish learning sites for scaling CSPM technologies and practices. • Awareness creation and sensitisation campaigns organised among stakeholders on CSPM technologies. • Awareness creation among youth on pests and CSPM technologies. • Mass rearing and release of parasitoids for maize stemborers, stemborers and *T. absoluta* to enhance adaptability and will be	• At least 105,000 farmers (~40% women) reached with either of CSPM technologies in both countries by 2022. • Synthetic insecticides use reduced by 30% by 2022. • At least 500 CSPM learning sites established in the target areas by 2022. • 840,000 beneficiaries aware of and farmers have access to CSPM technologies and practices through multiple communication strategies. • 1,500 extension materials distributed by 2022 • 100 secondary and high schools reached by 2022.	• Project implementation reports. • Training reports. • Feedback from project partners. • Data from mobile phone application. • Reports from trained scouts. • M&E survey report. • Seasonal field reports • Feedback from NARS laboratories.	• Mobile phone application data. • M&E survey data. • Field data. • Laboratory data. • Training data.	• Partners commit and adhere to the MOUs/ agreements. • Parasitoids adapted to local conditions. • CSPM technologies and practices are socially and economically acceptable to smallholder farmers. • Value chain actors are proactive to supply CSPM technologies and other inputs. • Partners are willing to take part and join in events organised by the project. • Partners actively engage and commit to scale technologies as per the agreement. • Partners have capacity to effectively rear parasitoids. • Local government regulatory bodies and partners are proactive to facilitate granting of parasitoid import permit in time. • NARS partners manage the laboratories and colonies in a sustainable manner. • Private sector demonstrates willingness to participate in mass rearing and commercializing parasitoids.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	released by local partners. • Select viable solutions with public and private sector stakeholders to promote partnerships for scaling CSPM. • Strengthen farmers' linkages with CSPM technology providers to facilitate uptake. • Monitor and evaluate the uptake of information and CSPM technologies (e.g. demographic data) by getting feedback through the mobile phone application.	• 41,500 students and school communities made aware of impact of pests and CSPM technologies. • 1,000 parasitoids per hectare mass produced in local laboratories of NARS in Ethiopia and Uganda. • 65,100 ha of land under maize and tomato systems benefit from the release of parasitoids for key pest species by 2022. • At least 100 private-public sector organisations/ institutions/societies involved. • Level of linkages between farmers and private-public sector improved. • 200 mobile phones are made available to role model farmers (champions).			• Farmers and private-public partners are willing to cooperate in delivering the technologies.
3. Existing insect pest monitoring networks improved and strengthened to support risk prevention and rapid response.	• Strengthen existing community-based pest monitoring system networks through the use of semio-chemical traps, training of scouts in selected villages, and using the mobile phone application. • Strengthen access to downscaled climate	• At least one best existing pest monitoring system improved by 2020. • At least 20 scouts involved in carrying out pest surveillance by 2022. • At least 180 voluntary farmers participate in pest scouting by 2022. • 20 scouts trained on collecting pest data using	• Project implementation reports. • Feedback from project partners. • Data from mobile phone application. • Reports from trained scouts. • Training reports.	• Field data. • Mobile phone application data. • Training data.	• Partners commit and adhere to the MOUs/ agreements. • Parasitoids adapt to local conditions. • CSPM technologies and practices are socially and economically acceptable to smallholder farmers. • Value chain actors are proactive to supply CSPM technologies and other inputs. • Farmers are willing to participate in pest scouting. • Scouts collect data as per training provided to them.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	projections and remote sensing data for the NARES and policy makers.	mobile applications by 2022. • 180 voluntary farmers trained and participate in pest scouting by 2022. • By 2022, at least 20 community-based system pest monitoring established. • At least 10 NARES have improved access to climate projection and remote sensing database by 2022.	• Project annual reports.		• NARS have the interest and capacity to use the available databases.
4. Impact of and barriers to scaling of CSPM technologies and practices determined.	• Identification of barriers and opportunities to scale CSPM technologies. • Generate and document evidence on the benefits of CSPM technologies, practices and services to foster a learning environment and further strengthen the scaling processes in other countries.	• Constraints and opportunities to access CSPM technologies and practices identified, documented and shared by 2020. • Gendered economic and food and nutrition security effects of integrated CSPM technologies and economic impacts of key pests determined by mid-2022. • Data on barriers and opportunities on scaling CSPM technologies available by 2020. • A working paper on barriers and opportunities to upscale CSPM technologies produced by 2020.	• Reports from partners. • M&E survey data. • Project implementation reports.	• M&E data. • Field data.	• Partners commit and adhere to the MOUs/ agreements. • Parasitoids adapt to local conditions. • CSPM technologies and practices are socially and economically acceptable to smallholder farmers. • Value chain actors are proactive to supply CSPM technologies and other inputs. • Data of sufficient quality collected on time and participating farmers other actors cooperate in providing the necessary information through in-person surveys. • Capacity of national country teams sufficient for timely completion of surveys. • Political and security conditions will allow collection of household surveys and secondary data in all countries.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
		• Data on socio-economic analysis of CSPM technologies and impacts of key pests available by mid-2022. • At least two papers documenting benefits of CSPM technologies produced by mid-2022.			
Specific Objective: Established a decision-oriented tool to predict insect damage on crops under climate change by 2021.					
1. Experimentally measure yield losses to insects, empirically develop crop damage and loss functions.	• Mechanisms that govern maize yield losses due insects established.	• At least one high impact paper published.	• Laboratory data. • Peer-reviewed publications.	• Experiments using phytotron. • Literature search.	• Maize plants adapt and growth normally in the phytotron. • Insect adapt and feed normally on plant in the phytotron.
Objective 3: Assess the effect of hermetic storage on mold and aflatoxin contamination of stored maize and the qualitative changes in grain legumes during hermetic storage by 2018.					
Specific Objective 3.1: Assess the effect of hermetic storage on mold and aflatoxin contamination of stored maize.					
1. Effect of hermetic storage on mold and aflatoxin contamination of stored maize assessed.	• At least 5 village communities in Makueni (Kenya) are aware of the effect of hermetic storage on mold and aflatoxin contamination of stored maize by early 2015.	• At least 1 study on mold and aflatoxin contamination of stored maize conducted by end of 2014. • One scientific publication by end of 2015.	• Scientific publications. • Primary data from field and laboratory experiments.	• Experiments. • On-farm storage trials. • Laboratory trials.	• Security situation. in target areas favorable to project implementation. • Willingness of communities to cooperate. • Political situation is favorable.
Specific Objective 3.2: Evaluate qualitative changes in grain legumes during hermetic storage.					
1. Qualitative changes in grain legumes during hermetic storage evaluated.	• Qualitative changes in at least 2 grain legumes during hermetic storage known by early 2015.	• At least 1 research report and one draft journal article produced by end of 2015.	• Scientific publications. • Primary data from field and laboratory experiments.	• Laboratory and field trials.	• Security situation in target areas favorable to project implementation. • Willingness of communities to cooperate. • Political situation is favorable.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
Objective 4: Undertake acoustic fingerprinting of postharvest insect pests' sound spectra for long-term monitoring of storage pests of grains in bulk storage warehouses in Kenya by 2018.					
Specific Objective 4.1: To carry out acoustic profiling of sounds produced by 5 postharvest pests of adult and immature stages of *Prostephanus truncatus, Sitophilus zeamais, Sitophilus oryzae, Acanthoscelides obtectus, Tribolium castaneum*.					
1. Acoustic profiles of *Prostephanus truncatus, Sitophilus zeamais, Sitophilus oryzae, Acanthoscelides obtectus, Tribolium castaneum* developed.	• Acoustic profiles developed for at least 5 storage pests by end 2015.	• At least 1 research report and one draft journal article produced by end of 2015.	• Laboratory experiments.	• Laboratory trials.	• Availability of insects. • Acoustic devices functioning perfectly.
Specific Objective 4.2: To undertake the selection of specific unique frequency identifiers for *Prostephanus truncatus, Sitophilus zeamais, Sitophilus oryzae, Acanthoscelides obtectus, Tribolium castaneum* using sound characteristics that were developed in Specific objective 4.1.					
1. Unique frequency identifiers for *Prostephanus truncatus, Sitophilus zeamais, Sitophilus oryzae, Acanthoscelides obtectus, Tribolium castaneum* selected.	• At least 5 unique frequency identifiers selected for at least 5 storage pests by end 2015.	• At least 1 research report and one draft journal article produced by end of 2015.	• Research reports. • Scientific articles.	• Laboratory trials.	• Availability of insects. • Acoustic devices functioning perfectly.
Specific Objective 4.3: To assess the preference for acoustic early warning system in bulk storage warehouses in Kenya.					
1. The value warehouses would attach to acoustic sensors (devices) if developed, i.e. their willingness to pay for the devices gauged.	• One report on the valuation (willingness to pay) for acoustic devices by the last quarter of 2015.	• At least 1 research report and one draft journal article produced by last quarter of 2015.	• Survey data from warehouses in Kenya.	• Focus group discussions. • Questionnaire surveys.	• Security situation in target areas favorable to project implementation. • Willingness of warehouses to cooperate. • Political situation is favorable. • Practicability of obtaining the information and necessary tools to design the survey.
Specific Objective: Implement innovative pest biocontrol technologies for sustainable intensification of fruit production systems in Kenya and Senegal by 2021.					
1. Existing farmers' knowledge, perception and practices that may enhance or constraint the adoption of innovative fruit fly management strategies understood.	• Farmers' knowledge, perception and practices that may enhance or constraint the adoption of innovative fruit fly management strategies documented and	• One baseline survey in at least two sites in Kenya and Senegal by end of 2019. • At least one working paper by mid-2020.	• Primary survey at household level; qualitative information from key informants.	• Household survey. • Key informants' interviews.	• Farmers will cooperate in providing data.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
	shared with stakeholders.				
2. Demonstrate the agronomical and socio-economical effectiveness of innovative fruit fly management strategies on a pilot territory.	• Socio-economic impacts of the innovative fruit fly management strategy established and shared with partners.	• Field pilot experiment (RCT format) in in at least two sites in Kenya and Senegal by end of 2021 • At least one peer review manuscript by end of 2021.	• Primary survey at household level; qualitative information from key informants.		• Other team partners will be successful in developing the IPM interventions at the laboratory for field piloting.
Objective 5: To generate sustainable wealth creation for improved livelihood and poverty alleviation in rural areas, through green economy and SCP promotion in Africa.					
Specific Objective 5.1. Implementing and achieving the triple certification scheme.					
1. A trained operational structure (staff, organisation, equipment) in charge of the project implementation; project database created; 21,000 contracts with farmers for GI, FT and ECO certification.	• Mt Rwenzori coffee production chain is capacitated and empowered. • An organised structure is created, which is suitably trained and equipped, and meant to remain operational after the termination of the project.	• Training publication (factsheets, guidebooks) by September 2019. • A practical handbook on triple certification scheme. • GI book of requirements.	• Literature. • Interviews with and contacts of local actors.	• Literature and field exploration. • Interview forms.	• Difficulties in training. • Difficulties to make contact.
Specific Objective 5.2. Creating and implementing a dynamic, interactive knowledge platform, supporting the project development.					
1. The basic structure of the information system is created; WIFI, mobile phone, Interfaces development; a GIS system-based, descriptive and dynamic presentation of Mt Rwenzori certified coffee production; a production traceability platform interface.	• It provides a powerful organisation tool for information exchange, learning, management (monitoring) visibility and advocacy of the triple certification process.	• GI, FT and ECO certification criteria compendium. • Various site maps created (topography, administration, climate, agrosystems, production quality, quality traceability) for project management and commercial interface (relation with buyers).	• Use by farmers and extension agents.	• Field survey. • Cooperative participation.	• Difficulties to use the platform.

Outputs	Outcomes	Performance Indicators	Data Source	Means of Obtaining Data	Risks and Assumptions
Specific Objective 5.3. Generating conditions for sustainability; SCP promotion.					
1. Expertise transferred to and acquired by NUCAFE in the domains of IT, quality management, certification programs implementation.	• Farmers' coffee income is improved by a minimum of 35% from certification premium obtained through the general improvement of Mt Rwenzori CVC performance.	• Quality management procedure. • Recruited staff position. • Social and legal prospective study developed.			• Lack of local expertise in the area of IT.
2. IPM strategy for Mt Rwenzori coffee production; climate change impact assessment and adaptation strategy developed; a GIS system-based, descriptive and dynamic presentation of Mt Rwenzori certified coffee production; publicizing the action and generating optimal conditions for visibility and replication.	• The "green" performance of Mt Rwenzori CVC and number of SCP practices implemented are enhanced: waste production are reduced, inorganic chemical are banned.	• Compendium on coffee pest and disease control measures in compliance with ECO certification. • IPM and climate change adaptation strategy guidebook. • Pamphlets, factsheets presenting the action. • SWITCH regional conference compendium. • Policy recommendations documents. • Platform implementation.	• Use of the platform.	• Field and forms.	• Difficulties to use the platform.

INSECTS FOR FOOD AND FEED PROGRAMME (INSEFF) at *icipe*

a.) Overview of activities

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 to such problems innovatively. In accordance, the Centre has established itself as a leader in the globally emerging insects for food, feed and other uses, research agenda. This topic, which has captured the imagination of the global scientific community, donors and general public, is inspired by three sets of interconnected issues.

The first relates to the growing world population, which, currently standing at around 7.4 billion, is projected to increase to 9.6 billion by 2050, pushing the demand for food up by 60%. This population surge, combined with urbanisation, climate change, diminishing land and water resources, over and undernutrition, and persistent poverty, has created uncertainties and pressures on current food and economic systems. The impact is especially significant in SSA, where almost a third of the world's hungriest people live, with 23% of the continent's population undernourished. Insects can provide a solution to the rising food insecurity and malnutrition in this region because they reproduce quickly, and they are also valuable sources of protein, minerals and vitamins essential for human development. For instance, recent observations on amino acid profile and digestibility characteristics show the protein quality in edible insects to be outstanding. Several essential amino acids, especially lysine, threonine and methionine, which are limited in cereal and legume-based diets, are also present in adequate quantities in edible insects. Worldwide, zinc deficiency is responsible for 450,000 deaths annually, especially in children under five years. Compared to conventional sources, edible insects are rich in zinc. For instance, while 100g of beef contains only 12.5 mg of zinc, the same amount of palm weevils contains 26.5 mg.

The second driver of the insects for food and feed research agenda is connected to constraints in the poultry, fish and pig industries. Although these enterprises are the fastest growing agri-businesses in many developing countries, their full potential is hindered by poor availability and high cost of feed protein additives, which include soybeans, fish oil, fish meal, seed cakes and several other grains. Currently, feed costs are estimated to represent 60 - 70% of the poultry, fish and pig production costs. In addition, it is becoming unsustainable to rely on fishmeal, soybean and cereals as protein sources in feed production. Soybeans and cereals are also foods for human consumption, and land for their cultivation is diminishing. Further, due to overexploitation, the small pelagic forage fish from which fish meal and fish oil are derived, are declining steadily. Because they have similar (if not higher), protein content compared to fish and soybean, and since their amino acid profiles are superior to those from plant supplements, insects represent a solid substitute for livestock feed.

The third set of factors driving research on insects is in regard to the global quest of incorporating 'greening' measures into agricultural systems, aimed at climate change mitigation and biodiversity conservation. Compared to other livestock, insects are far more efficient in converting organic matter into protein, leading to lower greenhouse gas emissions. In addition, insect species such as black soldier flies and house flies can be used in organic waste management. Despite these clear reasons for the integration of insects as a sustainable component in addressing food, nutritional and

feed security, and as part of the transition towards 'greener' agriculture, a number of challenges stand in the way. Although in many countries across Africa, Asia and Latin America a range of insect species have traditionally been part of people's diets, there is minimal understanding of their contribution to food and nutritional security. Moreover, edible insects are often harvested in an uncontrolled manner from the wild or through semi-domesticated informal set-ups. Ultimately, this can lead to habitat destruction and even extinction of species.

There is also lack of a proper institutional framework to oversee and document edible insects. Therefore, proper research is required to gain solid understanding of appropriate insect species that can be mass-reared, including knowledge on breeding, production management, and ways to pre-empt and control diseases and environmental risks. Moreover, for it to succeed, mass-rearing of insects must appeal as an emerging industry to entrepreneurs and investors across the value chain. Importantly, the sector also has to be supported by regulations and policy frameworks encompassing food safety and trade issues on national, regional and international levels. The initiatives should also be inclusive, for instance by deliberately enabling the participation of women and the youth.

b.) Goal and Broader Objectives

icipe's insects for food and feed research aims to establish itself as a leader in the globally emerging insects for food, feed and other uses, research agenda.

c.) Strategic Outlook (up to 2020)

Since identifying the insects for food and feed as a strategic research area in 2013, *icipe* is helping to address the challenges discussed above. In 2014, the Centre compiled an inventory titled "*African edible insects for food and feed: inventory, diversity, commonalities and contribution to food security*," which was published in the new Journal of Insects for Food and Feed. *icipe* also established the Insect for Food, Feed and Other Uses (INSEFF) Programme, as the platform for consolidating and strengthening its activities. Currently, the Centre is implementing four projects: GREEiNSECT (Mass-rearing insects for greener protein supply); INSFEED (Integrating Insects in Poultry and Fish Feed in Kenya and Uganda); ILIPA (Improving Livelihood by Increasing Livestock Production in Africa) and EntoNutri (development and implementation of insect based products to enhance food and nutritional security in sub-Saharan Africa)

GREEiNSECT initiative: Which is led by the University of Copenhagen, Denmark, *icipe* is working with a consortium of public and private sector partners from Africa, Asia, Europe and USA, to investigate ways of mass-rearing insects in small, medium and large scale industries. The aim is to merge traditional and modern scientific knowledge, and to provide a platform for international collaboration, bringing together South–South and North–South partnerships.

The INSFEED Project; Which is jointly supported by the International Development Research Centre (IDRC), Canada, and the Australian Centre for International Agricultural Research (ACIAR), aims to take a holistic approach in regard to the use of insects as feed for poultry and fish around three focus areas: establishing strong scientific bases; testing the technical feasibility and economical profitability and creating favourable social and political conditions for large scale application of the technologies.

ILIPA Project: This is a collaboration between *icipe* and Wageningen University, The Netherlands. The initiative aims to use scientific research and a participatory approach involving farmer groups, with particular focus on women and youth, to exploit the commercial potential of insects, mainly the black soldier fly (BSF), *Hermetia illucens* , in the production of affordable, high-quality protein for poultry, pig and fish industries.

The EntoNutri Project, which is funded by the Federal Ministry for Economic Cooperation and Development (BMZ), Germany, is being implemented by *icipe* with the Center for Development Research (ZEF), University of Bonn and the Food Security Center, University of Hohenheim, both in Germany in partnership with national agricultural research systems partners from Kenya and Uganda. The initiative is focusing on four insects – cricket, grasshopper, Zambezi emperor worm and shea butter caterpillar – selected on the basis of their growing popularity as food in Kenya and Uganda. Special effort is being paid towards supporting participation of women along the value chain, and to assess nutritional attributes based on the unique needs of women, girls and infants.

Insects for Feed and Food (INSEFF) Results Based Management (RBM) Rolling Framework

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
Overall Objective: Promote the utilisation of insects for food, feed, organic waste recycling and pharmaceutical purposes to enhance food security and income generation capacity in sub-Saharan Africa by 2020.					
Specific objective: Develop and promote Insects for Green Economy (GREEiNSECT) by 2018					
1. An appraisal study to document culturally and environmentally acceptable insect species in Kenya conducted.	• Knowledge regarding edible insects in Kenya enhanced.	• Culturally and environmentally acceptable edible insect species in Kenya documented by end of 2014.	• Questionnaires. • Reports. • Publications. • Student theses	• Inventories of insects. • Surveys. • Responses to questionnaires.	• Cooperation from the community. • Political situation is favourable.
2. The microbiological content of the key edible insects in Kenya (fresh, processed or stored form) identified and analysed.	• Food safety and risk factors associated with edible insects documented.	• The microbiological content of key insects as food in Kenya identified by end of 2017.	• Reports. • Publications. • Student theses.	• Laboratory bioassays. • Field sampling.	• Pathogens are amenable to growth on media and can be identified. • Availability of insect samples.
3. Potential entomopathogens that pose a threat in the farming of insects profiled and documented.	• Knowledge of entomopathogens that threaten production of edible insects enhanced.	• Potential entomopathogens that pose a threat in the farming of insects documented by end of 2017.	• Reports. • Publications. • Student theses.	• Surveys. • Laboratory bioassays.	• Pathogens are amenable to growth on media and can be identified. • Availability of insect samples.
4. Molecular characterisation of microbial composition (DNA barcoding and/or RAPD) conducted.	• Information regarding the microbial composition of the edible insects improved.	• Molecular characterisation of microbes attacking edible insects and that pose a threat for food safety conducted by end of 2018.	• Reports. • Publications. • Student theses.	• Field sampling. • Molecular laboratory analysis.	• Markers are available or can be developed. • Availability of insect samples.
5. Recommendation s for enhancing food safety and	• Information to enhance policy regulations and	• Workshops to provide recommendations to inform policy for development of standards for use	• Reports. • Publications. • Policy briefs.	• Workshops. • Secondary data.	• Political situation is favourable. • Cooperation by the relevant governmental bodies and policy makers.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
quality control of edible insects in Kenya, and for international trade provided.	legislations governing the use of insects as food and feed available.	of insects as food and feed conducted by end of 2016.			
Specific objective 5.2: Develop and promote insect feed for poultry and fish production in Kenya and Uganda (INSFEED) by 2018					
1. Socio-economic surveys carried out on the use of insects for feed in poultry and fish farming. 2. Market demand analysis for insects as feed ingredient for poultry and fish conducted. 3. Economic performance of insect-based feed assessed.	• Farmers and feed producers invest more in insect-based feed production and use and increase adoption by 2018.	• At least 3 focus discussions per target country by end of 2015. • At least 500 small-scale farmers surveyed per target country by end of 2015. • At least 100 livestock feed processors surveyed per country by end of 2015. • Comparative costs of at least 3 insect-based feeds assessed by end 2018. • Market demand and cost-benefit analysis conducted for at least one insect-based feed by 2017. • Cost efficiency studies of poultry and fish reared on insect-based feed evaluated by 2018. • Key market segments described by December 2015.	• Questionnaires. • Project reports. • Student theses. • Publications. • Policy briefs.	• Farmer interviews. • Surveys. • Focus group discussions.	• Stakeholders willing to participate in trainings. • Political situation is favourable. • Security situation in target areas does not prevent or interrupt project implementation. • NARS cooperate in the project implementation.
4. Rearing techniques for key insects suitable for use as feed developed and adapted. 5. Wild harvesting techniques for swarming insects developed and adapted.	• Efficiency improved in insect, poultry and fish rearing for low-cost production and high profit margin by 2018.	• Rearing techniques developed for at least 3 insect species by June 2015. • Safe and cost-effective substrate for rearing of at least 3 insect species documented by end of 2016. • Chemical and microbial toxicity of at least 3 insect species under different rearing techniques profiled by end of 2017.	• Student theses. • Publications. • Reports. • Training manuals. • Policy briefs. • Rearing facilities in the different countries. • Wild harvesting traps. • Feed formulas.	• Laboratory records. • Field experiments and data collection. • Surveys.	• Stakeholders willing to participate in trainings. • Political situation is favourable. • Security situation in target areas does not prevent or interrupt project implementation. • NARS cooperate in the project implementation.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
6. Chemical and microbial contamination determined, and protocol developed for safe rearing and handling. 7. Nutritive profile of key insects assessed. 8. Insect-based feed formulated and tested.		• Entomopathogens affecting at least 3 insect species colonies documented by 2017. • Wild harvesting techniques developed or adapted for at least 3 species by September 2018. • Effect of trap and postharvest handling on contamination documented by 2017. • Insect based feed formulas developed by 2017. • Nutritive profile of at least 3 insect-based feed assessed by 2016. • Palatability and utilisation rate of at least two insect-based feeds tested on fish and poultry by end of 2017. • Effect of at least two insect-based feeds on fish and poultry growth assessed by end of 2017. • Storage techniques developed for at least 3 insect-based feeds by September 2017.	• Storage materials.		
9. Results used to inform policy to support use of insect-based feed in poultry and fish farming.	• Enhance awareness among stakeholders and inform policy by 2017.	• At least two stakeholder workshops held by 2017. • At least 10 media coverage stories on the INSFEED project by December 2017. • At least two policy briefs documented by December 2017. • At least two desk studies and expert interviews conducted per country by 2016. • At least one situation paper on the use of insects for feed produced by June 2018.	• Publications. • Project reports. • Theses. • Training manuals and leaflets. • Policy briefs. • Project website. • Media coverage.	• Trainings. • Workshops. • Desk studies. • Interviews.	• Stakeholders willing to participate in trainings. • Political situation is favourable. • Security situation in target areas does not prevent or interrupt project implementation. • NARS cooperate in the project implementation.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
		• Documentation of processed feed leading to national and international standards (Codex) developed by December 2017.			
Specific objective: Development and implementation of insect-based products to enhance food and nutritional security in sub-Saharan Africa (EntoNUTRI) by 2019					
1. Insect farming and harvesting techniques for edible saturniids, grasshoppers and crickets developed, and production systems optimised using locally available substrates. 2. The nutritional attributes of target insect species (fresh, stored and processed) established and appropriate post-harvest technologies for preservation tested and implemented. 3. Food safety (chemical and microbiological) and regulatory requirements to inform policy on the use of insects as food established. 4. Socio-economic assessment –	• Edible insect-based technologies to enhance productivity and consumption of insects as food to improve livelihoods and wellbeing of rural and urban communities developed and disseminated by March 2019.	• At least two improved rearing and two improved harvesting techniques for edible insects developed and disseminated by March 2019. • Field ecology of at least two target edible insects assessed by December 2017. • Wild harvesting techniques for at least 1 target edible insects developed by December 2018. • Nutritional attributes of at least 3 edible insects assessed by December 2017. • Improved postharvest handling techniques for at least 2 edible insects developed by December 2018. • At least 2 target edible insects screened for chemical risk factors by December 2018. • Microbial risks associated with 3 target edible insects assessed by March 2019. • At least 2 target country level surveys on community knowledge attitude and practices with edible insects completed by July 2017. • At least 1 survey on consumer willingness to accept edible insects completed by December 2018.	• Databases in public/institutional data repositories. • Project reports. • Project website. • Publications/journal websites. • Policy briefs on EntoNUTRI's website. • Training reports. • Participant list. • Manuals, posters and leaflets. • Student theses and publications.	• Field ecology surveys. • Field experiments. • Laboratory bioassays and experiment records. • Socio-economic survey. • Desk studies. • Workshops. • ToT activities.	• Conducive weather conditions for outbreaks of edible insects prevail. • Community members are willing to participate in the research. • Continued participation of students in the project research. • Insects are amenable to rearing. • Microbes are amenable to artificial culturing on media. • Stakeholders are willing to participate. • sufficient number of women are willing to participate in the socio-economic surveys.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
communities' perception of insects as food and the willingness to accept insects as part of their diets as well as the livelihood effects of edible insects in households assessed and documented. 5. Innovations on insect farming and utilization as food transferred to beneficiaries, and R&D capacity and entrepreneurship in the field disseminated.		• Economic situation of edible insect value chain actors assessed in 1 of the target countries by September 2018. • ToTs on insects to enhance food and nutritional security undertaken for at least 40 stakeholders (20 each for Kenya and Uganda) by December 2018. • Outreach materials (manuals, posters and leaflets) on insect rearing/harvesting/processing/packaging technologies developed and distributed to at least 1,000 beneficiaries in each country by March 2019. • A project website established by March 2016. • Advanced level training of at least 4 PhD and 5 MSc students, especially women, from Africa and Germany accomplished by March 2019.			
• **Specific objective: Improving livelihood by increasing livestock production in Africa: An agribusiness model to commercially produce high quality insect-based protein ingredients for chicken, fish and pig industries (ILIPA) by 2019**					
1. Pilot production and demonstration facilities established at *icipe*. 2. Potential scavenging feed resources that can be used as substrate for insect rearing investigated.	• Knowledge regarding practicality of scientific methods based on the availability of these feed resources in Kenya enhanced by 2017.	• Pilot production facility and feed sources for rearing black soldier fly that is culturally and environmentally acceptable in Kenya documented by end of 2017.	• Reports. • Publications. • Student theses	• Inventories of substrates. • Laboratory work	• Availability of insect samples.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
3. Socio-economic surveys carried out on the use of insects for feed in poultry, fish and pig farming. 4. Market demand analysis for insects as feed ingredient for poultry, fish and conducted.	• Farmers and feed producers invest more in insect-based feed production and use, and increase adoption by 2019.	• At least 500 small-scale farmers surveyed by end of 2017. • Comparative costs of at least 1 insect-based feed assessed by end 2017. • Market demand and cost-benefit analysis conducted for at least one insect-based feed by 2018.	• Questionnaires. • Project reports. • Student theses. • Publications. • Policy briefs.	• Farmer interviews. • Surveys. • Focus group discussions.	• Stakeholders willing to participate in trainings. • Political situation is favourable. • Security situation in target areas does not prevent or interrupt project implementation. • NARS cooperate in the project implementation.
5. Awareness on the potential of insect-based feeds for poultry, pig and fish farming raised.	• Farmers consider insects as an alternative source of feed for poultry, pig and fish farm enterprises by 2018.	• At least 10 awareness stakeholders meeting organized by 2018. • 5 radio spots realized by 2018. • At least 30% of farmers attending awareness meetings consider insect as an alternative source of feed for poultry, pig and fish farm enterprises by 2018.	• Publications. • Project reports. • Theses. • Training manuals and leaflets. • Policy briefs. • Project website • Media coverage.	• Trainings. • Workshops. • Desk studies. • Interviews.	• Stakeholders willing to participate in trainings. • Political situation is favourable. • Security situation in target areas does not prevent or interrupt project implementation. • NARS cooperate in the project implementation.
6. Capacity of youth and women farmers (small-scale and commercial) in	• Youth and women farmers (small-scale and small commercial) engage in mass-production,	• At least 10 youth and 10 women groups trained in mass-production, harvesting and primary processing of black soldier fly protein by 2018.	• Reports. • Photos of demonstration session in mass-production,	• Established learning sites. • Model farmers contacts. • Lists of model farmers.	• Political stability. • Farmers cooperate and allow access to insect-rearing facilities in their farms. • Favourable weather conditions.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
mass-production, harvesting and primary processing of black soldier fly protein built.	harvesting and primary processing of black soldier fly by 2019.	• At least 30% of the group members produce, harvest and process black soldier fly by 2019.	harvesting and primary processing of black soldier fly.	• Farmer and NARS attendance lists. • Demonstration sites with display panels.	
7. Formulations for nutritious insect-based feeds for poultry, pigs and fish established and tested.	• Nutritious insect-based feed formulation for poultry, pigs and fish ready for release for mass-production by 2018.	• At least one formulation for insect-based feeds for poultry, pigs and fish established and tested by 2017. • At least two commercial small-scale feed companies willing to take nutritious insect-based feed formulation for mass production by 2019.	• Training manuals. • Project documents, reports. • Publications.	• Field trials. • Developed businesses/enterprises.	• Willingness of feed manufacturers, value chain actors and stakeholders to cooperate. • Availability of farms to carry out field trials. • Adequate resource mobilisation.
8. Insect based feed tested for microbial pathogens and toxins.	• Insect-based feed formulation free from microbial pathogens and toxins ready for release for mass production by 2018.	• At least 1 feed formulation is tested free from microbial pathogens and toxins, and can be proposed for mass-production by 2018. • At least two commercial small-scale feed companies willing to take safe insect-based feed formulation for mass production by 2019.	• Reports. • Publications. • Student theses.	• Laboratory bioassays.	• Pathogens are amenable to growth on media and can be identified. • Markers are available or can be developed. • Availability of insect samples.
9. Protocols and tools for production of safe insect-based feeds for poultry, pigs and fish in the prospect of certification developed.	• Protocol and tool for production of safe insect-based feeds used by small-scale feed processors by 2018.	• At least 1 protocol and tool for production of safe insect-based feeds available by 2018. • At least 2 small-scale feed processors use the protocol and tools for feed formulation by 2019.	• Project reports. • Scientific publications. • Market surveys. • Theses.	• Laboratory bioassays. • Fieldwork. • Communities.	• Various stakeholders demand alternative protein source for poultry, fish and pigs.
10. Youth and women farmer groups linked to profitable markets (e.g. feed companies) for the	• New sector for employment, value chain for insect protein created in Kenya by 2019.	• At least 10 youth groups and 10 women groups linked to profitable markets for insect-based feeds by 2018. • At least 20% of the farmer group members are selling insects to	• Training manuals. • Project documents, reports. • Publications. • Registry of youth.	• Field surveys. • Network partners in collaborative agreements. • Developed marketplaces.	• Willingness of youth, value chain actors and stakeholders to cooperate. • National cooperation. • Adequate resource mobilisation.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
insect-based protein products.		small-scale feed processors by 2019.			
Specific objective: INSect-based agriBIZiness for sustainable grasshopper and cricket production and processing for food in Kenya and Uganda (INSBIZ) by 2020					
1. Market potential and market performance of insect-based food products assessed.	• Informed investment in insect-based food product commercialization increased by 2020.	• At least two private sector players invest in insect-producing agro-businesses in Kenya and Uganda by 2019. • Market potential for grasshopper and cricket products in Kenya and Uganda established by 2018. • Market performance (penetration and cost-benefit performance) for grasshopper and cricket products in Kenya and Uganda established by 2020.	• Company investment reports. • Field survey reports. • Publications. • Farmer interviews. • Domestic and export agro-statistics. • Project reports.	• Field surveys. • Interviews and questionnaires. • Visits to partner companies. • Field data, secondary data collection. • Developed marketplaces.	• Key informants willing to cooperate. • Partners willing to cooperate in testing the insect-based food products. • Permission granted by the bureau of standards in both Kenya and Uganda. • Stable political situation in the region.
2. Mass rearing protocols for crickets and grasshoppers adapted, piloted and upscaled.	• Safe protocols for cricket and grasshopper rearing established and widely adopted at various scales by 2019.	• At least two SMEs mass rearing crickets and grasshoppers in Kenya and Uganda by 2020. • Rearing facilities for grasshoppers and crickets established and active insect rearing activities initiated by 2018. • At least two SMEs use the protocol and tools for safe crickets and grasshoppers mass rearing by 2018. • Protocols for healthy insect rearing documented by 2018. • Post-harvest protocols for cricket and grasshoppers under SMEs rearing and trading conditions documented by 2018. • Insect-based products commercialized are maintained under safe conditions by 2019. • Well packaged insect-based food products on the market by 2019.	• Field survey reports. • Catalogue of pest and diseases. • Insect rearing data. • Training materials. • Company investment reports. • Vibrant colonies. • Project report. • Training manual. • Training register. • Publication. • Research data. • Web resources. • Bureaus of Standard's evaluation reports.	• Field surveys. • Interviews and questionnaire. • Visits to partner companies. • Catalogue of pest and diseases. • Training evaluations. • Samples in laboratory and on the market • Bureaus of Standard's assessments.	• Partners willing to use protocol for the safe and mass production of crickets and grasshoppers. • Political situation is favourable. • Key potential diseases and pests in target areas occur during project period, and mitigation strategies found. • SMEs follow the post-harvest rearing protocol to enhance production.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
		• Regional large-scale retailers commercializing insect-based food by 2020.			
3. Ready-to-eat whole insects, insect flours for use as ingredients in food preparation developed and characterized, and insect-enriched porridge flours and cookies processed.	• Adoption and use of insect-based food standards in Kenya and Uganda, and increased consumer confidence in insect-based products by 2020.	• At least two food-based SMEs produce and commercialize insect-based food by 2019. • At least two safely packaged insect products available on the market by 2019. • Effect of various rearing and processing conditions on nutritional characteristics of crickets and grasshoppers documented by 2018. • Insect-based products for women of reproductive age and 5-year-old children or below developed and commercialized by 2019. • Insect-based novel food available on supermarket shelves by 2020.	• Publication. • Project reports. • Research data. • Web resources. • Bureaus of Standard's evaluation reports. • Theses. • Field survey reports.	• Lab analyses and surveys. • Experimental data. • Data collection and analyses. • Field surveys. • Market surveys. • Consumer surveys. • Key Informant Interviews with food traders.	• Supermarkets willing to sell • Costumers identify advantages in purchasing products marketed. • Stable political situation in the region. • Crickets and grasshoppers available, and various rearing and processing techniques developed. • Consumers' willingness to purchase insect-based products.
4. Favourable enabling environment for insect-based food through policy, advocacy and awareness creation established.	• High consumer acceptability for insect-based products in Kenya and Uganda by 2020.	• Policy briefs, advocacy and awareness creation materials established by 2019. • Insect-based food standards developed and approved in both countries by 2020. • At least three workshop reports documented by 2019. • At least one policy brief on food standard development documented by 2019. • Insect-based food advocacy materials developed by 2018. • At least 2 radio programs held by 2019. • At least one policy briefs developed on insect-based food by 2018.	• Project reports. • Workshop reports. • Publications. • Policy briefs. • Standards. • Radio programs. • Exhibitions reports.	• Market surveys. • Consumer surveys. • Key informant interviews with policy makers and food traders. • Exhibitions. • Workshops.	• Consumers' willingness to give information, attend exhibitions and listen to radio programs. • Policy makers willingness to attend workshops and facilitate standard development and approval. • Stable political situation in the region.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
		• At least two promotion materials disseminated on insect-based novel foods by 2019. • At least 2 exhibitions of insect-based food products done by 2020.			
Specific objective: Testing business models for scaling insect-based protein feed for use in poultry farming and aquaculture in Kenya (SiPFeed)					
1. Markets and marketing channels for insect-based protein feed using different business models developed.	• Identify and adapt potential business models for insect-based protein for feed in poultry and fish production by 2019. • Map the potential insect-based protein feed supply chains by 2019. • Establish and monitor the linkages between insect-based protein feed value chain actors by 2020. • Work with the private sector partners to support various components, including training, financing and awareness creation by 2020. • Develop insect-based protein feed production and marketing information exchange	• Cost-effective and suitable commercial models identified and adapted for use of insects as feed enhanced by 2020. • Supply chains model (e.g. rearing substrates, equipment) for commercial production of insects documented by 2019. • Out-grower models utilising insect for feed by farmers and private sectors established by 2020. • Private sector feed millers subcontract entrepreneurs and contribute to the training and awareness campaigns of black soldier fly production by 2020. • Pre-financing for different needs in the production system (e.g., drying and storage equipment) documented by 2020. • SMEs develop outgrower models for sourcing insects from farmers/cooperatives and established market linkages with feed processors by 2020.	• Databases in public/institutional data repositories. • Project reports. • Completed thesis. • Publications/journal websites. • Policy briefs. • Training reports. • Participant list. • Manuals, posters and leaflets. • Student thesis .	• Field experiments. • Socio-economic survey. • Desk studies. • Workshops. • ToT activities. • Market surveys. • Consumer surveys.	• Respondents' willingness to give information. • Policy makers willing to attend workshops and facilitate standard development and approval. • Stable political situation in the region.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
	platform to link actors along the value chain by 2020.				
2. Transfer and promote insect-based protein feed technologies among the various actors along the value chain.	• Establish black soldier fly rearing facilities for demonstration and training on best practices related to production, processing and packaging by 2019. • Provide starter kits for production of insect-based protein by 2019. • Develop and disseminate, production protocols, training and outreach materials to sensitize and create awareness on insect-based protein feed by 2020. • ToT workshops on all aspects of the project outputs by 2020.	• Simple and cheap mass production technology with high potential for scale at the farm and SME levels established by 2020. • The most effective technologies for different commercial models documented by 2019. • The constraints/challenges of black soldier fly production and options/challenges documented by 2020. • At least 200 entrepreneurs and start-ups have access to proven low-cost technologies by 2020. • At least 200 farmers adopt the technology of mass production of black soldier fly for feed on-farm by 2020.	• Publication. • Project reports. • Research data. • Web resources. • Bureaus of Standard's evaluation reports. • Theses. • Field survey reports.	• Lab analyses and surveys. • Experimental data. • Data collection and analyses. • Field surveys. • Key informant Interviews with food traders.	• Farmers willing to cooperate. • Stable political situation in the region. • Black soldier fly available, and various rearing and processing techniques developed. • Feed millers' willingness to purchase insect-based products.
3. Evidence-based data to support scaling and adoption of insect-based protein feed enterprises generated.	• Establish baseline and end-line data by 2020. • Optimize modular insect production systems for scaling, based on stakeholder feedback and	• At least develop a business case for production of insect for feeds via the different model (farmers and SME developed) and make recommendation on the most viable business models by 2020. • Develop and distribute easy to use manual for setting up of successful	• Publication. • Project reports. • Research data. • Web resources. • Bureaus of Standard's evaluation reports. • Theses.	• Lab analyses and surveys. • Experimental data. • Data collection and analyses. • Field surveys.	• Farmers and other stakeholders are willing to cooperate. • Stable political situation in the region. • black soldier fly available and various rearing and processing techniques developed. • Feed millers' willingness to purchase insect-based products.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
	monitor for product quality and safety by 2020. • Assess the household level socioeconomic benefits of insect-based protein feed farming and formulation among millers and farmers in the poultry and aquaculture industry by 2020. • Assess the potential for employment generation and country level economic benefits of insect-based protein feed for poultry farming in Kenya by 2020.	insect farming with details on costing by 2020. • At least 2500 metric tonnes of insect-based protein produced and utilised for on-farm trails by 2020. • At least 3 optimal facilities for effectively scaling out on-farm production of black soldier fly established by 2020. • The nutritional and safety qualities of black soldier fly reared on various substrates under different production models compared to laboratory-reared black soldier fly documented by 2020. • 200 farmers recruited to participate in on-farm assessment and performance of insect-based protein feed on poultry and fish in target locations by 2020. • Nutrient quality established of formulated feeds produced by private feed millers to meet the nutritional demand of poultry and fish for optimal on-farm productivity by 2020. • Establish the socio-economic benefits of insect-based protein farming and feed formulation in poultry and aquaculture production by 2020. • Establish the viability of insect-based protein enterprises for job creation among youths and women by 2020.	• Field survey reports.	• Key informant interviews with feed millers.	
Specific objective: INSFEED2: Insect feed for poultry, fish and pig production in Sub-Saharan Africa- Phase 2 by 2021					

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
1. Cost-effectiveness and potential livelihood effects of insect-based feed technologies assessed through a gender lens along the value chain.	• The economic benefits of insect farming and insect-based feed for poultry, fish and pig production systems along the value chain determined by 2019. • The long-term potential impact of insect-based feed technologies on food and nutritional security predicted by 2019. • Economic viability of insect-based feed supply chain models to guide scaling up pathways by 2020.	• Two scientific papers on efficient insect mass rearing techniques as affected by different agro-ecological zones. • One training guide on insect mass-rearing for feed with reference to production scales and gender developed. • 3 scientific publications on cost-effective organic fertiliser production through insect mass-rearing. • Stories of change focusing on experience and success from youth, men and women and other actors involved in the use of insect as feed documented. • At least 300 insect mass-rearing enterprises owned by women, men and youth established. • At least 10 feed producers integrating insect in their feed. • 2 Msc and 1 PhD student trained.	• Field survey reports. • Catalogue of pest and diseases. • Insect rearing data. • Training materials. • On-farm vibrant black soldier fly colonies. • Project report. • Training manual. • Training register. • Publication. • Research data. • Bureaus of Standard's evaluation reports.	• Field surveys. • Interviews and questionnaire. • Visits to partner companies. • Catalogue of pest and diseases. • Training evaluations. • Samples from the laboratory and in the market. • Bureaus of standard's assessments.	• Partners willing to use protocol for the safe and mass production of black soldier fly. • Political situation is favourable. • SMEs follow the post-harvest rearing protocol to enhance black soldier fly production.
2. Finetune and deploy rearing techniques under small- and medium-scale on-farm conditions to improve capacity planning to meet customer demand for insect-based protein and fertiliser.	• Traceability and capacity planning for reliable and timely meeting of customers' demands improved by 2021. • Quality organic fertilizer alongside high yielding insect production developed by 2020. • Insect rearing under various on-farm conditions present,	• Report on existing supply chain models for key commodities in Kenya and the role of the youth, women and men in feed supply chain produced. • Paper on the gender differential economic benefits of insect farming and insect-based feed for poultry, fish and pig production systems along the value chain in Kenya. • Paper on the long-term potential impact of insect-based feed technologies on food and nutrition security in Kenya.	• On-farm vibrant black soldier fly colonies. • On-farm fertilizer report. • Training manual. • Publication. • Research data. • Product certification reports.	• Field surveys. • Interviews and questionnaire. • Visits to partner companies. • Catalogue of pest and diseases. • Training evaluations. • Samples in laboratory and on the market. • KEB assessment report.	• Partners willing to use protocol for safe mass production of black soldier fly. • Political situation is favourable. • SMEs follow the postharvest rearing protocol for enhanced black soldier fly production. • No adverse weather conditions prevail. • Farmer cooperate to provide land for planting trials. • Good seeds available for propagation.

Outputs	Outcome	Performance Indicators	Data Source	Means of Obtaining data	Risk assumptions
	and its performance assessed based on different models (gender and age of farmer, scale of production, agro-ecology) by 2021.	• Report on economic viability of insect-based feed supply chain models in Kenya. • At least 2 Msc students trained.			
3. Develop and test gender-inclusive insect feed supply models and build capacity along the value chain.	• Awareness creation conducted by 2019. • Develop, test and compare different supply chain models linking insect production with feed manufacturing by 2020.	• Training manual developed. • At least 3,000 fliers produced and distributed. • At least 300 posters produced and distributed. • At least 6 training reports produced. • A curriculum on insect use in animal feed developed. • At least 3,000 youth, men and women trained in the different target groups. • At least 10 entrepreneurs with successfully financed business models. • Report on existing supply chains in other commodities and their applicability to insect-based feed produced. • At least 5 radio and TV programs held.	• Training workshop reports. • List of participants. • Flyer. • Posters. • Audio tape. • Video documents. • Publication. • Project reports. • Research data. • KEBS evaluation reports. • Theses. • Field survey report. • Pilot facilities.	• Value chain data collection and analyses. • Field surveys. • Key informant interviews with stakeholders.	• Farmers and other stakeholders are willing to cooperate. • Stable political situation in the region. • black soldier fly available and various rearing and processing techniques developed. • Feed millers' willingness to purchase insect-based products from producers.

ANIMAL HEALTH at *icipe*

a.) Overview of activities

In Africa, livestock are vital to food security. Over two-thirds of the population are dependent on livestock for their everyday survival. If livestock are lost, households can slip into chronic poverty traps. In Africa, most livestock are raised on small farms or herded by pastoralists. Improvement of livestock health and productivity, therefore, provides a significant opportunity to improve the livelihoods of these resource-poor people and to help them escape the poverty cycle. It is also important to improve livestock productivity to meet the increased demand for livestock products and to enhance traction power of oxen for improved agricultural productivity.

icipe continues to apply its considerable expertise in developing tools and strategies for integrated livestock vector and disease control to the two major vectors affecting livestock productivity in sub-Saharan Africa: the tsetse fly, vector of animal and human trypanosomoses, and ticks which, among other diseases, transmit East Coast fever. Research will also be enhanced on arthropod vectors with zoonotic potential that are responsible for trans-boundary animal diseases.

Over the years, *icipe* has developed capacity along the full research continuum, from strategic basic research to adaptive research and finally to technology development, transferred through strategic partnerships. The Centre has amassed considerable expertise in quantitative vector ecology, behavioural and chemical ecology, biological control and integration of this basic knowledge in developing technologies in a form that farmers can use themselves. Our research and experience in Africa's two most important vectors of animal diseases—tsetse and ticks—have generated technologies which enable farmers to undertake better ecological management of these major livestock disease vectors and help in intensifying and diversifying smallholders' farming systems to generate more cash income and enhance food security. The emphasis has been on developing environmentally safe methods that can be applied together in tailor-made, site-specific packages. *icipe*'s Integrated Pest and Vector Management (IPVM) approach, relies on biological control, use of botanicals and anti-tick pasture plants, repellents and behavioural modification. Components of such a package include the Centre's well-known NGU tsetse traps whose efficacy is enhanced by odour baits, biological control and the use of potent repellents. *icipe* also has gained extensive experience in community mobilisation, empowerment and in developing the management and organisational capacity for successful implementation of the required prevention and control techniques. Indigenous knowledge of communities in the management of ticks is also incorporated in developing appropriate adaptive control strategies for these important pests and vectors. Capacity building at all levels of society is an integral part of all *icipe* activities.

Climate change is expected to have a large impact on the interactions between vectors, pathogens and their animal and human hosts. Vector-borne diseases are particularly sensitive to global warming because temperature changes can alter vector development rates, shift their geographical distribution and transmission dynamics, or modify host susceptibility to infection. In fact, climate change is beginning to change the map of important tropical diseases like malaria, Rift Valley fever, animal and human trypanosomoses, leishmaniasis, bluetongue disease and dengue fever, among others.

Livestock and the ecosystems they depend on are also affected by climate change, and important livestock and human diseases are likely to spread to new regions and become more severe. At the same time climate variation in the tropics, and its effects on the frequency of flooding and drought, could modify the dynamics of the transmission of diseases with the emergence of vectors that alter the population immunity and resistance. Harnessing its unique and extensive expertise in animal and human vectors, and pathogens in sub-Saharan Africa (SSA), *icipe* will investigate climate-sensitive aspects of vector and pathogen biology to predict changes in disease prevalence to improve vector and disease detection and response.

The Horn of Africa experiences recurrent and extreme climatic shocks and drought that severely affect food security and livelihoods in this region. Pastoral communities are the worst affected. *icipe* will assist in the mitigation of this increasingly devastating impact through the development of baits and repellents for biting flies, which includes the major vectors of surra in camels. Camel health and productivity is central to the pastoral economy, and any improvement in this area has a significant effect on its resilience to climatic shocks.

The integrated animal health packages developed for enhancing milk production in Kenya in the smallholder sector offer opportunities for the integration of plant health such as mixed farming practices ('push–pull' for increased fodder production) and human health, such as the livestock protective net-fence that reduces malaria-transmitting mosquito populations. Development of such holistic projects is one of *icipe*'s priorities, and in line with the global One Health philosophy. Evidence shows that investing in smallholders is the most effective method of stimulating poverty reduction and growth, and improving the livelihood opportunities of young farmers, especially women.

b.) Goal and Broader Objectives

icipe's animal health research aims to improve livestock health and productivity through the development of integrated strategies and tools for livestock vectors' control, thus leading to greater availability of meat and milk, hides and draught power, and thus enhancing food security.

c.) Strategic Outlook (up to 2020)

Research on vectors of trypanosomosis (both human and animal) and tick-borne diseases will continue. Greater use of genomics and bioinformatics, and behavioural and chemical ecology will be prioritised for technology development, optimisation and implementation. Research will be extended to other arthropods of medical and zoonotic importance, including new emerging infectious diseases, to develop technologies for the integrated management of these vectors and the diseases they cause. Neglected zoonotic tropical diseases are under researched although they affect millions of people in particularly rural Africa and have dire consequences for the socio-economic conditions of families and countries. Little is known of how and to what extend ecological and environmental conditions determine the spread of tropical diseases in Africa and movement of the vector. Training is thus needed on various levels in order to enhance knowledge in this regard. Climate change may increase the range and efficiency of vectors; but, icipe is continuing its research and preparation to deal with these consequences. More holistic projects will be developed to catalyse sustainable

agriculture with rural development, and to ensure that improvements made in livestock and human health will lead to tangible results in terms of improved food security and poverty reduction. Holistic, innovative, site-specific, packages for sustainable animal health management/production will be developed and tested at the farmer/community levels in different production systems and agroecological zones. This will achieve greater potential for successful adoption at the community level. Capacity building to create cadres of research, vector control specialists and managers in livestock IPVM, and increasing the skills and management ability of communities to ensure sustainability of control efforts, will continue to be given high priority.

d.) Specific future thrusts:

Tsetse

As one of the few institutes in Africa working on vectors of trypanosomosis, *icipe* will continue to develop and optimise technologies for effective integrated control of tsetse and the diseases they transmit.

The tsetse repellent technology developed by *icipe* is ready to be rolled out to tsetse affected countries in SSA in collaboration with other regional and continental initiatives, and in partnership with the African Union's Inter-African Bureau for Animal Resources (AU-IBAR), whose mandate is to support and coordinate the utilisation of livestock for human well-being and economic development in all member states of the AU. The repellent technology will be further optimised and validated for up scaling and commercialisation for large-scale uptake. The prototype dispensers developed will be refined through appropriate partnerships with the private sector into commercial products that are non-metallic, cheap, affordable and easy to use by livestock keepers.

The repellent technology in general provides good opportunities for **engagement with the private sector** as, through public–private–partnerships, *icipe* can undertake the technical refinement of the dispensers more effectively. Large-scale validation trials will also be undertaken to determine under which herder and agroecological conditions the technology would work best.

Repellents also open up the possibilities of developing integrated tsetse and trypanosomosis control strategies in conjunction with other control strategies. For example, repellents can be used to push flies away from cattle, and traps or targets used to pull and kill the flies. Alternatively, a few animals can be sprayed with insecticide pour-ons to pull and kill.

Repellents may also be useful in developing barriers to stop reinvasion by flies into controlled areas. Since the current repellents have been developed only for savannah tsetse, they need to be evaluated for flies that transmit human sleeping sickness. Thus, research needs to be extended to identify and develop potent repellents for the *palpalis* group of flies (riverine tsetse), which are major vectors of human sleeping sickness. Repellents can be used to protect humans from tsetse bites and thus significantly reduce cases of human trypanosomosis.

Since the identified repellent compounds also affect other biting insects, these need to be evaluated in detail as they may have global implications.

Advances in genomics and bioinformatics, together with detailed knowledge of the behaviour of the flies, will be used for optimising existing baits and for development of new innovative technologies and intervention strategies.

Studies on the characterisation of tsetse–trypanosome interactions are providing a better understanding of the disease epidemiology. These valuable data will continue to be used for the development of novel anti-parasite agents for blocking transmission of trypanosomes in the vector.

As the **FAO-Reference Centre** for tsetse and trypanosomosis and as one of the few institutes working on tsetse, *icipe* provides advice and technical support to African countries for interventions against African trypanosomoses and their vectors, including vector identification and ecology.

Biting flies and camel health packages

In addition to tsetse, biting flies (tabanids, stable flies, etc.) also mechanically transmit trypanosomosis (non-tsetse transmitted trypanosomosis) to cattle and to camels (i.e. surra), considerably affecting their productivity. *icipe* develops integrated technologies for control of biting flies based on exploitable weaknesses of the vectors along the lines of those developed for tsetse. Improving camel health and productivity has direct impact on the livelihoods of pastoralists in reducing the effects of recurrent climate shocks and drought in the Horn of Africa region and eastern Africa.

Development of holistic animal health packages

Since several diseases can affect the same animal simultaneously, *icipe* recognises the need for developing and testing of holistic animal health packages for sustainable animal health management and production. The Centre is currently developing such packages, as a collaborative project with Food and Agriculture Organization of the United Nations (FAO), to enhance productivity of dairy cows in Kenya and pig production in Ghana. The intensive zero-grazing units for milk production will be integrated with *icipe*'s push–pull technology, which focuses on controlling the parasitic striga weed, cereal stemborers and improving soil fertility. Further, *icipe* in partnership with an international team of researchers completely mapped the genome of the tsetse fly, the blood-sucking insect that transmits African sleeping sickness in humans and nagana in animals. The precise knowledge of the insect's biology and physiology promises to yield powerful genetic tools that could one day eliminate the disease from sub-Saharan Africa. Such holistic packages will not only alleviate poverty but also enhance food security and human health. *icipe* plans to expand and scale-up these initiatives over the coming years. Such projects, when integrated with the plant and human health activities, have the advantage of impacting the global One Health agenda.

Ticks

icipe continues to spearhead the development of simple sustainable technologies for on-farm management of ticks and the diseases they cause. These on- and off-host tick management strategies will be based on the use of biopesticides, botanicals and behavioural manipulation of the cues ticks use to find hosts, mates and preferred feeding sites. Availability of new technologies for tick control will result in significant reduction in synthetic acaricide use.

Ticks are obligate haematophagous ectoparasites that transmit a wide range of

pathogens to humans and animals. *icipe's* research in this area in Kenya has revealed significant presence of agents of ehrlichiosis, anaplasmosis, rickettsiosis and babesiosis, theileriosis and hepatozoonosis among ticks feeding on, and possibly transmitting to domestic animals with undetermined impact on humans in certain areas of the country. The information therein is important to public health in mitigating tick borne pathogens and possible disease outbreaks.

Medical vectors of zoonotic importance

icipe will develop new tools and strategies for the integrated management of important arthropod vectors that not only impact transboundary trade but also those with great zoonotic potential. Basic knowledge on the biology, behaviour and ecology of vectors responsible for diseases such as bluetongue, lumpy skin disease and Rift Valley fever will be generated to guide development of appropriate control technologies. Development of diagnostic tools will also be undertaken, together with the production of predictive maps of disease burden for assisting in the identification of hotspots for guiding interventions. These studies also provide important linkage with *icipe*'s human health focus.

Climate change interaction

In-depth studies on the effect of climate change on the range and efficiency of vectors will be undertaken to improve their detection and response.

Socio-economic and impact studies

The Centre has long recognised that the quest for effective and sustainable vector control technologies will remain futile unless socio-economic, cultural and environmental, considerations are adequately addressed. The success of the development and implementation of integrative control technologies rests on sound longitudinal socio-economic and environmental impact studies. These will, therefore, be central to the progress of this work.

Capacity building

To ensure sustainability of vector control, *icipe* undertakes capability building at all levels, including service providers, practitioners, technicians, community health workers and managers of control operations. Furthermore, to enable rural communities to adopt, use and sustain intervention control strategies, *icipe* also helps communities in the establishment of organisational, management and financial community structures through providing appropriate training and surveys, and involves communities in developing the effective control methodologies.

Animal Health Results Based Management (RBM) Rolling Framework

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: To develop attractive and effective killing and repellent system for control of vectors of camel trypanosomosis (surra) and to reduce vector and disease levels by 50% by 2020.					
1.At least one potential control technology developed for vectors of surra.	• At least one olfactory bait and one repellent blend tested and available for control of vectors of surra.	• At least 50% decrease in flies attracted to camels. • At least 50% decrease in disease incidence. • Favourable assessments by participating livestock keepers and veterinary staff. • Publications produced.	• Scientific reports. • Peer-reviewed publications . • Project progress reports.	• Project reports. • Field data. • Questionnaires. • Surveys.	• Visual and olfactory baits and repellent collars are effective and accepted by nomadic pastoralists.
Objective 2: To upscale and adapt tsetse repellent technology in partnership with the private sector and to reduce trypanosomosis risk by 50% by 2020					
1.Repellents for control of vectors of human sleeping sickness evaluated.	• Synthetic and waterbuck repellent blend evaluated for *Glossina fuscipes fuscipes* in Kenya.	• -At least two tsetse repellent blends evaluated for control of vectors of human sleeping sickness, *Glossina fuscipes fuscipes* • At least 50% decrease in fly catches in presence of repellents.	• Scientific reports. • Peer-reviewed publications . • Project progress reports.	• *icipe* project reports. • Peer-reviewed publications. • Field data.	• New repellents effectively control vectors of human sleeping sickness. • Favourable environment for project replication. • No competitive public/private interventions take place.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
		• No. of trials undertaken. • Publications produced.			
2Integrated use of repellents with traps and screens, and olfactory baits evaluated in push–pull strategies to stop flies reinvading areas where they have been controlled.	• Effective barrier system developed to stop flies from reinvading tsetse-controlled areas.	• Complementary technologies identified with potential for integration with repellent technology to stop reinvasion. • Barrier prevents at least 80% flies from entering a controlled area.	• *icipe* project reports. • Peer-reviewed publications .	• *icipe* project reports. • Field data.	• Identified technologies are practical and fit in farmers' conditions and practices. • National and local organisations cooperate in prevention of tsetse reinvasion. • Political environment remains conducive for field work.
3 Technology for large-scale production of dispensers and repellent compounds passed over to private sector.	• At least one agreement signed with entrepreneurs for further improvement of the dispensers for commercialisation of tsetse repellent technology • At least one local entrepreneur identified for manufacturing/ distribution of repellent collars.	• No. of agreements signed. • No. of meetings held. • At least one design prototype tested for upscaling.	• *icipe* project reports. • Peer-reviewed publications .	• Project reports. • Field data. • Technical specifications of new dispensers. • Public–private–partnership agreements.	• The private sector partners remain committed to repellent product and market development. • New tsetse repellent products are registered, and their price structure is commercially viable. • New tsetse repellent technology is compatible with broad based agriculture development practices.
3.1. Business plan for commercialisation, packaging, product registration, marketing and dissemination for	Business plan developed for commercialisation, dissemination, registration and roll out.	• Business plan developed. • At least one P-P-P partner using the business plan.	• *icipe* project reports. • Business plans. • Public–Private–	• *icipe* project reports. • Business plans. • Public–Private–Partnership agreements.	• New tsetse repellent products are registered and their price structure is commercially viable.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
rollout of the technology developed. 3.2. Advocacy of the repellent technology enhanced.	• Advocacy of repellent technology enhanced in collaboration with stakeholders.	• At least 3 advocacy events undertaken.	Partnership agreements. • *icipe* project reports. • Stakeholder reports.	• *icipe* project reports. • Stakeholder reports.	• New tsetse repellent technology is compatible with broad based agriculture development practices.
4. Integrated validation trials in Shimba Hills upscaled in partnership with the local county staff of the Ministry of Agriculture and Fisheries in Kwale and KWS, and impact on disease levels and drug use and animal productivity assessed.	• Tsetse repellent technology adapted, up-scaled and integrated with other tsetse and disease control tactics for sustainable trypanosomosis control in Kenya.	• Disease reduced by > 50%. • Incidence of tsetse populations reduced >50%. • Drug use reduced >50%. • At least 3000 households use repellent technology.	• *icipe* project reports. • Peer-reviewed publications.	• *icipe* project reports. • Peer-reviewed publications.	• New tsetse repellent technology is compatible with broad-based agriculture development practices.
5. Socio-economic impact of the repellent technology assessed.	• Awareness created and socio-economic impact of the tsetse repellent products documented.	• At least 3 stakeholder trainings held. • At least 3 awareness creation workshops held for local government departments and other stakeholders.	• Socio-economic impact study conducted. • No. of farmers adopting the repellent technology.	• Socio-economic impact study reports. • *icipe* project reports. • M&E report.	• Local governments and technology beneficiaries are cooperative, and committed to sustainable use of repellent products.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
		• Socio-economic impact study conducted. • *Ex-ante* and *ex-post* financial, socio- and economic impact assessments.	• Impact on livelihoods and livestock productivity documented. • Project reports. • Publications.		
Objective 3 - A novel ticks management strategy that is based on the use of bioacaricide, semiochemicals and/or botanical, developed and implemented by 2020.					
1. A joint committee (*icipe* and Real IPM) responsible for project implementation and monitoring of activities established. 2. Novel ticks product (bioacaricide) market survey expanded to Tanzania and completed. 3. A business plan to bring novel ticks control product into market developed.	• A novel ticks management strategy based on the use of bioacaricide, semiochemicals and/or botanical developed and implemented by 2015.	• At least 20 fungal isolates screened for virulence to at least two important tick species. • At least 3 isolates identified and their compatibility with semiochemicals, botanicals and synthetic acaricides completed. • A resistance management package for one synthetic acaricide developed.	• Project reports. • Scientific publications produced. • Market surveys. • Theses. • Veterinary services.	• Private sector. • Consultant firm. • Laboratory bioassays. • Cattle secondary data collection. • Fieldwork. • Private partners. • Herders. • Communities. • Veterinary services.	• Availability of funds. • Various stakeholders demand alternative tick control strategies. • No competitive public/private interventions take place. • Availability of farms to carry out field trials. • Availability of a package for acaricide resistance management.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
		• One large-scale field efficacy trial completed by 2015 for the combination of the most promising individual components.			
Objective 4. Developing a new strategy of trypanosome transmission blocking by enhancing trapping of trypanosome-infected tsetse flies by 2019					
Outputs	• **outcome**	**Performance indicators**	**Data Source**	• **Means of obtaining data**	**Risks and assumptions**
1. Investigate the impact of trypanosomes on host animal semio-chemicals change 2. To study the response of trypanosome positive biting flies to trypanosome induced semio-chemicals 3. To use trypanosome induced semio-chemicals for trypanosome diagnosis	• Trypanosome induced semio-chemicals identified • Smio-chemicals that are more attractive to trypanosome infected flies identified • Chemical markers for trypanosome diagnosis identified • Simple trypanosome diagnosis tool developed	• Compounds identified • # of trypanosome infected flies trapped • Sensitive and selective diagnosis tool developed	• Project reports • Publications • Products developed	• *icipe* project reports. • Peer-reviewed publications.	Trypanosome infection modifies host semio-chemicals as well as flies behavior Chemical markers can be used as diagnosis tool

HUMAN HEALTH at *icipe*

a) Overview of activities

Vector-borne diseases represent a significant public health problem throughout SSA. Parasitic diseases such as malaria, leishmaniasis, human African trypanosomosis, onchocerciasis and schistosomiasis are among the most prevalent in Africa. In addition, some arboviral diseases (such as dengue/dengue haemorrhagic fever, yellow fever, West Nile virus, chikungunya and Rift Valley fever), and bacterial diseases (such as plague and typhus) are among the re-emerging infections that pose a threat across many countries. *icipe* recognises that an increase in productivity cannot occur without a healthy workforce. The Centre's human health research therefore focuses on improving the health of people so that they can be more active in economic development. Although efforts have been made to reduce morbidity and mortality due to these diseases, they continue to increase in intensity and geographic coverage in certain areas because of insufficient action to break the transmission cycle, and partly due to climate change. During the 1970s, little attention was generally given to vector control. This resulted in a dramatic decrease in the necessary human and financial resources in many countries in Africa. However, a series of significant events over the last decade have underlined the growing interest and commitment to stepping up efforts to control these diseases. In 1998, the Roll Back Malaria (RBM) Partnership was launched by WHO, UNICEF, UNDP and the World Bank in an effort to provide a coordinated global response to malaria. More recently, funding from Foundations and the US President's Malaria Initiative are indicative of the (hitherto unknown) support and goodwill from donors as well as increasing political will in Africa through more investment in the public health sector. These have paved way for both the research community and implementing bodies alike to make an improvement in Africa's disease burden.

While current methods have reduced the burden of malaria, one child still dies every minute from the disease. New control tools are desperately needed as mosquitoes develop resistance to insecticides and avoid indoor controls such as bednets. In a world first, *icipe* researchers found in 2014 that a naturally occurring chemical attracts pregnant malaria-transmitting mosquitoes – a discovery which could boost malaria control efforts. The chemical, cedrol, found in mosquito breeding sites near Africa's Lake Victoria, could be used in traps that would 'attract and kill' the female mosquito, preventing reproduction before she lays hundreds of eggs. Further, *icipe*'s research on endosymbiont-based strategies to block disease transmission by vector insects have shown promise for the control of arboviral diseases (e.g. dengue). There is great interest in using endosymbionts to control vector-borne parasites (e.g. Plasmodium); however, more research is needed to identify and study endosymbionts that confer hosts with parasite-specific protection. In Drosophila, endosymbiotic spiroplasmas confer hosts with protection against a variety of parasitic infections.

Renewed support for an integrated approach to the control of vector-borne diseases will complement other efforts, such as those focusing on vaccines and drug development, as well as existing vector control tools. *icipe* is contributing to an integrated vector management (IVM) approach by developing environmentally-friendly tools and strategies to control vectors in all stages of their life histories. Specific interventions

being pursued include the use of botanicals (such as neem), biopesticides like *Bacillus thuringiensis israelensis* (*Bti)*, biological control through the use of larvivorous fish and attractants identified from preferred plant, human and animal hosts. Furthermore, *icipe* proactively engages communities through downstream research in recognition of the vital role their participation can play towards breaking the cycle of disease transmission.

a.) Goal and Broader Objectives

icipe's R&D activities in human health contribute to the reduction of malaria and other vector-borne diseases by developing tools and strategies that control the vectors and break the cycle of transmission, and which can be integrated with other disease management efforts. The broader objectives are to: (i) contribute to the national disease control programmes by focusing on the ecology and behaviour of arthropod vectors; (ii) strengthen linkages and networks with national research and teaching institutions in Africa; (iii) develop IVM strategies for use in different ecological settings; and (iv) contribute to the WHO/AFRO initiative of strengthening vector control capability for the national disease control programmes in Africa.

b.) Strategic Outlook (up to 2020)

Develop capabilities for monitoring and evaluation of interventions and control strategies of vector-borne diseases in SSA: Monitoring and evaluation is an integral part of the vector control strategy. However, capacity and structural framework for institutionalising it in vector control programmes in Africa is lacking. *icipe* intends to take a lead role in strengthening the co-ordination of a collaborative network of institutions and programmes across the continent to capture available data from key sources and to guide control decisions. Networks and capacity will be strengthened in national disease control programmes at different levels for data collection and management, monitoring vector populations, infectivity and insecticide resistance management. Focus will be given to factors that drive seasonal variability in disease endemicity in different ecological settings in Africa. Even though the dry season characterises most of the tropical areas of Africa, virtually nothing has been recorded on the influence of the dry season on malaria vector population dynamics in relation to transmission intensity.

Development of new and improved vector control tools: Vector control across Africa has been compromised by reduced efficacy of existing tools partly due to emergence of insecticide resistance and lack of functional institutional framework and capacity for the implementation of existing ones. A search for, and the development of, new tools for sustainable integrated vector control programmes in SSA, remains a high priority for *icipe*. One area of interest emanating from studies undertaken to date by *icipe's* R&D is the observation that adult mosquitoes have specific plant feeding preferences. Incorporating biological control agents and insect growth regulators (IGRs) with the mosquito-preferred plants as bait or delivery target is a novel method for vector control. Human odours are still the most potent attractants to mosquitoes. Building on the ongoing development of synthetic odour blends that mimic human attraction, the Centre will continue to optimise attractive blends as well as repellents that can be deployed singly for use in traps or in mosquito push–pull systems.

Investigate symbiont-based strategies to block vector-borne disease transmission: One of the most promising new vector management strategies involves symbiotic microbes that decrease the vectorial capacity of their hosts. Over the last decade, it has become apparent that most insect species harbour vertically transmitted endosymbiotic bacteria and viruses. Studies have shown that these microbes confer their insect hosts with protection against diverse pathogens and are, therefore, attractive tools for the control of vector-borne diseases. By virtue of their vertical transmission (mother-to-offspring) endosymbionts present a more sustainable strategy for the control of vector-borne disease transmission than conventional methods. Research at *icipe* will determine the utility of diverse symbiotic microbes for controlling vector-borne disease in the African context.

Capacity building within the existing study sites, expansion of activities in other regions and continuing education of African vector control specialists: The current decreased efficacy of control measures can, to some extent, be attributed to technical and operational issues related to acute shortage of personnel with sufficient skills and time to provide decisions on vector control at the programme implementation level. Although past capacity building efforts across Africa had aimed at producing skilled personnel for control programmes, only a small proportion plays an active role in vector control. It is on this basis that *icipe* has a focus, through its IVM programme, of training skilled personnel tailored to institutional needs of their respective national disease control programmes. The training aims to enhance skills and knowledge in control and prevention of vectors, and improve the utilising of such knowledge, resources and tools to sound decision making to prioritise disease prevention and control strategies. Capacity-building for implementation of IVM policies at the national and local levels will be a core programme area of the Centre's human health R&D. The main purpose of IVM is to improve the efficacy, cost-effectiveness, ecological soundness and sustainability of vector control to reduce vector-borne diseases through the prevention or interruption of disease transmission. Key elements of IVM that will be promoted are further discussed in other sections of this strategic document. They include integrated approaches, collaboration within the health sector and with other sectors, evidence-based decision-making, advocacy and social mobilisation, and capacity building at the community, researcher and policy-making levels. The Centre will also continue to expand training in disease vector management programmes across Africa in conjunction with participating institutions worldwide.

Establish vector-borne disease early warning systems: Epidemics (of malaria, leishmaniasis, arboviruses and other neglected tropical diseases) occur periodically in many parts of Africa as a result of a complex of biological, environmental and climate anomalies. These result partly from environmental degradation and the challenge of global warming. It is estimated that at least 110 million Africans live in regions prone to epidemics, and many more are potentially at risk. Because of low levels of immunity among these populations, the risk of death is high in all age groups when epidemics occur. Improved early warning and detection of disease epidemics remain among the key technical elements of the national disease control programmes. *icipe,* working with its strategic partners, aims to improve access to information on climate and environmental variability that could help affected national emergence mitigation and response planning, and their response to disease epidemics more effectively. This will primarily be aimed at understanding the transmission dynamics of vector-borne diseases, predicting the potential impacts of climate change, and the development of

early warning systems for disease epidemics. It will also enable the development of decision analysis tools designed to assist policy makers and programme managers with the selection and implementation of vector control interventions, based on prospective scientific assessment of their health, and economic and environmental impacts. The modelling work will build on two decision-analysis support models currently being developed in collaboration with the Millennium Institute, Duke University and the University of Pretoria.

New initiatives on interactions between agriculture and malaria: Initiatives in agriculture and health are often pursued in a parallel and unconnected fashion. Yet coherent, joint action in agriculture and health could have large potential benefits and substantially reduce risks for the poor. There is growing recognition in political and development sectors that agriculture influences health and vice versa, thus there is need to take advantage of these linkages to improve food security and health. *icipe* will facilitate new initiatives to foster greater interactions between agricultural and malaria control activities in Africa, with the goal of building sustainable partnerships for improved agricultural production and health. An 'ecohealth' approach to management of vector-borne diseases will be adopted.

Bioinformatics of pathogens and disease vectors: Capacity in genomics and bioinformatics will be increased for greater integration of these disciplines into the R&D and capacity building programmes. For instance, work on genomics will enable identification of novel target sites for biorational development of attractants and repellents, and species-specific biocides. This capacity will also improve taxonomy, allowing more accurate identification of species within complexes, such as *Anopheles gambiae*, the major vector of malaria in Africa, and enhance species identification in biological control (BC) programmes. To increase our knowledge of genetic determinants of disease occurrence and risk, the Centre will develop research and training competencies in computational analysis of large genomic datasets through building capacity in bioinformatics. We intend to develop knowledge on genetic determinants of vector–pathogen–environment interactions, and hence contribute to new tools and approaches for managing diseases.

Expand human health activities to include emerging and re-emerging infectious diseases: Arthropod vectors, such as mosquitoes, tsetse, ticks and sandflies, are responsible for the natural transmission of most parasitic, viral and bacterial pathogens to humans. The threat of these pathogens as potential emerging infections is real, mainly because of their epidemic potential and the favourable conditions for their transmission that exist in Africa. Good examples are Rift Valley and dengue fevers. Global demographic, climate and societal changes, and modern transportation have provided the mechanisms for these pathogens to break out of their natural ecological zones and become established in new geographic locations where competent arthropod vectors and a large population of non-immune hosts provide permissive conditions for them to cause major epidemics. There are huge gaps in knowledge on the natural history of arthropod-borne diseases in Africa and the relationship between their zoonotic cycles and the ecosystem. *icipe* will continue to expand this relatively new area of its research portfolio. The first major study the Centre intends to make in this area will be focused on the genetic diversity within vector populations and the relationship with landscape ecology to guide the development of appropriate management methods for specific vector populations and the landscape. Other target research areas will include

systematics, visual- and olfactory-based trapping systems and combinations, thereof, derived from a better understanding of the role played by different hosts in the feeding and reproductive behaviour of vectors.

Elucidate the epidemiology, transmission and diagnosis of human African trypanosomosis (HAT): African trypanosomosis has affected settlement and economic development in much of the African continent. Based on data from research conducted todate, capacities exist to increase *icipe*'s R&D activities in the areas of HAT. One of these is to identify trypanosome-specific protein–protein interactions within functionally relevant protein complexes, and use them as targets of anti-parasitic drug screening protocols. *icipe* will also undertake gene expression studies as a basis for designing a sensitive and specific diagnostic test. Diagnosis in Africa depends primarily on microscopic examination of wet blood films, a methodology that is limited both in sensitivity and in ease of use. Further research in the development of attractive bait/repellent technologies for the management of riverine tsetse (such as *Glossina fuscipes fuscipes, G. palpalis* and *G. tachinoides*), vectors of human sleeping sickness for integrated disease and vector control, will be undertaken. Tools for genetic structuring of the *palpalis* group populations for enabling control activities will be developed.

Conduct research leading to better understanding of the epidemiology and control of leishmaniasis in Africa: Visceral leishmaniasis is often under-estimated, while mortality can reach as high as 90% if untreated. *icipe* will lead a network of collaborators in conducting research leading to a better understanding of risk factors associated with transmission of the disease, as well as undertake studies on the biology of the vectors and their control. The Centre will coordinate an integrated project, bringing together experts from different African institutions and partners in the North. Other initiatives include the development of a system for delivery of conidia of entomopathogenic fungi (EPF) into termite mounds and animal burrows for control of the sandfly vectors. Previous studies at *icipe* showed that injection of conidia of EPF into termite mounds successfully kills termites. Since sandflies inhabit eroded termite mounds and animal burrows, a device similar to the one developed for termite control, could be adapted for sandfly control.
Advances in icipe's malaria research and development work:

- In a world's first, researchers have found that a naturally occurring chemical attracts pregnant malaria-transmitting mosquitoes - a discovery which could boost malaria control efforts. The chemical, cedrol, found in mosquito breeding sites near Africa's Lake Victoria, could be used in traps that would 'attract and kill' the female mosquito, preventing reproduction before she lays hundreds of eggs. Cedrol is the first chemical of its kind in the history of malaria control and can be used to attract and trap mosquitoes before they lay hundreds of eggs. Such a tool can hasten malaria elimination and improve the quality of lives. The OviART research group, a multinational team bringing together researchers from *icipe*, the London School of Hygiene & Tropical Medicine, the Swedish Royal Institute of Technology and the UK's Durham University, published the work in the Malaria Journal (*Lindh J.M., Okal M.N., Herrera-Varela M., Borg-Karlson A.-K., Torto B., Lindsay S.W. and Fillinger U. (2015) Discovery of an oviposition attractant for gravid malaria vectors of the Anopheles gambiae species complex. Malaria Journal 14, 119. doi: 10.1186/s12936-015-0636-0)* and has been picked up by popular media on http://images2.advanstar.com/PixelMags/lctc/digitaledition/April10-2015-

uk.html#8
http://www.chromatographyonline.com/gc-ms-detects-chemical-cue-mosquitoes-soil. The paper has ranked no. 1 in many categories compared at the journal and compared to 3,693,722 articles across other journals (article metrics.)

- New research has revealed that the Malaysian jumping spider *Paracyrba wanlessi* preys almost exclusively on mosquitoes. This finding was reported jointly by *icipe* and University of Cantebury, New Zealand and published in the journal *Royal Society Open Science* ***(Jackson et al (2014) Intricate predatory decisions by a mosquito-specialist spider from Malaysia. Royal Society Open Science 1, 140131)*** and featured on National Geographic http://voices.nationalgeographic.com/2014/10/07/mosquitoes-insects-jumping-spiders-alaysia-animals-science-predators-prey/

Endosymbionts and insect vector competency: With a longer-term horizon in mind *icipe* has a growing portfolio of work on the interactions of pathogens with their insect vectors. This work underpins the development of bio-control strategies and provides us with the potential risk profiles associated with such things as climate change and disease transmission. We have initiated an exciting research area on the interaction between symbiotic micro-organisms and their insect hosts with the aim to understand and potentially exploit this relationship. For example, the presence of symbiotic bacteria within a mosquito may prevent the establishment of a virus pathogen. Whilst these studies have significant potential benefits such as reducing disease prevalence they also represent an opportunity for *icipe* to add to the growing pool of literature on vector competency. The R. Geigy Foundation/Swiss National Science foundation funded Spirovector project was initiated to develop vector transmission blocking strategies that utilize insect-endosymbiotic bacteria. The insect-endosymbiontic *Spiroplasmas* are known for their ability to protect insects against parasites and are of great interest for their potential utility for vector transmission blocking in Africa, where many diseases of humans and livestock are cause by insect-vectored parasites. Prior to this project there had been only one published report of an endosymbiotic *Spiroplasma* from an African parasitic disease vector insect (*An. funestus*). We have been screening populations of numerous disease vectors throughout Kenya and have identified numerous *Spiroplasmas* strains that are of significant interest. Notably, *Spiroplasma* strains have been discovered in *Anopheles arabiensis* (major vector of *Plasmodium*), *Glossina fuscipes* (major vector of *Trypanosoma*) and *Culex quinquefasciatus* (major vector of filarial nematodes). These discoveries are an important step in the longer term vision to develop endosymbiotic microbes as a strategy that prevent the transmission insect-vectored parasites that are of great concern for public health and economic development in Africa. Whilst these studies have significant potential benefits such as reducing disease prevalence they also represent an opportunity for *icipe* to add to the growing pool of literature on vector competency.

Arbovirus research: The *icipe* Martin Luscher Emerging Infectious Diseases (EID) laboratory has developed an assay for differentiating various arboviruses in samples, which will have applications for use in surveillance programs. The technology platform also has the potential to be used to differentiate species of plasmodium, mosquito blood meal vertebrate host identification, mosquito species differentiation and Bovine MHC differentiation. The arbovirus assay has been submitted for publication to the prestigious journal PNAS.

Rift Valley Fever: *icipe* continues to focus on Rift Valley Fever ecology, epidemiology, surveillance and social aspects with the overall goal of understanding disease occurrence, risk pathways, improving early warning and identifying opportunities for disease prevention and control to minimize impact of outbreaks. Recent highlights in this area include:

a) Demonstration that livestock represents a significant reservoir for the virus between human outbreaks.
b) Tests developed for improved RVF vector sampling tools to target primary vectors of RVF, hence improved vector surveillance tools for monitoring RVF risk are in place and currently, capacity is being built on the use of the tools among public health and animal health stakeholders and also the community.
c) Knowledge gaps on RVF preventive measures were identified among communities in North Eastern hotspot areas within Kenya. Consultations have been initiated with public/animal health stakeholders, livestock owners and herders to address these gaps and recommendation made to the Ministries of Health and Livestock officials to include information in their public health animal health education routine.

Promoting One-Health: In recognition of the growing importance of the One-Health paradigm, deliberate efforts will be made to pool together relevant expertise in addressing research issues. This will include a growing component of geospatial sciences to enable a better understanding of disease epidemiology, and knowledge of environmental predictors of disease outbreaks and occurrence.

Community engagement and participation: Community engagement and participation has played a critical role in successful disease control and elimination efforts in many countries. However, the benefits of this approach for malaria control and elimination are yet to be fully realised. This may be due to a limited understanding of the influences on participation in developing countries, as well as the inadequate investment in infrastructure and resources required to support sustainable community participation. The current global malaria elimination campaign calls for a health system strengthening approach to provide an enabling environment for programmes in developing countries. To realise the benefits of this approach, *icipe* will strive to develop the 'people' component of health systems and understand the multi-level factors that influence their participation. The Centre's ultimate goals will be to: (a) harmonise efforts at building 'competent communities' and harness their efforts towards controlling several vector-borne diseases simultaneously; (b) engage communities in current elimination efforts; (c) optimise health system effectiveness, and (d) develop a community-driven, inclusive and continuous social licence acquisition platform to allow ethical roll-out and testing of new malaria control technologies.

Linking vector control to development: The health sector in many developing countries lags far behind the agricultural sector. Since the agricultural sector is associated with tangible economic gains, resource-poor communities participate more readily in agricultural production-based initiatives. It is, therefore, easier to encourage poor African communities to take up and develop new advancements in the agricultural rather than the medical field, even for a high impact endemic problem such as malaria control. *icipe* will, therefore, strive to nest vector control activities within developmental contexts that confer appreciable economic gains to individuals and families. For example, linking

malaria vector control to agricultural production has been shown to stimulate rural communities to take up an active role in implementing disease prevention measures.

Collaboration with government departments: The strength of *icipe* rests in its ability to generate robust scientific knowledge and evidence, which can be harnessed directly for formulation of vector control policies. If harnessed effectively this will enhance the ability of national governments to formulate policies and legislation that are tailor-made for local problems. The Centre will, through the next five years, strive to enter into co-learning activities with regulators in government health and research departments, focusing on R&D activities that are immediately useful to support national and international development. The interactions should initiate and foster the existence of a regularly updated *icipe*-research outcome policy document that provides evidence-based guidance to governments in Africa on vector control initiatives. This is critical in view of the ever-increasing trends towards globalisation.

Engaging with the science of disease elimination: In a traditional sense, disease control implies a focus on morbidity and mortality reduction. However, the science of elimination calls for interrupting transmission of disease. This requires a reduction in transmission and transmission reservoirs and in the rate at which infections are spread. This shift in paradigm corroborates the Centre's mission to improve the overall health status of peoples of the tropics by developing and extending management tools and strategies for harmful and useful arthropods.

Human Health Results Based Management (RBM) Rolling Framework

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
Objective 1: Contribute towards malaria elimination through the development of effective vector control strategies and public health initiatives by 2020.					
Specific objective 1.1 Strengthening the evidence -base for integrated vector management (IVM)					
Comprehensive evaluation of *icipe's* ongoing integrated vector management (IVM) sub-projects.	• At least two new proposals to mobilise funding for strengthening IVM research and capacity-building in eastern and southern Africa developed by 2016 • An additional two new IVM projects in Kenya and Ethiopia developed by 2019	• Regular evaluation reports of ICIPE IVM projects in Kenya and Ethiopia • New IVM proposal documents.	• Reports. • Publications.	• Review of *icipe*'s projects database • Field interviews with community members and other stakeholders. • Consultations with researchers from *icipe* and collaborating institutions.	• Community members and county and national programs interested in supporting participating in IVM for malaria control. • Researchers with interest and expertise in IVM are available.
Implementation of integrated vector management (IVM) promoted to improve health and livelihoods of communities in malaria-affected areas of Kenya and Ethiopia.	• At least 60% increased awareness among communities on IVM strategies for vector-borne disease control by 2018. • Adoption of IVM policy for malaria control by the Ministry of Health (Kenya) and Ethiopia by 2017. • At least 60% decrease in malaria prevalence and mosquito densities in target areas by 2018.	• Number of community members trained. • Number of combinations of vector control methods (non-chemical/chemical) being used at community level. • Availability of an IVM decision-making tool for policy makers and vector control personnel. • Number of IVM workshops for policy makers and other key stakeholders. • Levels of malaria prevalence and mosquito relative density.	• Annual project reports. • Social economic impact assessment reports. • Regional and national training workshop reports • Journal publications.	• Field visits to IVM implementation sites in Kenya and Ethiopia. • Focus group discussions. • Stakeholder workshops and key informant interviews.	• Community members willing to participate in IVM for malaria control • National programmes willing to embrace IVM to consolidate gains made in malaria control since 2000.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
		• Improvement in socio-economic status of households. • Number of articles published in peer reviewed journals.			
Regional and national IVM capacity strengthening for control of malaria and other vector-borne diseases expanded in eastern and southern Africa	• At least 20 staff of national malaria control programmes of Ethiopia, Madagascar and Eritrea trained in IVM in 2016. • *icipe's* role as a regional hub for participatory IVM training in Africa is significantly enhanced from 2016 onwards as a result of increased collaboration with key partners including WHO-AFRO, UNEP, GEF, Stockholm Convention, and Biovision. • IVM training of at least 100 program staff of southern Africa countries dependent on DDT for malaria control achieved by 2019	• Ten-day IVM training course conducted for participants from Ethiopia, Eritrea and Madagascar in July 2016. • *icipe's* ongoing participation as a co-executing partner and lead research organization for evaluation of new innovative IVM interventions in the context of AFRO-II project Global Environment Facility (GEF)/UNEP- through the main Executing Agency is WHO-AFRO	• Project report • Journal publications	• Interviews with national malaria control programmes (NMCPs) • Interviews with WHO-AFRO project staff	• National programmes willing to embrace IVM in view of challenges currently facing traditional insecticide-based methods of vector control, including long-lasting nets and indoor residual spraying. • Countries in eastern and southern Africa continue to support activities contributing to the goal of malaria elimination.
Specific objective1.2 Development of non-insecticidal monitoring and control tools based on the odour-orientation behaviour of vectors					
A potent synthetic lure derived from screening three	• Scientists' use of synthetic lure in at least	• Number of peer-reviewed publications. • Number of proposals.	• Project reports. • Publications.	• Laboratory notebooks.	Availability of funds.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
mosquito-preferred plants developed.by 2020	one malaria endemic site in Kenya.	• Graduate student thesis. • Availability of lure.		• Field notebooks. • Department database. • Adult mosquito responses	
At least two chemical-based technologies for surveillance and/or disruption of malaria transmission developed.	• Two large semi-field systems established at ITOC for investigating push-pull systems under near natural conditions by end 2016 • Oduor-baited traps used by scientists for mosquito surveillance in research programmes. • Use of odour-baited traps for mosquito surveillance by at least five locally active government and/or non-governmental agencies by 2020.	• At least two push-pull strategies evaluated for the control of host-seeking malaria vectors under semi-field conditions by end 2017. • At least one push-pull system investigated under field conditions by end of 2018. • Available trapping systems developed further to improve catching efficiency based on preliminary semi-field and field trails by end 2018. • Presence/use of attractant baited traps by researchers and national malaria control programmes. • Availability of a potent spatial mosquito repellent or repellent principal. • Number of publications in peer reviewed journals. • Project progress reports. • Theses. • Posters.	• Publications. • Theses. • Posters. • Repellent strategy.	• Semi-field (screenhouse) studies • Field studies. • Laboratory experiments. • Secondary data.	• Funding availability. • Industrial partners will invest in odor-based mosquito surveillance tools.
Studying the egg-laying behaviour of primary and secondary malaria vectors to develop novel attract and kill strategies (2017-2020)	• Protocols for rearing secondary vectors developed and colonies established at ITOC by 2019.	• Secondary vector colonies established. • Successful implementation of routine bioassays in	• Field surveys • Semi-field and laboratory studies,	• Laboratory bioassay experiments. • Semi-field assessment	• None of the screened agents actually attract vectors.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
	• Oviposition bioassays implemented in cages and under semi-field conditions to screen for novel oviposition attractants from soil, swamp grasses and water-associated fungal cultures. • Different dispensing mechanisms for potential oviposition attractants tested in traps under semi-field and field conditions. • Field surveys implemented to investigate the correlation between swamp grasses and vector habitat colonization.	cages and semi-field system with gravid female vectors. • Fungal cultures identified for natural vector habitats. • Swamp grass associated chemicals identified from water and headspace. • A number of new infusions and possibly chemicals tested for oviposition attractants. • Dispensers for attractants developed. • Risk factor analyses of field data implemented. • 1 PhD student trained/thesis produced. • No. of peer-reviewed publications.	• Reviews, • Publications	of laboratory results in greenhouse setting. • Simulated open-field trials and field tests under natural conditions. • Systematic and desk reviews.	• Technical limitations in identifying putative semiochemicals.
Specific objective 1.3 Transmission blocking approaches					
The development of symbiotic microbes harbored by mosquitoes as potential tools to control malaria transmission investigated.	• Detailed survey of the symbiotic microbes associated with vector mosquitoes. • Experimental investigation into the effects of harbouring symbiotic microbes on mosquito vector biology. • Discovery of several symbionts with Malaria transmission-blocking properties	• No. peer-reviewed publications. • Semi-field tests completed	• Field collection of mosquitoes. • Laboratory and semi-field experiments, including membrane feeding assays (MFA) to quantify transmission-blocking.	• Screening material from the field. • Laboratory assays. • Semi-field experiments	• Discovery of suitable symbiotic microbes. • Additional funding.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
	• Investigation the methods that could be used to usefully disseminate discovered microbial symbionts with transmission blocking capacity.				
Specific objective 1.4 Cattle-targeted interventions for integrated control of human and animal disease vectors					
Novel biorational products developed for the control of arthropod vectors on and around cattle Impact of cattle-targeted integrated control evaluated in a cluster-randomized controlled trial.	• Private sector partners approached for registration and marketing of products (by 2023). • Further funding applied for Phase III testing of intervention (epidemiology trial by 2023)	• Novel concepts perceived and products developed. • Laboratory tests, semi-field and field experiments completed. • Peer-reviewed publications. • PhD student training and thesis. • KEMRI SERU approval • Study site selection • Stakeholder and community engagement • Data collection tools developed. • Community-based resource persons trained. • Community-based entomological monitoring protocol designed and implemented.	Laboratory and field surveys, Insectaries and cattle Qualitative and quantitative field surveys	• Experiments at ITOC and in field sites Ento-mological trapping Animal health surveys • Qualitative surveys, interviews, focus group discussions, open space meetings	• Products perform to the expected standard, • Biopesticide (Metharizium) provided, • Animal research approval • KEMRI-SERU approval • Animal research approval • Community support • Unexpected restriction for field work •

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
		• Intervention implemented after baseline year. • Qualitative surveys implemented. • PhD student trained and thesis. • Publications. • Donor reports. • International conferences.			
Objective 3: Epidemiologic assessment of risk of yellow fever (YF) and dengue (DEN) transmission and outbreaks in Kenya.					
Objective 3.1. To determine existence and locality of YF, DEN transmission foci in Northern Kenya at border with endemic countries.					
1. Existence and locality of YF, DEN transmission foci in Northern Kenya at border with endemic countries determined.	• Research team confirms presence/absence transmission between primate and human populations.	• Community engagement. • Publications. • Donor and other reports. • Stakeholder information sharing meetings.	• Study sites. • Villages and households. • Biological samples from humans and primates.	• Community sensitisation and sampling. • Primate sampling and mapping. • Laboratory analysis.	• Access to study sites. • Security. • Cooperation of communities. • Smooth cooperation of project collaborators.
Objective 3.2. Assess vector species presence and their YF/DEN vector potential in the selected areas.					
1. Vector species presence and their YF/DEN vector potential in the selected areas assessed.	• Research team detects and maps known and/or other potential YF and dengue vectors.	• Publications. • Donor and other reports. • Stakeholder information sharing meetings.	• Study sites. • Villages & households. • Habitat types. • Biological mosquito materials.	• Vector sampling. • Sample identification. • Taking of GPS points. • Laboratory analysis.	• Access to study sites. • Security. • Cooperation of communities. • Smooth cooperation of project collaborators.
Objective 3.3. To assess the potential for urban *Aedes* vectors to sustain an outbreak in major urban centers in Kenya.					

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
1. The potential for urban *Aedes* vectors to sustain an outbreak in major urban centres in Kenya assessed.	• The researchers identify the competent and refractory vector populations for transmission of YF and DEN.	• Publications. • Donor reports. • Stakeholder information sharing meetings.	• City suburbs households. • Habitats. • Biological mosquito materials.	• Mosquito rearing. • Laboratory analysis. • Computer software.	• Access to study sites. • Security. • Smooth cooperation of communities. • Smooth cooperation of project collaborators.
YF and DEN seroprevalence in West Pokot estimated and found to be indicative of very limited virus activity in the area.		• Submitted donor report			
Stegomyia indices and densities in rural sites at border with Uganda estimated and found to be too low to sustain outbreaks		• Submitted donor report • One paper submitted, under review			
Aedes aegypti densities in major Kenyan cities established as a means of essessing risk of transmission		• Submitted donot report • One paper published			
Objective.3.4. To develop trapping tools for conducting vector surveillance to improve surveillance of YF and dengue.					
1. Trapping tools for conducting vector surveillance to improve surveillance of YF and dengue developed.	• The team identifies suitable odours and tools for attracting and sampling YF and DEN vector populations.	• Publications. • Donor and other reports. • Stakeholder information sharing meetings.	Field surveys	• Mosquito sampling and rearing. • Volatile trapping and analysis. • Trial.	• Access to study sites. • Security. • Smooth cooperation of communities and collaborators. • Equipment performance.
Objective. 4. Understanding the risks and benefits of newly developed irrigation schemes in western Kenya in the context of malaria elimination					
Specific objective 4.1. How does introducing gravity-fed irrigated agriculture impact land-use, aquatic habitat distribution and vector production?					

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
1. Assessment of the risk factors that increase and decrease vector production based on irrigation and land use	• Improved awareness of the association between irrigation, land use practices, cropping patterns and vector larval habitats by all project stakeholders by end 2020.	• SOP developed • Study boundaries and enumeration of households in study sites complete • Training field assistants on ground mapping of study households using GPS • All risk factors identified and mapped • Publications. • Stakeholder information sharing meetings, workshops and focus group discussions. • Conference presentations • Progress reports	• Farms and other fields within study sites • Households	• Remote sensing and GIS to map study sites • Mapping of land use, cropping patterns and diversity, and frequency of aquatic habitats by ground truth teams. • Larval and adult mosquito surveys.	• Access to study sites. • Smooth cooperation of communities and collaborators. • Equipment performance.
Specific objective 4.2. Does irrigation lead to an increase in adult malaria and non-malaria vectors, changes in species composition, seasonality, biting patterns or sporozoite infections?					
1Association between irrigation and malaria vector abundance, seasonality and biting patterns and sporozoite infection established over a 3-year period.	• Improved awareness of the association between irrigation and vectors by all project stakeholders by end 2020	• SOP developed • Training field assistants on adult mosquito sampling • Comprehensive dataset on adult malaria vectors, other mosquitoes and changes in species composition, seasonality and biting pattern compiled over 3 years. • Multivariate risk factor analyses implemented annually. • Publications and conference presentations. • Stakeholder information sharing meetings. • Progress reports	• Farms and other fields in study site • Households	• Adult mosquito sampling from selected households and rearing. • Molecular analysis for mosquito species identification and sporozoite analysis • Trial.	• Access to study sites. • Smooth cooperation of communities and collaborators. • Equipment performance. • Withdrawal of household from study

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
Specific objective 4.3. Can irrigated agriculture be associated with changes in socio-economic and nutritional status, malaria prevention measures and/or behaviours and prevalence in the population?					
1. Association between irrigation and socio-economic and behavioral factors and malaria established over a 3-year period.	• Improved awareness of the association between irrigation and socio-economic factors and malaria by all project stakeholders by end 2020.	• SOP developed • Ethical approval granted for study. • Comprehensive dataset on adult household data on socio-economic and nutritional status and behavioural factors compiled over 3 years. • Multivariate risk factor analyses implemented annually. • Publications and conference presentations. • Stakeholder information sharing meetings. • Progress reports	• Household and community surveys and interviews • Key stakeholder engagements	• Individual household questionnaire surveys • Focus group discussion and key-informant interviews • Malaria parasite surveys. • Use of mid upper arm circumference for evaluation of nutritional status • Molecular analysis for Plasmodium species identification	• Access to study sites. • Smooth cooperation of communities and collaborators. • Withdrawal of study participants during survey
Specific objective 4.4 What are the important geo-spatial variables responsible for malaria propagation on a farm- and landscape-scale?					
1. Geospatial variables for malaria propagation on farm and landscape identified.	• Improved awareness of the important geo-spatial variables responsible for malaria propagation on a farm- and landscape-scale by all project stakeholders by end 2020.	• The spatiotemporal dynamics in terms of expansion of irrigated lands, changes and current status of cropping patterns (paddy versus upland crops), and land surface dynamics due to irrigation patterns and soil-moisture regime fluxes in various land-use systems assessed. • Landscape and farm-level changes linked to land-feature specific data on vector diversity, density and	• Remotely sensed data • Data collected by ground truth teams	• Remote sensing - GIS mapping • Hand-held GPS by ground truth teams	• Access to study sites. • Smooth cooperation of communities and collaborators. • Equipment performance.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
		abundance data and malaria prevalence and incidence for several seasons. • Publications and conference presentations. • Stakeholder information sharing meetings. • Progress reports			
Objective. 5. Understanding freshwater pollution and the links to the distribution of Schistosoma host snails in Western Kenya					
Specific objective 5.1. Does the abundance of host snails for human pathogenic trematodes increase with pesticide pollution, and is this increase associated with a decrease of antagonistic macroinvertebrate species? Does the portion of infected host snails and the number of Schistosoma cercariae produced by infected snails change with pesticide pollution? Can the pesticide pollution in tropical freshwater bodies after runoff be predicted from the community composition of sensitive and insensitive macroinvertebrate taxa?					
1. Risk factor analyses implemented. 2. Pollution associated with abundance of snails, antagonistic invertebrates, and ceracaria infection.	• Pesticides bioindicator index developed for the effect of pesticide pollution on macroinvertebrates to tropical freshwater habitats by 2020.	• Filed sites identified • Two field campaigns successfully completed, • Dataset compiled for analysis. • Publications. • Donor and other reports. • Thesis chapter.		• Pesticides and macroinvertebrates (including snails and their parasites) will be monitored after run-off events in freshwater habitats in western Kenya • Host snails will be collected and investigated for carcariae.	• Access to study sites. • Smooth cooperation of communities and collaborators. • Equipment performance. • No unpredicted climate events.
Specific objective 5.2 What is the acute pesticide sensitivity of host snails compared to relevant antagonistic species?					
1. Pesticide sensitivity established in comparison to antagonistic species.	• Tools available to predict impact of pesticide pollution on snail distribution by 2020.	• Toxicity tests designed and successfully implemented. • Publications. • Donor and other reports. • Thesis chapter		• Acute toxicity assays with field-collected organisms	• Access to study sites. • Smooth cooperation of communities and collaborators. • Equipment performance.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
Specific objective 5.3 Does the composition of pathogenic and non-pathogenic trematode species differ in host snails from polluted and non-polluted sites?					
1. Composition of pathogenic and non-pathogenic trematode species from host snails identified.	• Risk of schistosomiasis based on habitat pollution assessed for predicting disease risk by 2020.	• Laboratory techniques established, • Successful analyses of data • Publications. • Donor and other reports. • Stakeholder information sharing meetings. • Thesis chapter.		• Trematodes will be determined using molecular techniques	• Equipment performance.
Specific objective 5.4. Experiments to investigate how pulse exposure to pesticides affects the competitive balance and the predator-prey relationship of the most common host snails and their natural antagonists; how does pulse exposure to pesticides affects the production of cercariae in the host snails, and how pesticide exposure affects the survival of cercariae in the absence and presence of predators.					
1. Experimental assessment of impact of pollution on predator-prey relationships, snail vector competence and parasite survival.	• Risk of schistosomiasis based on habitat pollution assessed for predicting disease risk by 2020.	• Macrocosm experiments established and completed, • Database established, • Publications. • Donor and other reports. • Stakeholder information sharing meetings. • Thesis chapter.		• Macrocosm experiments under semi-field cosnditions	• Equipment performance.
Objective. 6. Investigating the disease ecology of tungiasis (sand flea disease) for the development of treatment and prevention strategies					
Specific objective 6.1. Analyzing school- and household-based risk factors associated with disease outcome					
Risk factors associated with disease identified.	• Improved awareness of the association between certain environmental, socio-economic and behavioural risk factors and disease by all project stakeholders (scientists,	• Ethical approval for study. • Field surveys completed. • Dataset compiled for analysis. • Statistical analysis. • Publications. • Donor and other reports.	- Community and school surveys	• Household and school surveys • Focus group discussions and interviews. • Clinical surveys to screen for tungiasis	• Access to study sites. • Community consent.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
	Ministry of Health, communities) by end 2018. • Recommendations for prevention articulated by end 2018.	• Proposals for prevention trials developed.		infestation and severity	
Specific objective 6.2. Testing of herbal remedy used by communities based on neem oil for tungiasis treatment in a clinical trial (phase II)					
The impact of neem oil treatment on tungiasis infestation and inflammation established.	• Novel treatment recommendations that can be incorporated in the Kenya National Guideline for Tungiasis Control by end 2018.	• Ethical approval for study from KEMRI granted. • Approval for the study granted by the Expert Committee for Clinical Trials of the Pharmacy and Poisons Board. • Independent Trial monitor contracted. • Trial documentation, forms, SOPs, monitoring plan, etc compiled as per national guidelines. • Project staff training completed. • Field survey completed. • Dataset compiled for analysis. • Statistical analysis. • Report to Expert Committee for Clinical Trials. • Donor eport. • Publication. • Proposals for phase III study	- Clinical surveys in schools	• Clinical surveys to screen for tungiasis infestation and severity; treatment with test and control	• Regulatory frameworks for clinical trials with herbal medicine. • Access to study sites. • Community consent.
Specific objective 6.3. Developing tungiasis prevention tools					
Impact of novel prevention tools known.	• Recommendations for prevention made to	• Proposals developed. • Funding secured.	- Field samples	• Bioassays • Semi-field trails.	• Funding • Access to study sites

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
	Minsitry of Health for incorporation in the Kenya National Guideline for Tungiasis Control by end 2020.	• Ethical approvals from KEMRI granted. • Project staff training completed. • Field tests completed. • Datasets compiled for analysis. • Statistical analyses. • Donor reports. • Publications.	- Development and testing of novel floor materials - Testing of neem solution and pyriproxyfen (insect growth regulator) for control of off-host stages of sand fleas.	• Filed tests. • Randomized controlled trials.	• Community consent
Objective 6.4: Identify the factors driving intense transmission & responsible for a high tungiasis disease burden					
• Environmental behavioural socio-economic risk factors identified • Intra-domiciliary and extra-domiciliary transmission sites identified • Seasonal changes in transmission dynamics analysed and described	• Factors driving intense transmission & responsible for a high tungiasis disease burden identified. • County and National MoH and NTD Unit engaged and recommendations provided by 2022.	• Ethical approval from KEMRI-SERU granted. • Study locations selected. • Stakeholders identified and engaged. • Cross-sectional studies in schools and household (HH) in three endemic areas implemented. • Examination of soil/floor sample, systematically collected during the cross-sectioned and the longitudinal studies, analysed. • Molecular tools for identification of off-host stages developed and applied. • Longitudinal studies (school, HH, floor, soil during dry and wet seasons implemented. • 2 manuscripts • PhD student training	• School and community surveys	• Qualitative surveys in schools and households	• SERU approval • Approval of County Administration • Consent of community and assent of children • Unforeseen interruption of field work

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
		• Donor reports and presentations			
Objective 6.5 Understand pathogenesis & identify determinants of severe morbidity in tungiasis					
• Impact of tungiasis on life quality documented • Impact of tungiasis on academic achievement documented • Novel rapid assessment of tungiasis-associated inflammation established • Scores for acute and chronic pathology validated • Impact of T. penetrans on host mobility documented • Pathogenic bacteria in inflamed lesions identified and pig as model for tungiasis associated morbidity in humans validated.	• Impact of tungiasis on cognitive child development estimated. • Care giver behaviour risk factors established. • Guidelines for thermography for pathology survey compiled. • County and National MoH and NTD Unit engaged and recommendations provided by 2023.	• Development and application of tools to assess tungiasis-associated life quality impairment in children • Development and application of tungiasis-associated impairment of school performance • High resolution infrared thermography for quantifying inflammation surveys implemented • Semi-quantitative assessment of clinical pathology completed, • Impaired mobility [using pedometers and GPS-trackers assessed. • Small scale metagenomics analyses comparing bacterial infection of tungiasis lesions between human and pigs implemented.	• Field surveys in schools and households, • Animal samples • Molecular analysis	• Qualitative surveys and assessments • Molecular laboratory assessments	• Approval of County Administration • Consent of community and assent of children • Unforeseen interruption of field work
Objective 6.6 Determine the ecology of off-host stages of *T. penetrans*					
• Optimal transmission conditions identified • Seasonality in development of off-host stages described • Environmental conditions for off-host stages identified	• Better understanding of the heterogeneous distribution of tungiasis in different climate and ecological zones.	• Soil/floor sample surveys implemented. • Identification of off-host stages completed. • Repeated cross-sectional studies (school/HH/floor)	• Soil surveys in schools, households and in laboratory	• Field collections	• SERU approval • Approval of County Administration • Consent of community and assent of children • Unforeseen interruption of field work.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
	• Contribution to prediction of disease outbreaks by end 2024.	during dry and wet seasons completed. • Field experiments to assess environmental conditions needed for off-host development done.			
Specific objective 7 – Surveillance of arbovirus and mosquito vector diversities and their blood-meal host populations.					
Development of a cost-effective multiplex PCR-HRM assay	• Discovery of Wesselsbron virus and diverse insect-specific flaviviruses in mosquitoes. • Identification of diverse arbovirus infections in mosquitoes, livestock, wildlife and humans.	• Proposals developed • >10 students trained • 5 peer-reviewed publications	field samples reference viral sample from KEMRI	• Laboratory assays	•
Development of HRM-based blood-meal host identification	• Unique arbovirus-mosquito host relationships identified	• 2 peer reviewed publications • Additional grant funding obtained based on this work. • 3 students trained	field samples	• laboratory assays	•
Characterization of larval habitats near Lake Victoria	• Key effect of fertilizer components found at high concentrations in breeding sites with more *Anopheles* mosquitoes	• Q peer reviewed publication • 1 MSc	field survey field sampling	• laboratory assays • 16S next-generation sequencing	•
Specific Objective 7.1. – New Arbovirus transmission blocking strategies					
Characterization of endemic insect-specific flaviviruses (ISFVs) in their capacity to affect vector competence of mosquitoes to arboviruses.	• The potential utility of ISFV's for blocking arbovirus transmission identified. • Strategy for arbovirus transmission pursued	• Funding • Publications • Experimental data collection completed	field samples laboratory co-infection experiments.	• Laboratory assays • Cell culture • Transcriptome sequencing	• Funding • Equipment performance • Viral cultures remain viable.
Objective 8: Understanding leishmaniasis transmission dynamics in Kenya and development of control strategies					

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
Specific objective 8.1: Mapping of leishmaniasis disease vectors					•
Determination of densities, species diversity and host feeding preference of sand flies	New vectors of leishmania species identified in Marsabit and Gilgil Vector species of leishmaniasis from various habitats in disease endemics regions documented Sandfly densities recorded Source of bloodmeals established	• Publication • Project reports • Conference presentations.	• Sandfly habitats • Study villages • Villages & households.	• Vector sampling • Sample analyses • Coordinates recording • Laboratory analyses	• Distance to the study sites. • Access to the homesteads • Security. • Harsh climatic conditions
Leishmaniasis parasite identification	• Vectors screened of leishmaniasis parasite species	• Publication • Project reports • Conference presentations.	• Field samples	• Vector trapping • Laboratory analysis.	• Distance to the study sites. • Access to the homesteads • Security. • Harsh climatic conditions
Specific objective 8.2: To develop an odour baited sandfly attraction trapping device - the "SanTrap" for the control of leishmaniasis					
Development of odour baited sandfly attraction trapping device - the "SanTrap" for the control of leishmaniasis	• Novel approach in the control of sandfly bites developed • Efficacy and efficiency of the attract-and-kill tool on sandflies established	• Publications. • Reports • SanTrap tool • Patent	• Study villages • Attractant prototype •	• Vector sampling. • Sample identification. • Laboratory analysis	• Access to households • Trap testing villages • Household consent
Specific objective 8.3: Epidemiological factors associated with cutaneous leishmaniasis transmission in Gilgil, Nakuru County, Kenya.					
Vector species for Cutaneous leishmaniasis and parasite transmission in Gilgil, Nakuru County identification	• Identification and mapping of cutaneous leishmaniasis vectors • Ecological factors mapping • Cutaneous Leishmania reservoir identification	• Publications. • 1 MSc • Stakeholder information sharing meetings.	• Study villages • Habitat types • Ecological parameters	• Vector sampling. • Sample identification. • Laboratory analysis	• Trapping sites access

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
Correlation of exposure to sand fly bites and the CL outcome and the risk factors associated with disease exposure in Gilgil	• Identification of exposure to sand fly bites and the associated risk factors	• Publications.	• Study villages • Patient screening • Habitat types	• Vector sampling • Patient samples analyses Laboratory analysis	• Access to study sites. • Patient consent
Specific objective 8.4: Identifying sand-fly endosymbionts and their potential effect on CL transmission.					
Identify the diversity of *Wolbachia*, *Rickettsia*, *Spiroplasma*, *Arsenophonus*, *Cardinium*, and microsporidia symbionts in Kenyan sand-fly species	• Identification and mapping of endosymbionts	• Publication • Stakeholder information sharing meetings.	• Field collection	• Vector sampling. • Sample identification. • Laboratory analysis	• Trapping sites access
Experimental correlation of symbiont infection with infectivity to *Leismania*	• Establishment of sand-fly colonies • Identification of transmission blocking potential of key endosymbionts	• Publication	• Experimental data	• Establishing sand-fly colonies • Clearing of symbionts in subset of colonized sand-flies • Experimental infection of *Leishmania* parasites in sand-flies with and without symbionts	• Maintaining stable colony of sand-flies

ENVIRONMENT HEALTH at *icipe*

a) Overview of activities

icipe's environmental health research and development (R&D) and capacity building activities seek to broaden knowledge on arthropods and their diversity and role in ecosystems, and to contribute to conservation and sustainable utilisation of biodiversity and climate change mitigation and adaptation. The environment, which consists of biodiversity, physical and cultural components, is crucial to the survival of all living organisms as it provides all their essential requirements. Environmental health, therefore, has a direct impact on human, animal and plant health. The health of the planet is, however, facing major challenges; one of which is the rapid destruction and loss of biodiversity, particularly in developing countries. Biodiversity provides crucial ecosystem services that include pollination, soil fertility, nutrient cycles, climate and disease regulation, carbon sequestration and watersheds. In addition, it offers a multitude of essential goods to humankind, including food, fuel, fodder, timber, medicine, building materials, industrial inputs, cultural provision of spiritual and recreational benefits, and revenue. Human-induced land use and land cover changes, together with climate variability and change, contribute to the increased pressure placed on habitats and biodiversity. This leads to ecosystems that are less resilient, more vulnerable to shocks and disturbances, and less able to supply humans and other organisms with the needed environmental services. Major factors that lead to destruction and loss of biodiversity include: loss of habitats, introduction of exotic species, over-harvesting, agricultural pollution and global environmental change. All these factors are induced by human activity, coupled with the ever-growing human population and poverty, making this the most important cause of the current decline in biodiversity.

icipe's environmental health activities are undertaken within three programme areas: (1) Biodiversity and conservation, (2) Commercial Insects and (3) Applied Bioprospecting; and supported by two units: Remote Sensing and Geographic Information Systems (GIS) and the Biosystematics Unit (BSU). The biodiversity and conservation programme activities seek to broaden knowledge on arthropods and their diversity and role in ecosystems. *icipe*'s CHIESA (Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa - http://chiesa.icipe.org) project conducts field and laboratory research on four important crops in Africa; coffee, avocado, maize and crucifers, examining the relationship and interactions among the crops, their pests, and associated natural enemies under different conditions of climate and altitude. Studies are also undertaken on arthropod diversity and distribution, as well as on the interaction between beneficial arthropods and pest species in various ecosystems, and the interface among them. In the Commercial Insects Programme, *icipe* seeks to establish and consolidate apiculture and sericulture as significant contributors to rural livelihoods in Africa and the Near East region. In addition to capacity building in traditional beekeeping and silkmoth rearing technologies, it researches the potential of stingless bees and wild silkmoths for commercial applications, and assists the establishment and development of viable and sustainable community-driven enterprises in both apiculture and sericulture. Activities in the Applied Bioprospecting Programme focus on research and capacity building in bioprospecting for useful products from biodiversity to improve livelihoods of rural communities, and on conservation and sustainable utilisation of the biodiversity and to mitigate the effects of climate change. The Remote Sensing and GIS Unit supports all R&D activities of *icipe* by providing integrative and innovative earth

observation based tools and mapping solutions (services). The Unit also avails spatial data and tools via the Centre's intranet, and contributes to capacity development through 'hands on' training at different levels, including students, technical staff as well as project stakeholders. BSU provides support to all activities of *icipe* that are related to insect taxonomy. This includes collection, preservation, curation and identification of insect and arthropod specimens. The Unit trains students and *icipe* staff in insect structure and function, and conducts an annual course on insect taxonomy for incoming African Regional Postgraduate Programme in Insect Science (ARPPIS) students and other interested *icipe* personnel.

b) Goal and Broader Objectives

The overall goal of *icipe's* R&D activities in environmental health is to improve on the environmental health of the planet, and within Africa in particular, for enhanced food security, health and income of peoples of the tropics. To achieve this it focuses on broadening the knowledge base of the African science community on: (i) arthropods, their diversity and ecosystem services, (ii) effective methods of conservation and sustainable utilisation of biodiversity, and (iii) successful methodologies for climate change mitigation and adaptation.

Within this overall goal, the following are broad objectives: (i) Participate in global efforts to catalogue arthropod biodiversity; (ii) understand how arthropod agrobiodiversity and wild habitats support agricultural production and human health through ecosystem services (pollination and natural pest and vector control); (iii) generate information on the impact of climate change on ecosystem services and food security, and strategies for climate change adaptation; (iv) establish modern apiculture and sericulture as significant contributors to rural livelihoods in Africa; (v) maintain bee health and conserve pollinators' biodiversity for food security and environmental protection in Africa; (vi) increase public awareness and appreciation of beneficial arthropods; (vii) enhance knowledge and skills of students, scientists, and rural and wider African communities in arthropod diversity and environmental health-related disciplines; (viii) develop new natural products from the sustainable utilisation of indigenous plants and insects for the benefit of rural communities and beyond; (ix) implement *icipe*'s technologies to alleviate poverty in forest-adjacent communities; and (x) take a leading role in stimulating greater conservation of biodiversity rich habitats within Africa.

c) Strategic Outlook (up to 2020)

Biodiversity and conservation

The strategic focus of *icipe*'s activities in the area of biodiversity and conservation will be on broadening the knowledge on arthropods and their diversity and role in ecosystems and contributing to biodiversity conservation and climate change adaptation. Available models and predictions of climate change impacts on agriculture and food security have not taken into account specifically how crop diseases, insect pests and pollinators are affected. Climate change and climate variability (extreme events) have impacts on pollinators as well as on insect pests, such as maize stemborer, which reduce crop yields and affect food security. Changes in temperature and relative humidity may lead to insect pest outbreaks in areas and at altitudes where they have not been experienced before. As a result of the affects of climate change, the geographical distribution of important pollinator species, insect pests and their natural enemies may change.

icipe's CHIESA project targets these gaps in knowledge and develops adaptation options, such as IPM, and strategies in close cooperation with affected rural communities. The team conducts field and laboratory research on important crops in Africa, including coffee, avocado, maize and crucifers, where it examines the relationship and interactions among the crops, their pests, and associated natural enemies under different climate and altitude conditions. This research will also generate data for developing models to predict changes in crop performance due to climate change. Changes in the responses of four target crop systems to varying climatic and altitudinal regimes will be documented. Data generated in laboratory and field research will be used to develop predictive models on crop performance and viability of cultivation under different global warming scenarios. These predictions will be the basis of recommendations bearing on crop and cultivar choice for farmers living in different areas and under different environmental conditions. Studies are undertaken on arthropod diversity and distribution, as well as the interaction between beneficial arthropods and pest species in various ecosystems, and the interface between them.

Africa has the fastest rate of urbanisation globally; currently 40% of its one billion people live in urban areas. Moreover, 60% of this urban population lives in slums and, as a consequence, are very vulnerable to climate change impacts. Hence environmental health challenges will also include vector and disease management, provision and restoration of habitats, food security and income generating activity development in the cities. Future studies in the urban environment will focus on the effective planning and utilisation of urban spaces for small-scale vegetable and fruit production, supported by apiculture. Also studies on improved management of disease vectors in urban environments will be implemented.

Commercial Insects

Insect-based enterprises are ideal for establishment in buffer zones adjacent to rich biodiversity habitats, such as the hotspot forests. Sericulture, apiculture and butterfly farming and other sustainable, eco-friendly, synergistic indigenous insect- and plant-based enterprises, can provide quick economic rewards. These enterprises are particularly effective in incentivising community driven conservation of these valued resources. Stingless bees and wild silkmoths have great potential in this context. Honey from stingless bees is extensively used in traditional medicine in Africa. The medicinal uses of honeybee products and of wild stingless bee honey (apitherapy) offer rich opportunities for future research. Commercial insects also offer good prospects for dryland revenue generation, particularly with bees and wild silkmoths that feed on dryland trees, such as acacias.

By demonstrating the commercial values of wild species, *icipe* provides support and motivation for biodiversity conservation. The core programmatic approach is based on close integration of investments into productive rural infrastructure, forest resources and human and institutional capital. These approaches, where effective, economically viable and environmentally sustainable, will reduce pressure on the protected biodiverse ecosystems and their resources. This also emphasises the critical factors of rural empowerment, which can be achieved where there is clear community ownership and operation of rural marketplaces where value addition quality control, processing and packaging is achieved to the standards of national and international markets. The vast

majority of insects gathered for food consumption in Africa are harvested from wild populations. *icipe,* in collaboration with partners, will promote sustainable collection and management practices. Key priorities in this domain are: managing and conserving ecosystems, developing sustainable harvesting practices, development of internal control systems, climate change impact assessment, the documentation of traditional knowledge and ethno-taxonomical practices, including all edible arthropod species, and tangible methods that ensure the conservation of the gene pool.

The work on bee health will advocate for active research in the field of honeybee pathology and pollination services to be conducted at the cutting edge of science to address the pressing questions for sustaining honeybee health, thus preventing colony losses due to diseases and pests, and ensuring crop pollination and honey production in Africa.

To sustain expanded Commercial Insects Programme activities, a greater effort will be needed to investigate the problems that will arise from scaling-up and intensifying insect enterprises across the continent. The best example concerns beekeeping and the dangers of emergent diseases and spread of invasive bee-pests such as *Varroa* mites and brood diseases. In line with this, *icipe* in 2014 finalised the construction and establishment of a Bee Health Reference Laboratory at its HQs in Nairobi as well as satellite stations across Africa, as its first priority, to save the pollinators for food security in Africa. African bee health research is a clear priority, particularly in the light of the recent and dramatic spread of colony collapse disorder (CCD), currently threatening beekeeping and related pollination services in North America and Europe. Positive and negative impacts (e.g., on other pollinators and plants) from expanded beekeeping will be investigated. Impacts on beekeeping are also anticipated in the context of climate change. These are likely to be both direct, through physiological/ecological effects on the insects themselves, and indirect, through an increase in invasive bee pests, and effects on the nectar, resin and pollen sources on which the bees depend.

Applied Bioprospecting

The risks that are associated with the use of synthetic pesticides have led to an increasing demand for sustainable alternatives for pest and vector management. Among the alternatives, the botanical (plant-derived) pesticide market has seen a steady increase. This growth has been witnessed mainly in the developed countries where a number of botanical pesticides have been registered. Although scientific literature documenting bioactivity of plant products to arthropod pests and disease vectors continues to expand, in Africa, there are few examples of botanical pesticides that are in large-scale use. Yet, the greatest benefits from botanical pesticides could be realised in developing countries where human pesticide poisoning is most prevalent. Numerous studies in the literature have shown that extracts of locally available plants in Africa can be effective as pesticides, either used alone or in mixtures with conventional insecticides at reduced rates. There is also a long history of traditional knowledge and practices in Africa related to use of plants for pest, vector and disease management. Effective insecticidal plants could easily be planted by rural communities' on-farm for local use and for marketing.

Over the years, *icipe* has identified a number of plant-based pesticidal products that have a potential for use in pest, vector and disease management. The strategic focus for the

Centre's bio-prospecting activities will, therefore, be on bringing some of the effective botanical pesticidal products into use, particularly among rural communities in Africa. Formulation of safe, effective, eco-friendly plant-based pesticidal products will be undertaken. These will include repellents, larvicides, insecticides, deterrents, acaricides, and antifungal and antibacterial products. The major targets will be mosquitoes, stored product pests, livestock ticks and a range of bee pests and diseases. The products will be trialled and evaluated under semi-field and field conditions in different agroecological zones in eastern Africa. Links will be established with the private sector for registration and marketing of some of the products. A major focus will be on capacity building of natural resource-dependent rural communities to domesticate, cultivate and process suitable pesticidal plants, and to use derived products for pest, vector and disease management and marketing. Communities living adjacent to biodiversity-rich habitats will be particularly targeted as the sustainable harvesting and product development activities will provide alternative income-generating avenues and will reduce the economic pressure on indigenous natural resources and habitats from less sustainable utilisation (i.e., for charcoal production and as source of timber). Additional studies will be undertaken to identify new effective and eco-friendly botanical pesticides, particularly based on indigenous knowledge and practices.

Biosystematics

The Biosystematics Support Unit (BSU) will provide support to all activities of *icipe* that are related to insect taxonomy, including collection, preservation, curation and identification of insect and arthropod specimens. Students and *icipe* staff will be trained in insect structure and function, and an annual course on insect taxonomy will be provided for incoming ARPPIS students and other *icipe* personnel. BSU will help to produce taxonomy-literate ARPPIS students with identification skills adequate to support a productive career in insect-related sciences and especially to quickly recognise changes in species relationships in plant, animal and human insect systems that result from environmental change. The Unit will provide and process the bulk of specimens for the Kenya country node of the International Barcode of Life (iBOL) Project. It will be the functional link between the Global Biodiversity Information Facility (GBIF) and *icipe,* which is an Associate Participant in GBIF. It shares data with both GBIF and iBOL.

BSU will maintain a webpage on taxonomy and online source for information on primary sources of insect identification, the African Insect Taxonomy Toolkit that it has developed. The study of aquatic macro-invertebrate as bioindicators will be a significant part of the Unit's future activities. The Unit will also upscale and replicate capacity building of communities that are particularly dependent on natural resources to monitor their environmental health using aquatic insects and other biological indicators. Of all continents, Africa's insect biodiversity is most poorly understood or documented. BSU will take a more active role in increasing knowledge of Afrotropical insect diversity and distribution by developing collaborations with major centres of taxonomic expertise in North America, Europe and Africa. Descriptive taxonomy projects will also be initiated at *icipe*, joining the international effort to inventory Africa's insect species before they disappear.

The GIS and Modelling Unit

This Unit addresses key strategic focal areas that enhance *icipe*'s research and working agenda and similarly contribute to important African developmental issues. The focal areas of food security, biodiversity, ecosystem service assessments, as well as wetlands dynamics mapping for water-borne disease control, will be addressed through concerted cooperation and proposal development. Innovative earth observation (EO) based tools will be developed for each focal area. To assist actors to address the food security agenda, newly available satellite data with improved temporal resolution will be aligned to the cropping calendar to map the actual distribution of key crops and cropping systems. This will improve crop acreage estimates in food security models. Targeting the biodiversity agenda, *icipe*'s Remote Sensing and GIS will be developing key activities relevant to the UN reporting EO indicators, using phenological metrics from satellite data and contextual knowledge on insect diversity. Spatial data sets will be derived to map landscape integrity and the distribution of flowering plants for bee health studies and to ascertain pollination effects. This is set to complement and improve the ecosystem service assessment of woodlands in Kenya and throughout Africa.

Environmental Health Results Based Management (RBM) Rolling Framework

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Survey, inventory, and description of new species of East African insects published and data made internet-accessible by 2020.					
1.1 At least 35 taxonomists agree to study and publish results of examination of insects collected in Burundi and Kenya, by 2020.	• Taxonomists agree to study East African specimens.	• Number of taxonomists agreeing to participate.	• Collaborative agreements agreed through emails.	• Copies of agreements made available.	• Taxonomists' priorities change. • Kenyan authorities change their insect export policies.
1.2. At least 35 manuscripts produced by 2020 exclusively devoted to, or incorporating significant numbers of, East African insect taxa.	• Taxonomists study and publish on East African insect taxa.	• Number of manuscripts published on generic revisions, species descriptions, and regional checklists.	• Journals index.	• Online publication searches.	• Risk (small): Collaborators end cooperation with ICIPE.
1.3. At least 15,000 specimens databased by 2020, matched, where possible, to unique-specimen barcodes and made available on the internet on the Global Biodiversity Information Facility (GBIF – (http://www.gbif.org)	• Taxonomists and biogeographers access data base.	• Number of visits to GBIF, including number of downloads of database information.	• Global Biodiversity Information Facility (GBIF – (http://www.gbif.org)	Access records from Global Biodiversity Information Facility (GBIF – (http://www.gbif.org)	• Barcodes are available. • Manpower is sufficient.
1.4. At least 10 taxonomists or biogeographers cite (via GBIF) *icipe* collection database in papers or reports by 2020.	• Taxonomists and biogeographers access data base and use data in independent reports or papers.	• Number of reports or published papers.	• Journals index.	• Online publication searches.	• Data is not uploaded in time to influence researchers by output date.
1.5 At least 200 new species discovered in East Africa, and described in peer-reviewed journals by 2020.	• Knowledge of East African insect diversity is increased and National Museums of Kenya type collection increased appreciably.	• Number of published papers.	• Journals index.	• Online publication searches.	• Enough undescribed species are sampled to enable us to reach our proposed output. • Expert taxonomists continue to express interest in studying insects from East Africa.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
					• Kenyan government continues to allow export of non-endangered insects for study in external institutions.
Objective 2: Information on important pollinating Diptera (true flies) collected and made available on the internet.					
2.1. ICIPE's collection of fly pollinators databased and made available to the international community on GBIF by 2019.	• Data on Diptera important in plant pollination services made available to conservation biologists, taxonomists and interested parties.	• Number of visits to GBIF, including number of downloads of data.	• Global Biodiversity Information Facility (GBIF – (http://www.gbif.org)	• Access records from Global Biodiversity Information Facility (GBIF – (http://www.gbif.org)	• Grantee (Royal Museum for Central Africa) completes the database on sub-Saharan fly pollinators including the Kenyan data, low risk.
2.2 Three field visits per year through end of 2019 made to Nairobi forests to collect fly pollinators.	• Information on fly pollinators is increased, underscoring importance of the insect order in providing pollination services.	• Database of fly pollinators increases during period indicated.	• Comparison of numbers of fly pollinators at beginning and end of defined period.	• Access records from Global Biodiversity Information Facility (GBIF – (http://www.gbif.org	
2.3 One two-week training of African nationals in fly identification and their importance in plant pollination to be held at Sokoine University of Agriculture in Morogoro, Tanzania in 2019, in connection with JRS Biodiversity Foundation grant on fly pollinators.	• Information on fly pollinators is disseminated throughout sub-Saharan Africa by trainees	• Post-training reports by trained African nationals. Aspects of fly pollination included in projects organized by trainees.	• Reports of nationals received along with project proposals.	• Submitted reports and project proposals.	Funds for the training are delivered as presently indicated in JRS Biodiversity Foundation agreement

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 3: Taxonomic information on African insects including major African pests and vectors used by scientists, students and public by 2020.					
3.1 10,000 DNA barcodes generated for the iBOL database.	• Scientists use the DNA-barcode library for the African pest and vector insects to identify pest species with DNA techniques. • DNA barcoding becomes a routine part of the taxonomic enterprise. • A taxonomic evaluation of poorly understood taxa, like stingless bees and African silkmoth species.	• Number of barcodes generated.	• www.ibol.org provides public interface to access the barcodes.	• Inspection of database.	• Projects covering barcoding costs are available
3.2 One training per year for 10–15 students and staff.	• Students and staff know and apply modern taxonomic techniques, including morphological identification, preparation and DNA techniques to identify insects.	• Number of students and staff members trained.	• Counting participants and modules.	• Test analysis.	• Students and colleagues have time and interest to participate in the courses.
3.3 At least four donor-funded projects with relevant taxonomic perspective request and receive taxonomic and/or photographic support from the Biosystematics Support Unit by 2020.	• Scientists incorporate taxonomic information into planning and carrying out of projects.	• Number of projects funded that incorporate taxonomic data.	• Donor and *icipe* internal reports and publications.	• Online publication searches, requests to administration and donors.	• Sufficient calls and project partners available requesting taxonomic support.
3.4 Aquatic insects of streams in East Usambara area of Tanzania are identified and local groups are trained in their identification by 2018.	• Local groups of farmers are capable of identifying these insects, and can monitor the quality of streams.	• Number of community members trained.	• Project reports to donor.		• Locals are incapable of identifying insects to the necessary taxonomic rank.
Objective 4: At least 6 new eco-friendly nature-based products for pest and vector control adopted for improvement of livelihoods of rural and wider community members by the year 2020.					
4.1.1 At least four new potential products for mosquito control identified from plants based on	• Two plant-derived insecticidal products adopted for use in	• Number of products produced and used.	• Records • Reports • Journals index	• Reviews • Inspection	• Products are acceptable. • Favourable weather conditions.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
efficacy, safety and ease of application. 4.1.2 At least two plant-derived products for mosquito control formulated and packaged. 4.1.3. Community-based cultivation of selected insecticidal plants initiated. 4.1.4. Community-based production and use of plant-derived products for mosquito control initiated in at least one project site. 4.1.5. At least two PhD and two MSc students trained. 4.1.6. At least three papers prepared and submitted to international journals.	mosquito control by a local community by 2020. • Three papers or patents on potential mosquito control products published by 2020.	• Number of community members using the mosquito control products. • Number of reports and publications. • Number of students trained.			• Funds are available.
4.2.1 Two plants with bioactivity against honeybee pests/diseases identified. 4.2.2. One plant-derived product formulated and evaluated for control of a honeybee pest/disease. 4.2.3. The bee pest/disease control product submitted for registration with relevant bodies. 4.2.4. Protocols for production of the bee pest/disease control product established.	• One plant-derived product for honeybee pests/diseases control adopted for production and in use by 2020. • Two publications/utility model/patent on potential honeybee pest control products published by 2020.	• Number of products produced and used. • Number of reports and publications.	• Records. • Reports. • Theses. • Journals index.	• Reviews. • Inspection.	• Products are acceptable. • Favourable weather conditions. • Funds are available.
Objective 5: Geographic information systems are fully integrated as a strategic research tool for *icipe* by 2020.					
5.1 GIS and remote sensing training courses set up and given to students and resource managers.	• *icipe* seen as an incubator for Earth Observation for insect science and ecology in Africa.	• 10 out of 12 ARPPIS students use a GIS derived map in their work in 2019.	• Project reports. • Student thesis. • GIS course material.	• Inspection • Internet review.	

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
		• Number of peer reviewed papers on the use of GIS and remote sensing in insect science and climate change studies published.	• List of trainees.		
5.2 Efforts undertaken to increase the use of GIS in new and existing projects.	• Remote sensing and GIS is an integral part of the *icipe* working and research agenda.	• Number of proposals and existing projects that make use of GIS and remote sensing.	• Proposal document.	• Proposal database.	• Funding.
5.3 Remote sensing (ecological) variables are derived and used for insect and disease mapping.	• Insect and disease assessments are localised/more accurate so that interventions can be formulated with more precision.	• Number of projects in *icipe* that use ecological variables derived using EO for improved assessments of pests and diseases, i.e. RVF, dengue, malaria, etc.	• Proposal documents and project products.	• Publications . • Training curriculum.	• The activities need to be funded and accessibility and usability of variables need to be demonstrated.
5.4 Landscape dynamic mapping framework developed.	• *icipe* can use freely-available satellite data and modelling tools for mapping landscape dynamics which form habitats for beneficial insects, pests and diseases as a marketing tool for funding.	• Number of ecological and remote sensing models available and significantly understood.	• Models optimized and set up/available.	• Publication, geo-data server.	• Staff members need to be regularly trained in the utility of the modelling framework.
Objective 6: Increasing honey and silk production by 20% in selected African farming communities by 2020.					
6.1 Potential and healthy silk and bee races identified for enterprise development in Africa by 2020. 6.2 Healthy silk and bee races are distributed to 1,000 trainers for the farmer groups. 6.3 At least 5 PhD and 10 MSc students trained. 6.4 At least 50 peer reviewed papers and five books/proceedings published in international journals.	• 60% of the farmers use improved bee and silk races. • Development of strains and identification of hybrids with productive merit.	• Number of farmers using improved races. • No. of thesis produced. • No. of manuscripts published.	• Morphometrics and DNA fingerprinting results.	• Field surveys.	• Bee and silkmoth diseases under control.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
6.5 Training material developed and training sessions held for 2,000 trainers.	• Knowledge of sericulture and apiculture is applied by at least 750 farmer groups (each 50 to 100).	• Number of farmers trained. • Number of certificates (exam). • Number of farmers applying their new knowledge.	• Registry data. • Baseline surveys.	• Records. • Training manuals. • Project reports.	• Beneficiaries adopt value addition skills.
6.6 Business model developed using value chain approach.	• Business model and business responsibility adopted by at least 400 farmer groups.	• Number of enterprises registered.	• Relevant Government ministries, agencies and private sector.	• Survey. • Records.	• Beneficiaries/private sector/stakeholder's willingness to support market-oriented values chains.
6.7 16 to 20 marketplaces (honey and silk harvesting, processing and selling units) established.	• 10% increase in honey and silk quantity by 2020.	• DC registry. • Production records.	• Records. • Bank statement of marketplace account.	• Survey. • Inspection.	• Conducive weather. • No natural disaster (floods, drought, pests and disease outbreaks. • Beneficiaries own enterprises. • Stable markets for silk and hive products. • Government support and integration of silk and honey value chains in the National Development Plans.
6.8 Modern beehives supplied to farmers and rearing houses (silk moth) established.	• 500 beehives supplied to farmers by 2020.	• Project records.	• Registry of farmers.	• Field evaluation.	• Farmers are willing to adopt modern beekeeping.
6.9. Internal control system (ICS) training for 3,000 trainers conducted.	• Percentage of communities producing honey and silk to European Union (EU) standards increases from 20 to 30% by 2020.	• Honey and silk quality assessed and certified.	• Government standards agencies (Kenya Bureau of Standards, Institute for Market ecology, Switzerland).	• Laboratory test.	• Farmer communities are willing to go for organic certification. • Control standards are in place and operational
Objective 7: Integrative Pollinator-Plant Interaction Assessment of Ecosystem Service Diversity in Sub-Saharan Africa (JRS Biodiversity Foundation Project) by the year 2020					

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
7.1 Web-based platform (database) for Plant-Pollinator Interactions.	• Deepened understanding of plant-pollinator interactions for conservation of pollination services.	• Web-based platform (APPI) in usage.	• APPI platform, project technical report.	• Visit of website.	• Partnership with Upande Ltd (private sector partner)
7.2 Data collected and deployed in database for two ecosystems in Kenya.	• Deepened understanding of plant-pollinator interactions for conservation of pollination services.	• Number of data records deployed in database (10,000 interaction records).	• APPI platform, project technical report.	• Visit website.	• Weather conditions, security in field sites.
7.3 Assess risks for common pollinator species using species distribution modelling.	• Assessment of risks for distribution due to climate change, land use change etc. to inform conservation measures.	• Species distribution models.	• Scientific publications. • Project technical report.	• Publication search. • Project report database.	• Weather conditions, security in field sites for field-based data collection. • PhD student in charge performs well.
7.4 Establish plant-pollinator networks for different land use types.	• Deepened understanding of plant-pollinator interactions for conservation of pollination services.	Plant-pollinator networks.	• Scientific publications. • Project technical report.	• Publication search. • Project report database.	• Weather conditions, security in field sites for field-based data collection. • PhD student in charge performs well.
7.5 Assess genetic diversity of pollinators using DNA barcoding.	• Deepened understanding of plant-pollinator interactions for conservation of pollination services.	• 300 molecular barcodes of bees provided.	• GenBank/iBOL database. • Scientific publication. • Project technical report.	• Data base search. • Publication search. • Project report database.	• Weather conditions, security in field sites for field-based data collection. • PhD student in charge performs well.
7.6 Capacity building of stakeholders in database usage.	• Increased uptake of database usage by other stakeholders.	• Data records on interactions deployed. • Database usage records (registered users).	• APPI database and database statistics.	• Database search.	• Lack of data to support database.
7.7 Capacity building for biodiversity bioinformatics for *icipe* staff.	• Independent database development and management at *icipe.*	• Number of staff to be trained in biodiversity databases.	• Project technical report.	• Project report database.	• Staff leaves *icipe.* • Dis-continuation of staff contract.
Objective 8: Promote knowledge and technology-based entrepreneurship through training in beekeeping and silk farming for youth employment in Ethiopia (YESH Project) by 2020					

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
8.1 In-depth value chain analysis of beekeeping and silk production in the targeted project zones undertaken.	• At least two value chain analysis reports produced and shared with donors and partners by end of 2016. • One scientific publication by end of 2019. • Gender mainstreaming strategy designed by 2017.	• Map the major processes that the raw materials produced (honey, beeswax, cocoons) go through before reaching the final consumption by early 2017. • Identify and map the main actors involved in the processes by end of 2017. • Identify the flows of products as well as information flow and knowledge in the value chain by 2017 • Quantify the volume of different products in the value chain by early 2018. • Identify relationships and linkages between value chain actors by 2018. • Identify the bottlenecks within the supply chain and where possible identify/refine interventions by 2018.	• Primary data from youth, silk and honey value chain actors. • Baseline database. • Relevant Government offices and private sector. • Scientific publications.	• Field surveys. • Questionnaire surveys. • Stakeholder and youth interviews.	• Willingness of youth, value chain actors and stakeholders to cooperate. • Security situation in target areas favourable to project implementation. • Political situation is favourable.
8.2 The knowledge, capacity and technology-based entrepreneurship within the currently unemployed youth population increased.	• At least 8,750 youth capable to generate or improve income from beekeeping and silk farming or other businesses from the acquired skills by 2020. • At least 12,500 youth trained in beekeeping and silk farming enterprise development	• Identify, profile and select youth to form groups with a good balance in gender by 2019. • Establish training and demonstration centres for beekeeping and silk farming activities by 2019. • Build capacity through training (technical, business and life-skills),	• Training manuals. • Project documents, reports. • Publications. • Registry of youth.	• Field surveys. • Stakeholder interviews. • Network partners in collaborative agreements • Technologies adopted.	• Willingness of youth, value chain actors and stakeholders to cooperate. • Regional cooperation. • Adequate resource mobilisation.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
	during the period 2016–2020 • Gender mainstreaming strategy designed by 2018. • Support at least one egg production facility by 2018. • Develop at least two training manuals by end of 2016.	provision of starter kits and material support to improve beekeeping and silkworm rearing technologies and post-harvest for high quality production and income by 2020. • Increase participatory tree plantation to improve bee biodiversity, provide silkworm feed and enrich the ecosystem by 2020. • Provide technical support using existing egg production facility (grainage) within the Region by 2020.			
8.3 The development of youth-led and owned, silk farming and beekeeping enterprises through business development/incubation supported.	• At least 70% of youth using skills acquired from the entrepreneurship training able to build or increase assets during the period 2016–2020. • At least 50% of youth engaged in beekeeping and silk farming able to access financial service by 2020.	• Provide training in assessing market information, improving marketing skills and analyzing market linkages in the value chain in the period 2016–2020. • Educate the young entrepreneurs in financial management and mediate in acquiring access to appropriate financial services and products by 2020. • Provide a pro-active business development service by mentoring and coaching by seasoned entrepreneurs and advisers as well as	• Training manuals. • Program documents, reports. • Publications. • Registry of youth.	• Field surveys. • Stakeholder interviews. • Network partners in collaborative agreements • Developed businesses/enterprises.	• Willingness of youth, value chain actors and stakeholders to cooperate. • Regional cooperation. • Adequate resource mobilisation. • Conducive weather. • Beneficiaries own enterprises.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
		helping to navigate regulatory requirements, standards and compliance by 2020. • Support youth to participate in agribusiness entrepreneur networks, competitions and fairs to promote products, forge partnerships and learn about developments in the industry by 2020. • Assist the young entrepreneurs to gain access to technology and information by providing technical training by 2020.			
8.4 Market opportunities for youth in beekeeping and silk value chains created	• At least 70% of targeted youth in the project areas employed in the beekeeping and silk farming value chain in the period 2017–2020. • Youth led cooperatives established within the period 2017–2019. • 25% increase in honey and silk production by end of 2019 of the initial enterprises established. • At least two by- products introduced by end of 2019.	• Facilitate the establishment of legalized enterprises and cooperatives that are youth-led by early 2019. • Develop youth-led marketplaces for harvesting, bulking, processing (value addition) and packaging of quality honey and silk products by mid-2020. • Work with relevant Ethiopian Government organizations and NGOs to increase honey and silk market opportunities – import substitution and export promotion by end of 2020.	• Training manuals. • Project documents, reports. • Publications. • Registry of youth.	• Field surveys. • Network partners in collaborative agreement. • Developed marketplaces.	• Willingness of youth, value chain actors and stakeholders to cooperate. • Regional cooperation. • Adequate resource mobilisation. • Continued demand for silk honey in local, regional and international markets.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
		• Facilitate the use of by-products of the silk and honey industries to benefit youth and their associations by end of 2020.			
8.5 Learning among the project participants facilitated and key project learning captured and disseminated amongst the key stakeholders.	• M&E and outcome mapping strategy developed by end of 2017. • Document the extent to which beekeeping and silk farming are used for solving youth unemployment problem by 2019.	• Develop a M&E plan for the project including a detailed learning plan to ensure uptake of the technologies by 2017. • Implement the M&E plan including baseline data, collection and analysis, review and refinement of methodology after completion of cohort one and subsequent ongoing evaluation including end of project review during the period 2016–2020 • Develop an outcome mapping strategy including impact pathways in order to understand and document the impact generated by project implementation process during the period 2016–2020. • Monitor different partners (NGOs and Government Ministries) in order to document the extent to which beekeeping and silk farming are used for solving youth	• Project files. • Project strategies and plans. • Publications.	• *icipe* project reports. • Stakeholder reports. • Independent midterm evaluation. • Independent final evaluation of the project.	• Willingness of youth, value chain actors and stakeholders to cooperate. • Regional cooperation.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
		unemployment problem by 2020.			
8.6 Awareness raised and access to the outcomes and information on the project progress and achievements among project partners, relevant key stakeholders and the communities ensured.	• Project website developed by end of 2017 • Project progress review and planning meetings with key stakeholders for dissemination of reports • A communications plan developed by end of 2017.	• Create a project website for use as a dissemination vehicle for the wider audience, including project activities, progress and results; project publications and presentations by 2016. • Organize conferences and workshops to maximize the impact of dissemination and the sustainability of project outputs by 2020. • Develop a communication plan in order to identify relevant key stakeholders (internal and external) and enhance communication among all parties involved in the project by 2017.	• Project web site. • Project Communications plan. • Reports. • Publicity materials (news articles, blogs, case stories, brochures, signboards).	• Communities. • Private partners. • Field level data collection by project team and partners.	• Regional cooperation.
Objective 9: Evaluate the pollination efficiency of different stingless bee species in enhancing fruit quality and contribute in discriminating the African stingless bee species using molecular tools by 2021.					
9.1 Assess of pollination efficiency of 10 stingless bee species and African honeybees in seven greenhouse crops in Kenya	• Pollination efficiency of seven stingless bee species and African honey bees assessed for seven horticulture crops in greenhouse in Kenya. • Plant-pollinator-microbe interaction a case study of 1 horticulture crop	• Fruits and seeds data records per tested crop species. • **Nectar-dwelling micro-organisms data released for 1 ested crop.** • At least one papers per crop prepared and submitted to international journals.	• Scientific publications. • Project technical report. • Field surveys.	• Field evaluation. • Publication search. • Project report.	• Conducive weather for bees to forage • Emergency of crop pest and diseases • Seeds of poor germination rates
9.2 Assess pollinator diversity of two Macadamia cultivar in three agro-ecological zones in Kenya.	• Pollinator diversity and their dynamics in two Macadamia cultivar assessed in Embu, Taita	• Pollinator species diversity records per seasonal flowering periods.	• Bee pollinator specimen collection.	• Field surveys. • Publication search.	• Willingness of stakeholders (Macadamia farmers) to cooperate. • Conducive weather.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
	Taveta, and Kirinyaga in Kenya. • One MSc student	• At least one paper prepared and submitted to international journals. • One MSc student thesis on Macadamia pollinators in Kenya.	• Scientific publications. • Project technical report. • MSc thesis.	• Project report. • Insect collection at Bee Health. • MSc thesis.	• Security in field sites for field-based data collection. • Taxonomists' priorities change. • Discontinuation of the student
9.3 Assess stingless bee species using species distribution modelling.	• Assessment of distribution due to agro-ecological zone to inform species conservation measures.	• Species distribution models provided for project countries. • Establish training Centre in Kenya for stingless bees farming activities by 2021. • At least one paper prepared and submitted to international journals.	• Scientific publications. • Project technical report. • Field surveys.	• Field surveys. • Project report. • African stingless bee book.	• Regional cooperation. • Bad weather not favourable to detect bee nest. • Security in field sites for field-based data collection. • Political situation is favourable. • Taxonomists' priorities change. • Kenyan authorities change their insect export policies.
9.4 Assess genetic diversity of African stingless bees using DNA barcoding and morphometric analysis.	• Species discrimination base of morphometric, genetic differentiation and species phylogeny of some African stingless bee species scientifically available by 2019.	• Wing geometric morphometric of African stingless bee species provided. • Molecular barcodes of African stingless bee species provided. • Booklet on African stingless bees. • At least one papers prepared and submitted to international journals.	• BOLD database. • Scientific publication. • Project technical report. • Morphometrics, DNA and microsatellites fingerprinting results. • African stingless bee book.	• BOLD Data base search. • Publication search. • Project report. • Laboratory test. • African stingless bee book.	• Regional cooperation • Bad weather not favourable to detect bee nest. • Security in field sites for field-based data collection. • Political situation is favourable. • Taxonomists' priorities change. • Kenyan authorities change their insect export policies.
9.5 Capacity building of stakeholders in meliponiculture.	• Training of at least one ToT from DR Congo, Kenya, Cameroon, Botswana and Ethiopia.	• List of trained people.	• Project technical report.	• Project report.	• Regional cooperation. • Political situation is favourable.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
9.6 Capacity building for pollination efficiency evaluation for *icipe* postdoc staff.	• One *icipe* postdoc staff scaled up on pollination knowledge from an European Research Institution.	• One post doc staff trained in pollination.	• Project technical report.	• Project report.	• Dis-continuation of staff contract.
9.7 Capacity building of university students on conducting pollination efficiency evaluation studies.	• Training of at least five University student (BSc or Master level).	• List of students on attachment.	• *icipe* Capacity Building unit. • Project technical report.	• Project technical report. • Publication submitted.	• Dis-continuation of the students.
Objective 10: Generate 100,000 dignified and fulfilling employment opportunities for unemployed young women and men in honey and silk value chains and complementary income generating activities by 2024 (MOYESH program)					
10.1 Establish partnerships and identify and develop resources for scaling up beekeeping and silk farming enterprises to increase employment and learning opportunities for youths (PARTNERSHIP AND RESOURCES MOBILIZATION)	• Increased honey, hive products and silk production by youth enterprises	• Amount of honey, hive products, silkworm cocoons and silk yarn produced by the youth enterprises	• Baseline survey database. • Relevant Government offices and private sector partners.	• Targeted surveys • Stakeholder and youth interviews • Agreements signed with partners	• Willingness of youth, value chain actors and stakeholders to cooperate. • Security situation in target areas favourable to program implementation. • Political stability prevails • No major natural disasters, like drought, disease outbreak, massive pest attack
10.2 Link young men and women with financial service providers through digital financial services and business-to-business (B2B) linkages (FINANCIAL INCLUSION)	• Increased utilization of affordable financial services for the young men and women targeted by the program • Youth enterprises secure working capital through linkage with private actors (producers, processors, aggregators and exporters) • Increased utilization of digital and youth friendly financial products and	• Number of youths that received credit services from financial service providers (MFIs and Banks) • Number of youth enterprises that accessed working capital through B2B agreements with private actors • Number of youths that used youth friendly financial products and services (saving, credit appraisal,	• Baseline survey database. • Reports of relevant Government offices and private sector partners.	• Targeted surveys • Stakeholder and youth interviews	• Willingness of youth, value chain actors and stakeholders to cooperate. • Security situation in target areas favourable to program implementation. • Political stability prevails • No major natural disasters, like drought, disease outbreak, massive pest attack

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
	services by young men and women • Youth mobilized saving and create funds for investment in beekeeping and silk farming or related businesses	mobile and agent banking services) • Amount of loans and savings mobilized through VSLA			
10.3 Develop market linkages and youth-owned profitable beekeeping, sericulture and complementary enterprises (MARKET LINKAGES AND ENTERPRISES ESTABLISHMENT)	• Youth enterprises established and generate income in silk and honey value chains • Increased honey and hive products value addition and processing for better market value and quality • Increased silk value addition and processing for better market value • Increased income from complementary side businesses • Increased honey and hive products quality and residue analysis for export certification	• Number of youth enterprises that started generating income from silk, honey and related value chains • Volume of honey and hive products processed in the marketplaces • Volume of silk yarn and fabrics produced at the silk processing centers in kg • Amount of income received by youth from complementary side businesses • Amount of honey and hive products tested for export	• Training manuals. • Project documents, reports. • Publications. • Registry of youth.	• Field surveys. • Stakeholder interviews. • Network partners in collaborative agreements • Developed businesses / enterprises.	• Willingness of youth, value chain actors and stakeholders to cooperate. • Regional cooperation. • Adequate resource mobilisation. • Conducive weather. • Beneficiaries own enterprises.
10.4 Develop skills and capacity of youth and partners to undertake and manage successful and sustainable beekeeping and silk enterprises as well as complementary activities (SKILLS CAPACITY DEVELOPMENT)	• Increased capacity of partners to support youth enterprises as well as complementary IGAs • Increased capacity of youth to establish and manage successful and sustainable beekeeping and silk enterprises as well as complementary IGAs • Improved youth business, entrepreneurship and soft	• Percent of stakeholders reported improved capacity in providing technical support and training to youth to establish successful and sustainable enterprises. • Percent of youth reported improved technical skills and knowledge in beekeeping and silk farming activities	• Training manuals. • Project reports, documents • Publications. • Independent program evaluations • Registry of youth.	• Field surveys. • Stakeholder interviews. • Agreements signed with partners • Technologies adopted.	• Willingness of youth, value chain actors and stakeholders to cooperate. • Regional cooperation. • Adequate resource mobilisation.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
	skills to run successful enterprises	• Percent of youth reported improved entrepreneurship, business and soft skills (soft skills score)			
10.5 Develop and implement gender sensitive monitoring, evaluation and learning (MEL) system to guide decision making and facilitate learning (MEL)	• MOYESH MEL framework developed and made operational • Baseline data collected and baseline values and target established • Web based (digital) monitoring system established and made operational • Periodic monitoring conducted and evidence of progress or lack thereof documented and shared • Evidence of success, failure and lessons documented and shared • Midterm and end term evaluations conducted	• MOYESH MEL framework in place • Baseline survey report and completed M&E Matrix • Functional web based (MIS) monitoring system in place • Number of monitoring reports produced and shared • Number of case studies, success stories, technical studies and best practices produced and shared • Mid-term and final evaluations conducted, and reports made available	• Program documents (M&E plan, log frame, baseline database, etc.) • Program website • Program strategies, guidelines, roadmaps • Publications • Reports of independent program evaluations.	• *icipe* reports. • Program documents • Stakeholder reports. • Independent midterm and final program evaluations • Targeted surveys	• Willingness of youth, value chain actors and stakeholders to cooperate. • Regional cooperation.
10.6 Establish effective project coordination, partnerships and communication strategies for successful management and implementation of the program (COORDINATION AND IMPLEMENTATION SUPPORT)	• Program launching conducted at regional and federal levels • Program planning and progress review meetings conducted at national and regional levels • National and regional steering committee meetings conducted • Program communication plan developed and implemented	• Number of program launching workshops • Number of annual program review and planning meetings conducted • Number of regional and national steering committee meetings conducted • Program communication plan in place and under implementation • Number of communication outputs prepared and	• Minutes and proceedings of meetings • Program reports • Stakeholder / partner reports • Publications • Reports of independent program evaluations.	• *icipe* reports. • Program documents • Stakeholder reports. • Independent midterm and final program evaluations • Targeted surveys	• Willingness of youth, value chain actors and stakeholders to cooperate. • Regional cooperation.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
	• Program achievements and best practices documented and disseminated • MOYESH Program website designed and launched • Digital information exchange/sharing platform developed • MOYESH training manuals published and translated to regional languages • Program partners (Private and NGOs) identified and engaged • MOYESH Program technical and financial reports and monthly briefs prepared and submitted to the MCF • MOYESH Program Quarterly and monthly briefs prepared and submitted to the MCF and Program Management Committee	disseminated (leaflets, banners, etc.) • MOYESH Program website developed and functional • MOYESH digital information exchange platform developed and used to share information with youth and stakeholders • Number of training manuals published and translated to regional languages • Number of NGOs and private sectors that signed MoUs to support implementation of MOYESH Program • Number of Technical and Financial Reports produced and shared with the Foundation • Number of quarterly and monthly reports produced and shared with the MCF and Program Management Committee			
Objective 11: Investigate the ecology and evolution of on sub-Saharan African stingless bees by 2024					
11.1. Analyse the physical chemical and bifunctional characterization of African stingless honey compared to honey produced by the Western honeybee, *Apis mellifera* (Hym. Apidae, tribe Apini),	• Chemical composition and bifunctional properties of various African stingless bees known and published	• One Msc and PhD staff trained • 2 publications	• Scientific publications. • Project technical report. • MSc and PhD thesis	• Field sample collection • Laboratory analysis • Project technical report.	• Regional cooperation. • Dis-continuation of the students • Political situation is not favourable in sampling countries.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
				• Publication submitted.	• Corona virus or any other human pandemic crisis • County authorities change their biological samples export policies
11.2. Determine host plants for the collection of pollen and nectar across a range of stingless bee species and habitats across African countries,	• Primary and secondary nectar and pollen host plant known for different African stingless bees regarding their agroecological zones	• One PhD staff trained • 1 publication	• Scientific publications. • Project technical report. • PhD thesis	• Field sample collection • Laboratory analysis • Project technical report. • Publication submitted.	• Regional cooperation. • Dis-continuation of the students • Political situation is not favourable in sampling countries. • Corona virus or any other human pandemic crisis • County authorities change their biological samples export policies
11.3. model the ecological niches of stingless bee species and their host plants under climate change and land use/land cover change, based on existing species occurrence records covering most of sub-Saharan Africa	• Suitable niche for various stingless bee species identified in relation to host plant • Impact of land cover lost and climate change predicted for various stingless bee species	• One Msc and PhD staff trained • 2 publications	• Scientific publications. • Project technical report. • Msc and PhD thesis	• Field sample collection • Project technical report. • Publication submitted.	. • Dis-continuation of the students •
11.4. Assess queen invitro techniques for some stingless bee species of economic importance	• Technique to mass produce queen invitro established for at least 5 species of the Meliponula genus	• Technical report in book chapter • Training manual	• Technical report. • Training manual	• Field sample collection • Laboratory notebook. • Technical and training manual submitted.	• Corona virus or any other human pandemic crisis • Regional cooperation
11.5. Assess mass colony production techniques through production of nuclei colonies for some stingless bee species of economic importance	• Technique to mass produce colonies established for at least 5 species of the Meliponula genus	• Technical report in book chapter • Training manual	• Technical report. • Training manual	• Field sample collection • Laboratory notebook.	• Corona virus or any other human pandemic crisis • Regional cooperation

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
				• Technical and training manual submitted	
Objective 12: Participatory beekeeping for ecological protection of Mangrove forests in Zanzibar (ZanBee)					
12.1 To develop a mutual link between beekeeping and environment for improved honey production, through promotion of multipurpose and all-season nectar and pollen supply plants through community nurseries and training	• Increase to 25% of beekeepers engaged in other environmental activities • Increase in planting of multipurpose trees in area to 100 pieces (per beekeeping group) by project end • 1-2 different products derived from beneficial trees	• Number of beekeepers who are engaged in environmental activities • availability of forage plants over the whole year • Number of products derived from beneficial trees produced	• Technical report	• Socio-economic report incl. additional questionnaires	• Willingness of beekeepers to participate
12.2 To promote beekeeping and enhancement of honey production through practical beekeeping training, development of capacity for monitoring of honeybee health and product quality	• Increase of honey production by 500 kg per year (by 2022 compared to 2021) • Increase of high quality of honey produced by 80% of farmers • 50% of participating farmers keep records of the health of their bees	• kg of honey produced • quality of honey produced • availability of information on bee health (provided by beekeepers)	• Technical report • Records (reports, notes) of beekeepers	• Socio-economic assessment (ex ante vs ex post) • Records (reports, notes) of beekeepers	• Good colonization rate of beehives and low absconding rate of bees • At least average weather conditions
12.3 To increase incomes through improved market access facilitated through hive product diversification and value addition	• At least 20% of farmers increase price of their products during project period by 20% • At least 20% of participating farmers engage in hive product diversification	• level of honey & wax price • number of farmers diversifying their hive products • number of marketing partners • kg of honey sold	• Technical report	• Ex ante vs ex post assessment and additional questionnaires; • Marketing data by groups	• Willingness of farmers to engage in product diversification • Willingness of farmers to contact new customers • Farmers are willing to use methods of value addition

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
	• Linkages with at least 5 marketing partners established • 500 kg of honey sold				

SOCIO-ECONOMIC AND IMPACT ASSESSMENT UNIT at *icipe*

Socio-economics and impact assessment unit RBM Rolling Framework

i. NAME of Project: Integrated pest management strategy to counter the threat of invasive fall armyworm to food security in eastern Africa (FAW-IPM)

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Livelihood, environmental, and gender impacts of FAW along the maize value chain in East Africa determined and utilized for decision making					
1. Understand Knowledge, Attitudes, and Practices (KAP) and the enabling policy related to FAW	• Stakeholders are aware of current knowledge and management practices of FAW and available policies	• One paper documenting information about current knowledge and management practices of FAW by stakeholders and enabling policies	• Farmers, key informants, agricultural experts	• FGD and household surveys	• Political stability in project areas • Farmers are willing to participate in interview and provide information • Data collection will be completed in time to allow early analysis to finalize the impact assessment studies
2. Quantify the economic impacts of FAW damage for the different social groups	• Stakeholder aware economic burden of FAW and make informed decision on control and management of FAW	• A paper documenting evidence on economic burden of FAW	• Farmers, key informants, agricultural experts	• FGD and household surveys	• Farmers are willing to participate in interview and provide information •
3. Establish the economic, environmental, nutrition, and human health impacts of pesticides use and the various biological control (BC) methods	• Policy makers and development partners use better evidence in decision making to diffuse biological control of FAW	• One paper on economic, environmental and nutrition impacts of BC	• Farmers	• FGD and household surveys	• Farmers are willing to participate in interview and provide information

ii. **NAME of Project: Integrated pest and pollinators management (IPPM) to enhance productivity of avocado and cucurbits among smallholder growers in East Africa**

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Impacts of integrating pollination services and Integrated Pest Management (IPPM) on farmers' livelihoods determined					
1. Assess the Knowledge, Attitude and Practices (KAP) towards integrating pollination services and IPM	• Enhanced information about farmers' KAP of pollination services and IPM	• Msc proposal by end of 2018 • Working paper on KAP by end of 2019	• Farmers	• FGD and household surveys	• Farmers are willing to participate in interview and provide information
2. Determine impact of IPPM interventions on livelihoods of avocado and cucurbits producers	• Policy makers and partners use evidence Improved evidence and knowledge on impacts of IPPM	• Peer reviewed paper on impact of combination of pollination services and IPM	• Farmers and published documents	• FGD, household surveys and secondary sources	• Farmers are willing to participate in interview and provide information •
3. Estimate ex-ante adoption of IPM pollination services in the target countries	• Improved evidence on potential adoption of IPPM	• At least one paper on ex-assessment of demand for IPPM by end of 2019 • Msc thesis by end of 2019	• Farmers and published documents	• FGD, household surveys and secondary sources	• Farmers are willing to participate in interview and provide information

iii. **NAME of Project: Insfeed: Strengthening "out-grower" models for commercial production of high-quality and sustainable Insect-based animal feed protein engaging smallholder farmers and other value chain actors in Kenya (SiPfeed)**

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1:					
Different out-grower based supply chain models linking insect production with feed manufacturing sector evaluated	• Enhanced information of partners and stakeholders about	• One report on mapping and feasibility of supply chain models	• Key informants along the feed supply value chain	• Key informant survey schedule	• stakeholders are willing to participate in interview and provide information

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
	the existing supply chain models for key commodities in Kenya				
Impact of insect farming and insect-based protein for feed on the livelihoods of farmers determined	• Policy makers, development agents are more informed about the potential benefits of insect farming and formulation of insect-based feed	• Working paper on optimal and economical feed ratios for poultry and fish production produced • A case study on impact of insect farming and insect-feed for poultry and fish production systems on productivity, income and, dietary diversity produced	• Farmers, small scale entrepreneurs (SMEs)	• FGD and household survey	• Farmers and SMEs are willing to participate in interview and provide information

iv. INSFEED2: Insect feed for poultry, fish and pig production in Sub-Saharan Africa- Phase 2 (Cultivate Africa's Future Phase 2 (CultiAF 2)

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Assess the cost-effectiveness and potential livelihood effects of insect-based feed technologies through gender lens[1] along the value chain					
Existing supply chain models for key commodities in Kenya and the role of the youth, women and men in feed supply assessed	• Enhanced information about the existing supply chain models for key commodities in Kenya	• One report the existing supply chain models for key livestock feed in Kenya produced	• Stakeholders along the livestock value chain	• FGD and household survey	• stakeholders are willing to participate in interview and provide information
Economic benefits of insect farming and insect-based feed for poultry, fish and pig production	• Policy makers and partners use improved evidence	• One paper on the gender differential economic benefits of insect farming and insect-	• Fish, poultry and pig Farmers	• FGD and household survey	• stakeholders are willing to participate in interview and provide information

[1] In this project, the term gender lens implies the gender heterogenous impacts of the insect-based technologies on men, women (female headed households and female with male headed households) and youth will be carried out by collecting sex disaggregated data.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
systems along the value chain determined	and knowledge on impacts of economic benefits of insect farming and insect-based feed	based feed for poultry, fish and pig production systems along the value chain in Kenya produced			
Long-term potential impact of insect-based feed technologies on food and nutrition security estimated	• Enhanced knowledge policy makers and partners on long-term potential long-term impact of insect-based feed technologies on food and nutrition security	• One paper on the long-term potential impact of insect-based feed technologies on food and nutrition security in Kenya produced	• Stakeholders (farmers, researchers, development agents)	• FGD and household survey	• stakeholders are willing to participate in interview and provide information
economic viability of insect-based feed supply chain models to guide scaling up pathways evaluated and determined	• Policy makers and partners devise scaling up strategies based on improved evidence and knowledge of economic viability of insect-based feed supply chain models in Kenya	• One report on economic viability of insect-based feed supply chain models in Kenya produced	• Stakeholders (farmers, researchers, development agents)	• FGD and household survey	• stakeholders are willing to participate in interview and provide information

v. **Leap-Agri Sustainable intensification of fruit production systems through innovative pest biocontrol technologies (Pest-free fruit)**

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Existing farmers' knowledge, perception and practices that may enhance or constraint the adoption of innovative fruit fly management strategies understood	• Farmers' knowledge, perception and practices that may enhance or constraint the adoption of innovative fruit fly management strategies documented and shared with stakeholders	• One baseline survey in at least two sites in Kenya and Senegal by end of 2019 • At least one working paper by mid-2020	• Primary survey at household level; qualitative information from key informants	• Household survey • Key informants' interviews	• Farmers will cooperate in providing data
Demonstrate the agronomical and socio-economical effectiveness of innovative fruit fly management strategies on a pilot territory	• Socio-economic impacts of the innovative fruit fly management strategy established and shared with partners	• Field pilot experiment (RCT format) in in at least two sites in Kenya and Senegal by end of 2021 • At least one peer review manuscript by end of 2021	• Primary survey at household level; qualitative information from key informants	•	• Other team partners will be successful in developing the IPM interventions at the laboratory for field piloting

vi. **Programme Name: Combating Arthropod Pests for Better Health, Food and Resilience to Climate Change (CAP-Africa)**

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Test innovative approaches for stimulating increased adoption and impact of push pull technology (PPT)					
1. The role of social learning on adoption of PPT determined and documented	• Policy makers and development agents have improved understanding and knowledge of social learning as a	• Working paper on the effect of social learning on adoption of PPT by gender groups (men and women)	• Farmers	• Household surveys	• Farmers are willing to participate in interview and provide information

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
	strategy for stimulating technology adoption				
2. Impacts of PPT adoption on maize and milk productivity, household food security, and income determined	• Enhanced knowledge policy makers and partners on milk productivity, household food security, and income determined	• Working paper on the impacts of PPT adoption on maize and milk productivity, household food security, and income	• farmers	• Household surveys	• Farmers are willing to participate in interview and provide information
3.Production risk impact of PPT adoption determined and documented	• Enhanced knowledge of policy makers and partners on the production risk implications of PPT adoption	• Peer-reviewed paper on PPT adoption and agricultural productivity risk	• farmers	• Household surveys	• Farmers are willing to participate in interview and provide information
4. Effect of PPT on Women's labor supply and dietary diversity of women & children determined	• Policy makers and development partners have improved evidence and enhanced knowledge on the gender differentiated impacts of PPT adoption	• Working paper on labor allocation impact of PPT Working paper on PPT and women's empowerment	• farmers	• Household surveys	• Farmers are willing to participate in interview and provide information
Objective 2: Establish the economic burden of malaria and livelihood impacts of IVM interventions for malaria prevention and control among rural households					
Assess the gender differential impact of malaria on labor	• Policy makers and development partners have	One paper on impact of malaria on labor supply and income	• farmers	• Household surveys	• Farmers are willing to participate in interview and provide information

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
productivity, and income determined	enhanced knowledge on the gender differentiated impacts of malaria burden in rural households				
Impacts of IVM intervention strategies on household health and Economic welfare determined	• Policy makers and development partners have enhanced knowledge on livelihood impacts of implementing IVM strategies	One papers on IVM intervention impact on household health and economic welfare	• farmers	• Household surveys	• Farmers are willing to participate in interview and provide information
Objective 3: Developed and operationalize Performance, Monitoring, and evaluation framework (PME) for the project to facilitate learning, monitoring and dissemination of lessons learned					
1.: M&E specialist trains researchers from host countries and project staff in implementing common result framework;	Enhanced knowledge and appreciation of the common result framework by researchers and project staff	20 stakeholders trained in M&E aspects and tools	• Partners: researchers and project staff	• Workshops ad meetings	•

vii. Promote sustainable management of *Tuta absoluta*, an invasive pest of Solanaceous vegetables for food and nutritional security in East Africa

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Knowledge on socioeconomic impact of the Tuta absoluta tomato growers' livelihood prior to the intervention enhanced					
Growers' knowledge, attitudes and practices (KAP) related to tomato	• At least 2000 farmers and other tomato value chain	• Baseline survey datasets • At least one (1) report on "Farmers' Knowledge,	• Farmers (men and women)	• Households surveys	• Political situation is favorable.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
production and IPM technologies assessed	actors are aware of the knowledge, attitudes and practices (KAP) of farmers as regards tomato production and IPM technologies assessed	attitudes and practices on tomato production and pest management in Kenya and Uganda" by end of Dec 2019	• Key informants (village elders, extension officers, etc)	• Focus group discussions • Key informants' interviews	• Farmers agree to be interviewed • Availability of funds.
Tomato farming systems in the study areas and availability, access and utilization of different pest management practices including IPM products for combating the invasive tomato leaf miner, T. absoluta documented	• Tomato production systems in the target sites documented and shared with stakeholders/tomato supply chain actors	• At least one (1) report produced before end of 2019	• Farmers (men and women) • Key informants	• Households surveys • Focus group discussions • Key informants' interviews	• Political situation is favorable. • Farmers agree to be interviewed • Availability of funds.
Economic impact (economic burden) of tomato leaf miner, T. absoluta on tomato production evaluated	• Stakeholders and partners made aware of the economic burden of tomato leaf miner, *T. absoluta*	• At least one (1) report produced before end of 2020 • At least 1 peer reviewed paper by mid 2020	• Farmers (men and women) Key informants	• Households surveys • Focus group discussions • Key informants' interviews	• Political situation is favorable. • Farmers agree to be interviewed • Availability of funds.
Potential adoption, implementation feasibility and future sustenance of *T. absoluta* management approaches determined.	• Potential demand of the innovative *T.absoluta* management approaches determined and shared with stakeholders	• At least one (1) report produced before end of 2020 • At least 1 peer reviewed paper by mid-2020	• Farmers (men and women) • Key informants	• Households surveys • Focus group discussions • Key informants' interviews • Secondary sources	• Political situation is favorable. • Farmers agree to be interviewed • Availability of funds.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Economic feasibility of commercialising the fungal based biopesticide by the private sector assessed.	• Tomato market value chain actors informed about the economic feasibility of commercialising fungal based biopesticide	• At least one (1) report produced before end of 2021	• Tomato supply chain actors	• Market survey	• Political situation is favorable. • Market value chain actors agree to be interviewed • Availability of funds.

viii. Combating the invasive tomato leafminer, *Tuta absoluta* through the Implementation of eco-friendly IPM approach on tomato in East Africa (Tuta IPM)

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: To assess socio-economic impact of vegetable pest management technologies					
Assess farmers' perceptions of the impacts of and management of tomato and other Solanaceous vegetable pests	•	• Baseline survey dataset • One (1) survey report on "Farmers' Knowledge, attitudes and practices on tomato production and pest management in Kenya, Uganda and Tanzania"	• Farmers (men and women) • Key informants (village elders, extension officers, etc)	• Households surveys • Focus group discussions • Key informants' interviews	• Political situation is favorable. • Market value chain actors agree to be interviewed • Availability of funds. •
Investigate the economic burden of T. absouluta in tomato production in the target project sites	•	• At least one (1) working paper on "Economic burden of tomato leaf miner, *T. absoluta* on tomato production in Kenya, Uganda and Tanzania	• Farmers (men and women) • Key informants (village elders, extension officers, etc)	• Households surveys • Focus group discussions • Key informants' interviews	•
Estimate ex-ante demand for IPM technologies for management of T. absoluta among tomato growers	•	• At least one (1) working paper on "Potential adoption, and constraints and opportunities of adopting IPM and in the study areas in	• Farmers (men and women) • Key informants (village elders,	• Households surveys • Focus group discussions	•

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
		Kenya, Uganda and Tanzania"	extension officers, etc)	• Key informants' interviews	

ix. Improving food and nutritional security through integrated control of tsetse and tick-borne livestock diseases (ICTLD)

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Impact of integrated tsetse and tick control using novel eco-friendly technologies on the livelihood of smallholder farmers evaluated					
Livestock producers' perceptions on the impacts and management practices of trypanosomiasis and tick-borne diseases, and constraints and opportunities to scale up improved livestock health management technologies in the target areas assessed	• Farmers perceptions and constraints to adoption of integrated tsetse and ticks management practices documented and shared with project partners and other livestock value chain actors	• Dataset • A report by end of 2019	• Farmers	• Households surveys • Focus group discussions • Key informants' interviews	• Political situation is favorable. • Market value chain actors agree to be interviewed • Availability of funds. •
Ex-ante demand of the integrated tsetse and tick control and management technologies in the target areas determined	• Traders and development partners in the livestock value chains made aware of the potential demand of the integrated tsetse and ticks management practices	• At least one (1) working paper by mid-2020	• Farmers	• Households surveys • FDG • Key informants' interviews	•

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Cost-effectiveness of the integrated tsetse and tick control and management technologies estimated	• Traders and development partners in the livestock value chains made aware of the potential demand of the integrated tsetse and ticks management practices	• At least one (1) working paper by mid-2020	• Farmers	• Households surveys • FDG • Key informants' interviews	• Political situation is favorable. • Market value chain actors agree to be interviewed • Availability of funds. •
Economic and nutrition effects of integrated tsetse and tick control and management technologies with emphasis on women and their children determined	• At least 3000 community members in tsetse and ticks prone areas are made aware of the economic and nutrition effects of integrated tsetse and tick control and management practices and results shared with project partners.	• At least one (1) working paper by end of 2020	• Farmers	• Households surveys • FDG • Key informants' interviews	•

x. PROSAFE: Promoting smallholder access to fungal biopesticides through Public Private Partnerships in East Africa

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Farmers' Knowledge and Management Practices of Cereal, Legume and vegetable insect pests, and willingness to pay (WTP) to pay for biopesticides					

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Farmers' knowledge and management practices of Cereal, Legume and vegetable insect pests, and willingness to pay (WTP) to pay for biopesticides determined	• project partners and stakeholders are made aware of the knowledge and management practices of cereal, legume and vegetable insect pests, and farmers' willingness to pay (WTP) to pay for biopesticides	• Survey dataset • At least one (1) research report produced by end of 2019	• Farmers	• Household survey • Focus group discussion	• Farmers cooperate in providing information

xi. Project Name: Three diseases, One Health; A one health, participatory approach to combating a complex of zoonotic diseases in northern

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1:					
Community awareness and practical knowledge on disease risk, prevention and control assessed and documented	• Stakeholders are aware of the community knowledge, beliefs and behaviors towards RVF, leishmaniasis and brucellosis	• Survey tool and dataset • One report on community knowledge Awareness and practical knowledge on disease risk, prevention and control	• Farmers	KAP analysis technical project report •	• Farmers are willing to provide information, enabling environment
Impact of interventions on knowledge about the diseases assessed and documented	• Policy makers and partners have improved evidence and knowledge of the impact of project interventions on community	• One working paper on interventions and their impact on the diseases	• Farmers	• KAP analysis technical project report	• Farmers are willing to provide information, enabling environment

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
	knowledge about the diseases				

xii. Evaluating The Feasibility And Impact On Malaria Transmission Of Community-Based House Screening As An Additional Vector Control Intervention In Zambia

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: To assess social / economic incremental costs and benefits of Integrated Vector Management interventions (addition of house screening to providing Long Lasting Insecticidal Nets)					
The effects of house screening on in-door mosquito prevalence, and the effect of the number of malaria cases averted and economic on households including labour productivity, incomes and educational attainment determined	• Policy makers and partners/stakeholders have evidence and enhanced knowledge on the health and economic effects of IVM in households	• One working paper on health and economic effects of IVM strategies	• Farmers	• Household surveys based on RCT design	• Farmers are willing to provide information, enabling environment
The incremental cost-effectiveness of adding house screening to LLINs from the societal and provider perspective measured and documented	• Stakeholders are aware of the cost-effectiveness of adding house screening to LLN	• One working paper on incremental cost-effectiveness of adding house screening to LLINs from the societal and provider perspective	• Farmers	• Household surveys based on RCT design	• Farmers are willing to provide information, enabling environment
The effect of price paid for screens on health promoting behavior and the future willingness to pay examined and determined	• Policy makers and partners are aware of the community's WTP for house screening	• One working paper on effect of price paid for screens on health promoting behavior and the future willingness to pay	• Farmers	• Household surveys based on RCT design	• Farmers are willing to provide information, enabling environment

xiii. Integrated Biological Control Applied Research Programme

a. Proven IPM technologies and classical biological measures to manage fruit flies adapted and implemented jointly with partners.

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Adoption and socio-economic impact assessment of fruit fly IPM					
1. Farmers' Knowledge and Perceptions on fruit flies and Willingness to Pay for a fruit fly IPM Strategy in Gamo Gofa Region, Ethiopia	• Development partners aware of farmer's knowledge and perceptions on fruit flies and WTP for fruit fly IPM	• At least one peer reviewed paper	• Farmers	• Household survey	• Farmers are willing to participate in interview and provide information
2. Adoption of Integrated Pest Management Strategy for Suppression of Mango Fruit flies East Africa): An ex ante and ex post analysis in Ethiopia and Kenya	• Development partners and other stakeholders aware of farmer's adoption of IPM strategy	• At least one peer reviewed paper	• Farmers	• Household survey	• Farmers are willing to participate in interview and provide information
3. Assessment of the effect of training Fruit Fly IPM use on Mango Value Chain in Elgeyo Marakwet County, Kenya.	• Development partners and other stakeholders aware of the effects of fruit fly IPM training on mango value chain in Eleyo Marakwet County.	• At least one peer reviewed paper	• Farmers	• Household survey	• Farmers are willing to participate in interview and provide information

xiv. NAME of Project: The African Fruit Fly Programme:

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Overall objective: Assess the spillover effects of mango IPM fruit fly control technology on farm productivity and environment in Kenya.					
Objective 2: Beyond mango fruit fly control: The impact of IPM technology for mango fruit fly control on Food security, gender, and intra-household dynamics					
1. Impact of fruit fly IPM strategy on food security among smallholders in Kenya determined	• At least 3000 households aware of the effects of the fruit fly IPM on their food security status	• One Follow-up survey conducted in previously surveyed sites in Kenya • One Msc thesis produced by end of 2018 • At least one journal article produced by end of 2018	• Primary data from households. • Scientific publications.	• Surveys (questionnaires). • Literature review. • Secondary data (from previous studies)	• Availability of funds. • Willingness of households to cooperate. • Committed MSc student identified. •
2. Effect of fruit fly IPM Technology on Gender roles and intra-household dynamics among smallholder mango producers in Kenya determined	• At least 3000 households and other mango value chain actors aware of the effects of the fruit fly IPM on women's decision making in mango	• One Follow-up survey conducted in previously surveyed sites in Kenya by end of 2017 • One Msc thesis produced by end of 2018 • At least one journal article produced by end of 2018	• Primary data from households. • Scientific publications. •	• Surveys (questionnaires). • Literature review. • Secondary data (from previous studies)	• Availability of funds. • Willingness of households to cooperate. • Committed MSc student identified.

xv. Improving food and nutritional security through integrated control of tsetse and tick-borne livestock diseases (ICTLD)

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Impact of integrated tsetse and tick control using novel eco-friendly technologies on the livelihood of smallholder farmers evaluated					
Livestock producers' perceptions on the impacts and management practices of trypanosomiasis and tick-borne diseases, and constraints and opportunities to	• Farmers perceptions and constraints to adoption of integrated tsetse	• • Dataset • A report by end of 2020	• Farmers • Key informants involved in cattle value chain	• Focus group discussions • Household surveys	• Farmers are willing to participate in interview and provide information

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
scale up improved livestock health management technologies in the target areas assessed	and ticks management practices documented and shared with project partners and other livestock value chain actors				
Ex-ante demand of the integrated tsetse and tick control and management technologies in the target areas determined	• Traders and development partners in the livestock value chains made aware of the potential demand of the integrated tsetse and ticks management practices	• At least one (1) working paper by mid-2021	• Farmers • Key informants involved in cattle value chain	• Focus group discussions and key informant interviews • Household surveys	•
Cost-effectiveness of the integrated tsetse and tick control and management technologies estimated	• •Traders and development partners in the livestock value chains made aware of the potential demand of the integrated tsetse and ticks management practices	• At least one (1) working paper by mid-2022	•	•	•
Economic and nutrition effects of integrated tsetse and tick control and management technologies	• At least 3000 community members in tsetse and ticks prone	A working paper by end of 2022			

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
with emphasis on women and their children determined	areas are made aware of the economic and nutrition effects of integrated tsetse and tick control and management practices and results shared with project				

xvi. Biovision Rift-Valley Fever (RVF) research project in Garbatulla sub-county, Isiolo, Kenya

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: To assess the impact of training of the RVF implemented training on change in knowledge attitude and behavior regarding RVF among the study communities.					
Knowledge, Attitude and Practices (KAP) towards Rift Valley Fever (RVF) Disease among households assessed	• Stakeholders are aware of community KAP towards RVF	• One KAP report	• farmers	• household survey	• Farmers are willing to provide information, enabling environment
The impact of training of the RVF implemented training on change in knowledge attitude and behavior regarding RVF among the study communities assessed and documented	• Policy makers and partners have evidence on the impact of stakeholders training on their RVF knowledge and behavioural change regarding RVF	• One Report on impact of community training on behaviour towards RVF	• farmers	• household survey	• Farmers are willing to provide information, enabling environment

xvii. Alien invasive fruit flies in Southern Africa: Implementation of a sustainable IPM programme to combat their menaces

Outputs	Outcomes	Performance indictors	Data sources	Means of obtaining data	Risks and assumptions
Objective 1: Assess the socioeconomic and gender impact of the IPM interventions in the mango production and value chain;					
Understand barriers and success factors for promoting, scaling up IPM technologies and increase women's and youth participation in the mango value chain.	Stakeholders are aware of the barriers and opportunities for promoting fruit fly IPM technologies especially among women and youth mango farmers	-Data sets (qualitative and quantitative) -One PHD thesis -At least 1 report and manuscript with a gender focus	Farmers	-Focus group discussion (FDG) -Household-level baseline survey	Farmers are willing to provide information, enabling environment
Forecast the potential demand for the developed IPM technologies in the target	Market players and development partners have evidence on the expected demand for the fruit fly IPM technologies	At least 1 report and manuscript	Farmers	-Focus group discussion (FDG) -Household-level baseline survey	Farmers are willing to provide information, enabling environment
Assess the impact of IPM interventions on income, nutrition, human health and environment outcomes using gender disaggregated data	Stakeholders have evidence on the impact of using fruit fly IPM products as opposed o conventional methods	At least 1 report and manuscript	Farmers	-Focus group discussion (FDG) -Household-level baseline survey	Farmers are willing to provide information, enabling environment
Conduct cost-benefit analysis of the existing management practices and the proposed IPM technologies	Farmers, policy makers and development partners are aware of the costs and benefits of the existing fruit fly management practices and proposed IPM technologies	At least 1 report and manuscript	Farmers	-Focus group discussion (FDG) -Household-level baseline survey	Farmers are willing to provide information, enabling environment

Outputs	Outcomes	Performance indictors	Data sources	Means of obtaining data	Risks and assumptions
Activity 3.5: Assessing and promoting successful modalities to connect smallholders with value chains	Farmers, policy makers and development partners are aware of successful market linkages for smallholder farmers	Market survey dataset -At least (1) report -At least (1) manuscript	Mango value chain actors	-Market survey	Mango value chain actors are willing to provide information, enabling environment
Analysis of women's empowerment in at least one target country	Policy makers and development partners are aware Women's Empowerment in Agriculture Index (pro-WEAI) among mango growers in one of the target project countries	At least 1 report and manuscript-	Farmers	-Focus group discussion (FDG) -Household-level baseline survey	Farmers are willing to provide information, enabling environment

xviii. Partnership for skills in Applied Sciences, Engineering and Technology (PASET) Regional Scholarship and Innovation Fund (RSIF)

Outputs	Outcomes	Performance indictors	Data sources	Means of obtaining data	Risks and assumptions
Specific Objective 1: To develop the capacity for growth and management of a scholarship, research and innovation fund					
Co-organize and participate in a major conference with women scientists and those working to advance women in STEM in sub-Saharan Africa.	Increase RSIF visibility and develop social networks among gender experts and women scientists in SSA.	• Conference organization and participation.	• Project M&E report	• Conference proceeding	

Outputs	Outcomes	Performance indictors	Data sources	Means of obtaining data	Risks and assumptions
Conduct a mixed-methods gender study to understand why women have low representation in STEM fields in sub-Saharan Africa.	Enhanced knowledge of the main socio-cultural, economic, and institutional factors that explain low representation of women in STEM fields.	• Gender consultant hired. •Mixed-methods datasets collected. •A report and journal manuscript prepared.	• Routine project reports	• Review of project reports	• Willingness of respondents to participate in the survey
Develop a gender strategy to enhance women's participation in STEM PhD programs and research at African Universities.	RSIF and host institutions informed of practical strategies to enhance women's participation in RSIF PhD programs.	• Gender strategy document.	• Routine project reports	Routine project reports	
Develop a program theory of change and evaluation framework	An enhanced understanding of the project approach and how it will be evaluated for impact	• Evaluation Framework published	• RSIF project report	• Review of project report	

xix. BioInnovate Africa

Outputs	Outcomes	Performance indictors	Data sources	Means of obtaining data	Risks and assumptions
Specific Objective 1: Project monitoring and evaluation system implemented					
Develop and implement baseline and follow-up surveys for Cohort I and Cohort II consortium projects	Project effectiveness and impact captured and documented	Two surveys designed and implemented	• Routine project report	• Review of project report	• Willingness of project stakeholders to participate in the survey

xx. INSBIZ project

Outputs	Outcomes	• Performance indictors	• Data sources	• Means of obtaining data	• Risks and assumptions
Objective: Review of the State of Research and Utilization of the Long-Horned Grasshopper *Ruspolia differens* in Africa: Past, Present and the Future					
Value chain mapping and analysis of R. differens - based food supply chains using Uganda as a case study	Value Chain of Edible insects (Nsenene) from harvesters, employees, traders in Uganda assessed and documented	• Dataset from various edible insect (Nsenense) value chain actors (harvesters to employees) • At least one report • At least one peer reviewed manuscript	• Traders, farmers, and consumers	• Market survey tools	• Willingness of edible insect value chain actors to participate in the survey

xxi. NAME of Project: Core project: *icipe* technologies and gender impact and M&E strategy document

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Objective 1: Assess role of adoption of push-pull technology impact on farm- and aggregate- level impacts					
1. Evaluate effects of push-pull technology (PPT) in Kenya and Uganda	• Enhanced evidence on performance of PPT	• One paper on impacts of PPT	• Farmers and published documents	• Household survey and literature review	• Farmers are willing to participate in interview and provide information • Necessary secondary data sources available
2. Assess women's empowerment impact on individual and household nutrition	• Policy makers, researchers and development partners use research results to enhance capacity and improve gender intervention in agriculture	• Working paper on women's empowerment on nutrition	• Farmers	• Household survey	• Farmers are willing to participate in interview and provide information

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
3. Explore determinants of women's empowerment indicators	• Trade-offs and complementarities among indicators of women's empowerment determined and documented	• Working paper on women's empowerment on determinants of indicators	• Farmers	• Household surveys	• Farmers are willing to participate in interview and provide information
4. To develop a strategic plan for the social science and impact assessment unit of *icipe*	• A strategic plan for the social science and impact assessment unit developed and adapted	• Strategic plan document	• Published document		
5. Assess the impact of Push-Pull technology on household livelihoods in Rwanda	• Enhanced evidence of PPT on households	• Manuscript on the adoption and willingness to pay of PPT among smallholder maize farmers in Rwanda	• Published manuscript	• Household survey	• Farmers are willing to participate in interview and provide information
6. Assessing the impact of upscaling and institutionalizing of fruit fly IPM technology among smallholder fruit growers in East Africa (Phase V)	• Improved evidence of IPM technology use for fruit fly among smallholder fruit growers in East Africa	• Baseline and follow-up data	• Project monitoring report	• Review of project monitoring and evaluation reports	• Successful submission of baseline data

CAPACITY BUILDING AND INSTITUTIONAL DEVELOPMENT at *icipe*

a.) Overview of activities

Building human resource and institutional capacity has been an integral part of *icipe*'s mandate since its establishment more than four decades ago. Within the area of insect science, it was clear that African countries lacked the necessary critical mass of scientists and institutions with capacity to undertake the relevant R&D work to provide the needed knowledge-based solutions to the development constraints resulting from arthropod pests and vectors. Sustained capacity building effort has, therefore, been necessary to improve indigenous capability at all levels, and institutional capacity to optimally use that capability. This implied the need for sustained human resource development in areas of scientific, technical, operational and research management, backed up with overall institutional development for the productive use and expansion of that resource pool.

From its genesis as a centre of excellence in insect science specialised in tropical problems and opportunities in Africa, *icipe* made significant investments in high-level manpower training at MSc, PhD and postdoctoral levels. This was considered strategic for the growth of national and sub-regional R&D systems in Africa, which would eventually be expected to develop their own capacities to identify problems, prioritise and undertake the necessary R&D work to address them.

It was also realised that a focus on capacity development at the higher echelons of the national systems needed to be backed up with training of recipient communities to facilitate the technology adoption process. To this end, *icipe* has had a vibrant programme for on-site interactive training of end-users in specific research techniques or pest and disease vector control technologies, as well as interactive technology development and adaptation with national staff and farmers, herdsmen or public health workers at country and sub-regional levels.

The institutional and organisational capacity of *icipe*'s key collaborators was strengthened. Professional development schemes for sub-regional and national partners were set up. Regional interchanges were carried out. Efficient result-oriented management, planning and monitoring of research institutions of higher education and research training in the sub-region was established.

This was achieved by: (i) Linking research expected outcomes to development objectives already at the planning stage; (ii) building and supporting partnerships, especially at sub-regional and pan-African levels; (iii) promoting early involvement of stakeholders as well as effective collaborative agreements with the private sector; and (iv) building human and institutional capacity at both *icipe* and partners' institutions level. The final goal is to become more efficient and responsive to end-users to facilitate the technology transfer process.

The programme is structured along the following major thrusts:
Training at the postgraduate level*:* Postgraduate training, both at doctoral and masters levels, is provided through the African Regional Postgraduate Programme in Insect Science (ARPPIS), and the Dissertation Research Internship Programme (DRIP).

a) ARPPIS was established in 1983 as a partnership programme with African universities and *icipe,* to provide young African scientists with the opportunity to study and learn in Africa, the insect pests and vectors that are a threat to the health and sustenance of the African people. The network draws upon the expertise and resources of both the African universities and *icipe* and is composed of the ARPPIS Sub-Regional Masters Programme hosted by universities in three different regions in Africa (Accra, Addis Ababa and Harare) and the ARPPIS Doctoral Programme hosted at *icipe.*

- *The ARPPIS Sub-regional Masters Programme* is a 2-year master's programme undertaken at sub-regional level, hosted by selected participating universities and provides graduate research training leading to award of MSc degrees. The programme consists of one year of taught coursework followed by one year of independent research and thesis preparation.
- *The ARPPIS Regional Doctoral Programme* is a 3-year programme hosted at *icipe,* and enrols on average 7 to 8 PhD research scholars annually, who undertake thesis research in various arthropod and insect science-related topics. ARPPIS training has been a model for postgraduate education especially since most of its trainee-output has remained in Africa pursuing their careers. In 2011, the Africa Platform for Development Effectiveness (APDev) coordinated by the African Union Commission and NEPAD Agency selected ARPPIS as one of the best African case studies for South–South collaboration.

b) DRIP enables postgraduate research scholars undertaking studies in insect science from universities in both developed and developing countries to access *icipe*'s research facilities. The flexible arrangement provided through the DRIP programme allows *bona fide* university registered scholars undertaking training at both MSc and PhD levels from universities throughout the world to access *icipe*'s research facilities and benefit from in-house supervision.

Technology dissemination to NARS through group training courses mainly targeted to practitioners in the national agricultural and health research and extension systems. Appropriate mechanisms for information/dissemination strategy/technology transfer to end-users were established together with setting up coordination mechanism among main research stakeholders.

Professional development schemes promote research interaction and networking through visits and exchange programmes that provide opportunities for both young as well as established scientists, including university faculty worldwide, to share and contribute to *icipe*'s research agenda. Such professional upgrading opportunities are carried out through Postdoctoral Research Fellowships (PDF), Visiting Scientists and Research Associate schemes. Interactive on-site training assures end-user participation and ownership of the technology alternatives being made available through formal, two-way consultation and awareness-building courses, field demonstrations and open days, undertaken at regular intervals in close partnership with the communities that *icipe* works with. Through these forums, practical technological packages are disseminated.

Fostering Africa-wide cooperation and networking ensures that a pan-tropic presence of *icipe'*s work is achieved through vibrant networking and outreach programmes. Through the ARPPIS Scholars Association (ASA), the alumni foster close collaborative linkages with the Centre's research and training work, and offer mentoring for trainees-in-residence. The African Association of Insect Scientists (AAIS) provides a continental platform for exchange of information and experiences with peers working in

Africa. Both ASA and AAIS have held biennial meetings since 2003. *icipe* provided expertise and back up for the development of the ASA strategic plan in 2006. *icipe*'s Information Resource Centre has been established as an information hub for collaborating universities and institutions throughout Africa, providing access to both print and electronic content for reference purposes.

Institutional development (through nurturing and strengthening of African organisations and institutions, both formal and informal, to mainstream the technology uptake process), facilitates upscaling and outscaling, in both production and market related aspects, and is vital if research is to impact on the socio-economic development of the African people. Seven ARPPIS universities have benefited from increased online info-access through a UNESCO-supported programme negotiated by *icipe* on their behalf. The three ARPPIS MSc Sub-Regional Centres have benefitted from support for equipment such as computers and literature access.

ARPPIS scholars are encouraged to attend and participate in international conferences in Europe and the Americas. Many *icipe* scholars have published in internationally recognised and highly rated peer-reviewed journals. Training in *icipe*'s capacity building programme is complemented by collaborative arrangements with university and research institutions in Europe.

b.) Goal and Broader Objectives

The major objective of *icipe*'s Capacity Building and Institutional Development Programme is to build human resource and institutional capacity in insect science and related areas of the biosciences. The programme, complemented by collaborative arrangements with university and research institutions, is structured along the following major thrusts: (i) Training at the postgraduate level for leadership in scientific research and policy formulation; (ii) technology dissemination to NARS through group training courses, mainly targeted to practitioners in the national agricultural and health research and extension systems; (iii) professional development schemes, where PDFs, research associates and visiting scientists come to *icipe* to develop and share expertise; (iv) interactive on-site training in participation with the beneficiary communities; (v) institutional development by nurturing and strengthening of African organisations and institutions; and (vi) fostering Africa-wide cooperation and networking to ensure a continental presence of *icipe*'s work.

c.) Strategic Outlook (up to 2020)

Education, especially at the postgraduate level, where research is an integral part of the training, will continue to be an important source of generating knowledge-based solutions to address the critical constraints in national and sub-regional development, more so in the areas of agricultural productivity, human and animal health, and natural resource management. While this will be the case, there is a greater realisation that universities throughout Africa are facing severe financial problems coupled with a decline in the quality of the educational experience. Another weakness appears to be a strong gender bias in science training, with African female participation rates in the agricultural sciences in universities roughly half of those in other fields.

These findings are very true across a wide spectrum of science training within universities. In its 2004 report, the Inter-Academy Council (IAC) has noted that unless

the current crisis in capacity building in areas of science is solved, Africa's next generation of students will be caught in a downward spiral, and the 'scientific divide' between the advanced North and the lagging South, especially in Africa, will be widened further.

Recent advances in methodologies and approaches in science will be incorporated within the curriculum. For example, developments in molecular biology have resulted in a number of significant cutting-edge researches in functional genomics and biotechnology. In order not to be left behind, Africa must position itself strategically to reap the full benefits that these new technological developments may offer. A number of training institutions in Africa, particularly at the university level, still do not have the capability of teaching and supervising research in these newer advances.

As a response to these challenges, and as a major research and training organisation working in Africa, *icipe* has the responsibility of ensuring that the incoming generations of African scientists and practitioners trained at the Centre have a strong and holistic science-based training within a socio-economic background that is relevant to the needs of the society they live and work in. Hence, *icipe*'s research and capacity development need to be designed based on a holistic, interdisciplinary approach that is anchored firmly on a strong disciplinary pillar, emphasising the creation and application of knowledge, strengthening of skills and changing of mind-sets so as to empower individual researchers and institutions to initiate problem-solving research that will impact on socio-economic development.

Capacity development in many countries involves two sorts of tasks. The first is to create networks of: (i) scientific actors around research themes such as biotechnology, and (ii) rural actors around development topics such as dryland agriculture. The second is to build links between these networks so that research can effectively promote rural innovation. It is assumed that interventions linking research- and community-based capacities add value to existing investments, produce pro-poor innovation technologies, and achieve very high returns at affordable costs.

In its current vision and strategy, *icipe* interprets its mission to be more about contributing to poverty alleviation, income generation and improved human health. Two kinds of strategic investments are required for this vision to be realised. First, investing in institutional strengthening so that African countries can build their own capacity and sustain their development process. Second, investing to the benefit of local communities.

Therefore, in developing a forward perspective for *icipe*'s human and institutional capacity strengthening activities, there is a growing need to focus on enhancing the dual complementarities between formal and informal training. As a future strategy, more emphasis will be made on need-based and opportunity-based training, putting acquired skills and experience before formal training. In this regard, there is need to design and develop programmes that will address missing links from both a value chain and innovation systems perspectives. It is strategically important to see more of *icipe*'s programmes and projects emphasising assistance to other partners' institutions through training of trainers (ToT) and working with qualified institutions and NGOs in undertaking the training function, especially at the end-users level.

4. External evaluation of the capacity building programme conducted in quarter 4 of 2012

In October 2012, two independent consultants evaluated the capacity building programme and proposed a revised framework for the period 2014–2020. The evaluation concluded that not all CB&ID results are equally important and the programme should be re-designed into three result areas to improve its focus. These are:

- Result area 1: Capacity building and professional development of African scientists and professionals.
- Result area 2: Institutional development by nurturing and strengthening of African higher education institutions (including existing *icipe* sub-regional centres).
- Result area 3: Promotion of innovation on insect science in collaboration with regional and national agricultural research and advisory services and the private sector.

The consultants recommended that this new programme shall address three sets of problems as priorities: (i) continuing significant lack of highly qualified African insect scientists and professionals; (ii) widely existing insufficient capacity of African tertiary education to enable cutting-edge research and relevant education in insect science; and (iii) widespread insufficient technology dissemination fostering the rapid application of innovation, with significant consequences on the 4-Hs (human, animal, plant and environmental health) paradigm. The proposed intervention logic of the 2014–2020 CB&ID programme has taken into consideration a combination of principal elements: (i0 *icipe*'s goals and supporting strategy, and (ii) global and continental policies and programmes (such as the MDGs and NEPAD/CAADP). The total financing requirements for the implementation of the proposed programme will require funding to the tune of US$ 78 million.

icipe has continued to make a significant contribution to building a critical mass of young researchers from Africa in arthropod-related sciences at MSc, PhD and postdoctoral levels, who are also contributing to the research programmes of all four health themes at *icipe*. Between November 2014 and February 2015, *icipe* was hosting 83 young researchers at postdoctoral, PhD and MSc levels. Although 65% of all fellows are from Kenya, 21 countries (including 16 African countries) are represented. Women are well represented as 40% of all fellows are women.

icipe has trained over 700 postgraduate students over the years and we are currently reaching out to these alumni to gather data on their careers post-*icipe*. The information obtained through this benchmarking exercise will provide the input material required to undertake detailed M & E of *icipe*'s capacity building activities (2015). Early feedback has revealed that 90% of *icipe* alumni are today employed in research or associated roles across Africa.

Capacity Building and Institutional Development Results Based Management (RBM) Rolling Framework

Output	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
Objective: Increase the number of high quality researchers and middle level practitioners required to respond to arthropod-related research and development challenges in Africa by 2020.					
1. Between 2014 and 2020, 100 PhD and 150 MSc postgraduate students (33% women) from at least 18 African countries representing all sub-regions of SSA, are at icipe at various stages of postgraduate training in arthropod and related sciences.	• At least 95% of students complete postgraduate training (33% women), representing 18 African countries. • At least 75% of PhD students who complete their training each year during 2014–2020 are contributing to research, development and higher education in Africa, dealing with reducing poverty, improving food and nutritional security, improving human, animal and environmental health; and working in Universities, National Research Systems, sub-Regional Organisations (SROs), International Research Centres (IRCs), and the private sector in Africa, • At least 50% of MSc graduates trained at icipe continue a career in R&D or higher education,	• Number of PhD and MSc students in the icipe postgraduate programmes at various stages of training, and number completing training with icipe, each year during the period 2014–2020. • Number of women in the programme each year. • Number of African countries represented in the postgraduate programmes each year. • Number of scientists trained at *icipe* engaged in research, development and higher education in Africa. • Number of researchers leading research and development projects or playing a leading role in higher education in Africa. • Number of research activities/projects implemented in African institutions by scientists trained at *icipe* during 2014 and 2020.	• Icipe student database • Student annual reports • Internet • Tracer studies conducted through email • Ad-hoc interviews. • icipe Alumni Network website	• Review of icipe student database and annual reports • Surveys by internet, email, interviews • Review of icipe Alumni Network website	• Continued availability of funds for training at icipe • Continued availability of opportunities and funds at NARS, RECs, SROs, CGIAR centres and universities in Africa for R&D and higher education

Output	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
	dealing with reducing poverty, improving food and nutritional security, improving human, animal and environmental health.	• Number of graduates with positions of leadership in public & private organisations/enterprises in Africa.			
2. Dissemination of research results by postgraduate students through 400 publications of research results (including theses, book chapters, peer-reviewed papers, conference abstracts and proceedings, training brochures and manuals, policy documents, print and online media) in the period 2014-2020	Research results disseminated in relevant formats at scientific community and policy maker levels	• Number of publications that result from research conducted by students at icipe during training (theses, book chapters, peer-reviewed papers, conference abstracts and proceedings, training brochures and manuals, print and online media). • Number of students contributing to policy documents. • Quality and relevance of *icipe* led-research results shared with scientific community determined by the number of citations in peer-reviewed publications. • Number of students participating in scientific meetings/conferences	• *icipe* Information Resource Centre (IRC). • Google Scholar • SCOPUS • University information repositories • Email questionnaires • Citation indices • Trip reports	• Search databases at icipe IRC, Universities, Google Scholar, SCOPUS • Review email questionnaire responses and trip reports • Query citation indices	• Continued availability of funds for publications and to attend scientific conferences
3. Career development opportunities for at least 20 early career scientists (short-term visiting scientists and postdoctoral fellowships	• At least 75% of PDFs and visiting scientists on completion at *icipe* proceed to contribute to research, development and higher education in	• Number of postdoctoral fellows and visiting scientists trained. • Number of grants applied for and received by PDFs each year.	• Project documents, reports. • Publication databases	• Review documents, reports, databases	• Availability of continuous funding to icipe programmes to support the professional

Output	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and Assumptions
(PDFs)) implemented during the period 2014–2020	Universities, NARS, SROs, IRCs, and the private sector in Africa each year during the period 2014–2020. • At least 50% of fellows attract competitive research grants during their tenure at *icipe*	• Number of research publications in peer-reviewed journals. • Number of postdoctoral fellows trained contributing to research, development and higher education in Africa.	• icipe grant database		development programme. • Funding opportunities open to early careers researchers
4. Researchers, mid-level practitioners and extension workers (2000) from 30 national systems in Africa trained in non-degree professional development courses during the period to 2014 - 2020.	• At least 50% of trained middle-level practitioners applying their knowledge and expertise in Africa each year during the period 2014–2020.	• Number of training courses. • Number of trainees. • Number of new technologies produced and adopted. •	• Training reports • Training follow up by email	• Review reports and email follow up	Trainees respond to information requests. Institutions where trainees apply knowledge have funds to support the work.
5. Undergraduate interns (200) trained during the period 2014- 2020.	• At least 50% of trained undergraduate interns progressing to research and development careers each year during the period 2014–2020.	• Number of interns trained. • Number of internship reports.	• icipe student database. • Internship reports.	• Review database and intern reports	• Availability of continuous funding to icipe programmes to support internships
6. Research and training capacities in insect and related sciences strengthened at national and regional research and higher education institutions through the development of partnerships.	• At least 2 new research or training activities developed with partners each year during the period 2014–2020.	• Signed MoUs and collaborative agreements. • Number of exchange visits by network partners. • Number of network partners. • Number of research projects started • Number of new training programmes in national systems	• MoUs • Project reports • Mission reports • Alumni website	• Review MoUs, reports, website	• Regional cooperation. • Adequate resource mobilisation.

BIOINNOVATE AFRICA PROGRAMME PHASE II at *icipe*

Preamble

The Bioresources Innovations Network for Eastern Africa Development (BioInnovate Africa) Programme is a regional initiative established in 2010 with support from the Swedish International Development Cooperation Agency (Sida). It assists countries in eastern Africa to benefit from the revolutionary advances in biosciences, by converting biobased research ideas and technologies into innovations that improve people's lives. The Programme is managed by the International Centre of Insect Physiology and Ecology (*icipe*) based in Nairobi, Kenya, and operates in six eastern African countries, namely Burundi, Ethiopia, Kenya, Rwanda, Tanzania and Uganda.

A. Goal and Outcome

BioInnovate Africa fosters the development of an innovation-driven bioeconomy in eastern Africa—using scientific research and knowledge—to add value to renewable bioresources, thereby creating new economic opportunities and social sustainability.

The desired impact of BioInnovate Africa Programme (BAP) is improved productivity (and hence living standards) of smallholder farmers and communities in eastern Africa through value addition and agro/bioprocessing that is competitive and environmentally sustainable.

The main desired outcome of the Programme is increased capacity of scientists, researchers and innovators in eastern Africa to link innovative biobased research ideas and technologies to business and the market.

B. Overview of activities

1. Research and innovation projects

The programme supports innovative bioscience projects undertaken by scientists and innovators in universities, public research organizations and private firms in the eastern Africa region through a competitive call process. The projects supported so far are in green chemicals, post-harvest management, biowaste conversion, crop value added products, and insect proteins.

Other activities include:

a. Strengthening capacities of implementing partners through trainings, workshops and conferences.
b. Undertaking systematic programme reviews of baselines and technical evaluation of projects.
c. Conducting programme outreach and communication activities.

2. Programme Management and administration

The Programme Management Office (PMO) provides the secretariat of BioInnovate Africa and its staff actively implement programme activities. The PMO is supported by the Programme Advisory Committee (PAC) which provides strategic guidance and technical backstopping during implementation of the programme.

3. Monitoring and evaluation

The PMO guided by PAC takes the lead in performing routine monitoring and evaluation of programmatic activities. In addition, annual external financial audits are planned to be undertaken as part of the monitoring and evaluation exercise.

C. Strategic Outlook (2020)

Our strategic outlook until 2020 is to demonstrate a clear link to business and regional relevance for the innovative bio-based ideas and technologies supported through the projects. We also aim to consolidate the BioInnovate Africa network and make BioInnovate Africa the leading platform for an innovation driven bioeconomy in eastern Africa. Building partnerships and expanding our stakeholder portfolio is a key undertaking going forward.

D. Specific future thrusts

For the future, we aim to make BioInnovate Africa the bioeconomy platform for eastern Africa, actively translating innovative bio-based ideas and technologies to market and creating business opportunities for smallholder farmers and their communities through value addition, agro-processing and biowaste conversion. We also hope to strengthen the BAP model of scaling technologies and contributing to societal impact through public private partnerships and professional business incubation.

BioInnovate Africa Programme Phase II Results Based Management (RBM) Rolling Framework

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Project purpose: To enhance the capacity of Eastern African universities, research organizations to translate modern biosciences into innovations targeting smallholder farmers and agro-process enterprises in the region					
Specific Objective 1: Generate biosciences innovations that address the needs of smallholder farmers and agro-processors in the region					
1. Bioscience knowledge that addresses the needs of smallholder farmers and agro-processors developed	Enhanced capacity of Eastern African universities and research organizations to translate modern biosciences into innovations targeting smallholder farmers and agro-process enterprises in the region	- % change in no. of bioscience ideas emerging from the projects - Number of intellectual properties (including patents) acquired at different levels of processing i.e. applied for, awarded, or in gazette	- Universities, firms and research institution reports - Farmers and agro-processors	- Review of six-monthly project reports	- Innovations exhibit adequate benefits to attract the private sector - Functional innovation platforms to allow further co-creation and testing of the innovations - Adequate supply of students into bioscience programs
2. Innovative value-added goods that address the needs of smallholder farmers and agro-processors.	Enhanced capacity of Eastern African universities and research organizations to translate modern biosciences into innovations targeting smallholder farmers and agro-process enterprises in the region	- % change in no. of bioscience value-added products at different levels of development (undergoing value addition, ready for market, market tested)	Project progress report	Review of project reports	- Value-added products are socially and economically sustainable - Partners are committed to promoting the bioscience value-added products
3. Innovative value-added services that addresses the needs of smallholder farmers and agro-processors.	Enhanced capacity of Eastern African universities and research organizations to translate modern biosciences into innovations targeting	- Number of bioscience services at different levels of development (undergoing value addition, ready for market, market tested)	Project progress report	Review of project reports	- Value-added services are socially and economically sustainable - Partners are committed to promoting the

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
	smallholder farmers and agro-process enterprises in the region				bioscience value-added services
4. Bio-based business models that increase access of smallholder farmers, agro-processors and owners of agribusinesses to bioscience innovations 5.	Increased linkages between research institutions and the private sector (agribusiness firms)	- Number of validated bio-based business models	Project progress report	Review of project reports	- Business models are scalable
6. Spin-off companies developed and supported	Increased linkages between research institutions and the private sector (agribusiness firms)	- Number of company registration certificates	Project progress report	Review of project reports	- Innovations exhibit adequate benefits to attract the private sector
7. Networks and partnerships developed	Increased linkages between research institutions and the private sector (agribusiness firms)	- Number of contracts and/or agreements signed to engage with various stakeholders	Project progress report	Review of project reports	- The right partnerships and networks are established for promotion of bioscience innovations
Specific Objectives 2: Evaluate relevant policy options to support scientists in their effort to promote bioscience innovations for smallholder farmers and agro processors					
8. Relevant policy options to support scientists in their effort to promote bioscience innovations for smallholder farmers and agro processors evaluated	Improved prioritization and coordination of policy responses to promoting bioscience innovations	Number of existing strategies/policies put by government that support and promote biosciences innovations Number of existing regulations put by government that support and promote biosciences innovations	Project progress report	Review of project reports	Available technical capacity to undertake policy analysis for promoting bioscience innovations

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Specific objective 3: Establish BioInnovate as an independent legally registered a non-for-profit "Eastern Africa regional network for bioscience innovations (EARNBIN)"					
9. Bio-Innovate as an independent legally registered non-for-profit entity "Eastern Africa regional network for bioscience innovations" (EARNBIN)	Improved prioritization and coordination of policy responses to promoting bioscience innovations	- Bio Innovate legally registered as an independent not-for-profit network "Eastern Africa regional network for bioscience innovations	Bio-Innovate charter Registration certificate	Review of project reports	- Universities, research institutions and firms are willing to sign memoranda of understandings for promotion of bioscience research

PARTNERSHIP FOR SKILLS IN APPLIED SCIENCES, ENGINEERING AND TECHNOLOGY (PASET) REGIONAL SCHOLARSHIP AND INNOVATION FUND (RSIF)

Preamble

The Regional Scholarship and Innovation Fund (RSIF) is a flagship initiative of the Partnership for skills in Applied Sciences, Engineering and Technology (PASET)[2]. The RSIF aims to address fundamental gaps in skills and knowledge needed for increasing the use of science, technology and innovation for sustained economic growth in sub-Saharan Africa (SSA). RSIF will support doctoral training and post-doctoral research and innovation in selected priority sectors for economic growth and development across SSA. The RSIF priority thematic areas are: ICTs including big data and artificial intelligence; food security and agribusiness; climate change; energy including renewables; and minerals, mining and materials engineering.

The RSIF Project was approved by the World Bank in June 2018, became "effective" in September 2018 and will be implemented over a six-year period ending 30 June 2024. The Project financing includes a World Bank International Development Association (IDA) grant and support from the Government of Korea. Individual country governments may join the PASET initiative by contributing US$2 million each, which is added to the RSIF General Fund, or in some cases, to the Permanent Fund. As at beginning of 2019, the RSIF contributing countries are Côte d'Ivoire, Ethiopia, Kenya, Rwanda, and Senegal but all countries are eligible to participate in RSIF activities.

The International Centre of Insect Physiology and Ecology (*icipe*) was competitively selected to serve as the Regional Coordination Unit (RCU) for the Project in August 2018, with mandate to implement the RSIF Project on behalf of PASET

A. Goal and Outcome

The goal of RSIF is to train high quality PhD and post-doctoral fellows to address the human resource gap of highly qualified specialists in the fields of applied sciences, engineering, and technology (ASET) and contribute to improving research and innovation capacities in those fields in SSA. RSIF will support PhD students, post-doctoral scientists and universities in SSA to establish high-quality training, research and innovation environments and to develop their institutional capacity for the benefit of the whole region. The RSIF is designed to ensure long-term sustainability of funding, and to enable countries to build functional innovation ecosystems for sustainable economic growth and development.

[2] PASET was launched in 2013 by the Governments of Ethiopia, Senegal and Ivory Coast, to respond to the critical need to strengthen Africa's science and technology capability for the socio-economic development of SSA. Kenya and Rwanda later joined the partnership. Championing a regional approach which complements individual country efforts, PASET functions as a convening platform by bringing together African governments, the private sector, and new partners, such as Brazil, China, India, and Korea, to invest in Africa.

B. Overview of activities

The RSIF has two components: i) Capacity for development for the operation and management of the scholarship, research and innovation fund, which includes building of *icipe*'s capacity; and ii) Scholarships and research grants for applied sciences, engineering and technology (ASET).

Component 1: Capacity development for the operation and management of the Scholarship, Research and Innovation Fund.

This component will focus on capacity building for managing and growing the RSIF General Fund and setting up the RSIF Permanent Fund. It will also ensure that capacity is built at *icipe* for the operation and management of doctoral training scholarships in selected African universities and for designing and managing research grants in ASET fields; for improving quality of PhD programs including research in ASET fields; and for the operation and management of innovation grants.

The Permanent or Endowment Fund is expected to grow to at least US$15m by 2024 with proceeds channeled into a General Fund. A Fund Manager will professionally and independently manage this Fund. The General Fund, which is expected to grow to at least US$50m by 2024, will support PhD training, research and innovation projects annually (Component 2). The General Fund supports students and universities in SSA to establish high-quality instruction and research environment and to develop institutional capacity through the three RSIF windows in Component 2. Contributors to the RSIF may contribute to either the General Fund or the Permanent Fund, or both; they may also contribute to one or more of the grant windows and/or specify which disciplinary areas they wish to sponsor.

Component 2: Scholarships and Research Grants for ASET.

Three windows will be used to implement this Component as below.

a) Window 1: Scholarships for PhD training: The scholarships will finance 3 to 4-year PhD training programmes for citizens of SSA countries at competitively selected Host Universities in Africa. Awards include 'sandwich' training that allows students to complete part of their PhD programme at selected international partner institutions or companies. Scholars are chosen competitively with priority given to promising young African faculty without PhDs, and females.
b) Window 2: Grants for research: Grants are awarded competitively to faculty engaged in PhD training in Host Universities in SSA and to RSIF graduates who obtain a post-doctoral or permanent position in an academic institution or research centre in SSA.
c) Window 3: Innovation grants: Innovation grants are awarded competitively to RSIF scholars and faculty who submit joint innovation project proposals with private companies. Innovation grants enable faculty and researchers to collaborate with industry and translate outputs of their research into practical uses either through existing companies or by starting up new enterprises.

C. Strategic Outlook (2020)

By adopting a regional approach, the project aims to strengthen *icipe* into a regional 'capacity builder' that offers technical support for the required specialization and excellence in selected SSA universities, so that students from all SSA countries benefit from training in high quality PhD education across disciplines and contribute to the development and application of transformative technologies. The project will also develop strategies to attract more women to these fields and monitor their contribution. The Project builds on *icipe*'s experience and processes in building science capacity and innovation systems.

D. Specific future thrusts

RSIF will contribute to build SSA`s capacity to enhance its scientific and technologically skilled workforce in ASET fields that can catalyze the generation and application of transformative technologies for economic growth in SSA. A regional approach addresses fundamental diseconomies of scale, as a critical minimum size is required for creating impact and to improve efficiency through lower administration costs. Furthermore, a regional platform brings together scarce organizational capital to attract and manage funding in an efficient manner from diverse partners who may wish to contribute to different windows or areas. The pan-African fund will complement the efforts of national research funds to build research and innovation capacity, creating a fertile environment for innovations and transformative technologies, and facilitate partnerships with industry and international partner universities. The aim is to develop sustainable education, research, and innovation eco-system to train students to be problem solvers for their own countries using their scientific and technical skills. It is expected that other SSA countries will join the initiative.

Partnership for skills in Applied Sciences, Engineering and Technology (PASET) Regional Scholarship and Innovation Fund (RSIF) Results Based Management (RBM) Rolling Framework

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
Overall Objective: To strengthen the institutional capacity for quality and sustainable doctoral training, research and innovation in transformative technologies in Sub-Saharan Africa (SSA)					
Specific Objective 1: To develop the capacity for growth and management of a scholarship, research and innovation fund					
Endowment Fund established with contributions from SSA governments, private sector, donors	Growth in endowment fund for sustained financing of scientific and technical talent development in Africa	• Permanent fund established by end 2020	Legal documents and other relevant governance documents and investment policy documents Annual financial statement of the permanent fund Annual financial statement of the general fund	RCU collects necessary legal and operational documents from those who will register the fund RCU retrieves the annual financial statement of the general fund and permanent fund from the bank account and compile as a report	• African governments and private sector are committed to making priority investments in PhD training and research development • RCU adheres to the World Bank procurement regulations • The World Bank provides the handholding for complex consultancies • Careful consideration of legal and financial complexities in design of endowment fund. • Permanent Fund manager to guard against poor investment performance • Effective coordination at various level of implementation
Capacity for operation and management of doctoral training scholarships and research grants built	Increased capacity to operate and manage doctoral training scholarships and research grants	• PhD administration unit established by 2019 • Research and Innovation grants administration unit established by 2019.	PhD scholarship and research grants operational manual, presence of necessary staff, functional office	RCU collects all data described in the data source and compile it as a report	• The doctoral training and scholarship program is built on the experience from similar programs at RCU and other programs

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
			and availability of bank account for grant disbursement		
Increased capacity of RSIF African host universities for improved quality of doctoral programs and research in ASET	Quality of doctoral programs and research in ASET enhanced at RSIF African Host Universities	• At least 10 agreements signed with RSIF African host universitiesby 2023 • At least 10 RSIF African host universities with an online application system in place by 2023 • At least 10 RSIF African host universities that start international accreditation process for the PhD programmes by 2023 • 10 cross-cutting training courses/workshops held for RSIF scholars and researchers by 2023	Signed agreements between RSIF African host universities and regional coordination unit Online application system Contracts signed with the accreditation agency and self-evaluation report of the RSIF African host university Course or workshop catalogue and syllabus	RCU compiles all signed agreements with host institutions and compiles a report RCU receives the report generated from online application system for each RSIF host institution RCU asks RSIF host universities to report on the status of the international accreditation process and submit supporting documents RCU compiles all available courses and workshops into a report RSIF universities report to the RCU	• RSIF African host universities are willing and ready to adopt RSIF changes and policies recommended for improving doctoral training

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
		10 implemented networks between RSIF African host universities and RSIF international partners for PhD training and research collaboration	Signed agreements with partners	with signed agreements RCU will compile the journal or database subscription confirmation in a report	
Capacity for the operation and management of innovation grants built	Improved research and innovation capacity in ASET including transformative technologies in SSA Increase in productivity More industry university partnerships More patents filed More enterprises developed More employment opportunities created	• Innovation grants unit established by 2020 • 10 firms co-finance innovations grants by 2023 • 6 innovations grants awarded to RSIF African host universities by 2023 • 5 innovation grants awarded to faculty at RSIF African Host Universities by 2023	Operational manual for innovation grant administration, staff for innovation grant, adequately equipped office for innovations grants administrator, available bank account for disbursing innovation grant Signed agreements on co-financing by the private sector Financial statement that shows the disbursement of innovation grant to RSIF host institutions and the recipients' documented acknowledgement	RCU collects all information in the data source and compile a report RSIF host universities report to the RCU with signed agreements RSIF Innovations Grants Administration Unit collects the necessary documentation including financial statements, acknowledgement from recipients and other supporting	• Host universities are willing to participate in the innovation grant scheme • Private sector partners are willing to collaborate and co-finance innovative projects with Host universities • Innovation projects are successfully transitioned into established enterprises

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
				documents and compile the data as a report	
Specific Objectives 2: To establish scholarships, research and innovation grants for ASET					
More female participants in RSIF	Increased stock of female (and male) scientists in the ASET	• At least 82 (26 female and 56 male) RSIF scholars graduate from PhD programs by 2023	RSIF host universities who track the progress of scholars	RCU collects data from RSIF host institution	• Selected host universities have the enough staff to teach ASET courses • Selected PhD grantees are committed to completing the PhD programs • Host universities are willing to implement strategies to attract and retain more women doctoral scholars and researchers
Increase in quality of research publications on ASET in Africa	Quality of doctoral programs and research in ASET including transformative technologies enhanced at Host Universities	• At least 20,000 scientific and technological journals and databases that can be accessed by RSIF scholars and researchers by 2023 • At least 35 research papers submitted by staff members or scholars supported by the project for publication to internationally indexed journals by 2023 (of which at least 10 by female authors or co-authors) • At least 10 implemented networks between host universities and international	Journal or database subscription confirmation RSIF host universities who track the submission of research papers by RSIF scholars and faculties Financial statement that shows the disbursement of	RSIF host universities report to the RCU with supporting documents RSIF Innovations Grants Administration Unit collects the necessary documentation including financial statements, acknowledgement from recipients and other supporting	• Host institutions have the capacity to effectively manage the research grants • Research grant projects use transformative technologies

Outputs	Outcome	Performance Indicators	Data Source	Means of obtaining data	Risks and assumptions
		partners for PhD training and research collaboration by 2023 • At least 120 student/staff that take cross-cutting courses, entrepreneurship and / or research commercialization courses supported by the project by 2023 • At least 10 grants awarded to faculty of RSIF host institutions by 2023 • At least 16 research grants awarded to RSIF scholars by 2023	research grant to faculty and the recipients' documented acknowledgement Online course system and trainers Financial statement that shows the disbursement of research grant to scholars and the recipients' acknowledgment	documents and compile the data as a report RCU collects the necessary data from online course system and trainers directly RSIF PhD and research Grants Administration Unit collects the necessary documentation including financial statements, acknowledgement from recipients and other supporting documents and compile the data as a report	

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