2016 *icipe* CORE ANNUAL REPORT

BASED ON
RESULTS BASED MANAGEMENT REPORTING

15th May 2017

International Centre of Insect Physiology and Ecology

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icipe
African Insect Science for Food and Health

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TABLE OF CONTENTS

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Section 1: Introduction

icipe Brief Background

Established in 1970, the International Centre of Insect Physiology and Ecology (*icipe*) (www.icipe.org) is a pan-African, non-governmental and non-profit Centre of Excellence for research, development and capacity building in insect science and its application. It is headquartered in Nairobi, Kenya with over 500 scientific and support staff. The Centre works on a 4-H (Health) paradigm, including human, animal, plant and environmental health, with arthropods as the common denominator to help alleviate poverty, and ensure food and nutritional security for smallholders in Africa. *icipe* focuses on green and sustainable pest control and is presently engaged in over 35 African countries, and has thriving partnerships and excellent networks with many universities and research organisations in Europe and North America.

Founded by a renowned Kenyan entomologist, Prof. Thomas Risley Odhiambo, the Centre's mandate is to research and develop alternative and environmentally friendly pest and vector management strategies that are effective, selective, non-polluting, non-resistance inducing, and are affordable to resource-limited rural and urban communities.

The Centre has outstanding research facilities including Food and Agriculture Organisation of the United Nations (FAO) accredited quarantine facilities as well as a Good Manufacturing Practices (GMP)-compliant enhanced Biosafety level 2/3 laboratory (the Martin Lüscher Emerging Infectious Diseases Laboratory), insectaries, and a state of the art African Reference Laboratory for Bee Health, which addresses the increasing need for preparedness and response to emerging animal and human diseases in the region.

Additionally, *icipe* is a founding member of the Association of International Research and Development Centers for Agriculture (AIRCA), a nine-member alliance that was established in 2012, which is focused on improving global food security by supporting smallholder agriculture within healthy, sustainable and climate-smart landscapes (www.airca.org), and is hosted on its Duduville Campus. *icipe* is a designated FAO Reference Centre for vectors and vector-borne animal diseases, which include tsetse flies and animal trypanosomosis as well as arthropod-transmitted viral animal pathogens. Since 2010, *icipe* is a UNEP Stockholm Convention Regional Centre on Persistent Organic Pollutants (POPs). The Stockholm Convention is a United Nations international environmental treaty that aims to protect people, animals and the environment from chemicals. 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 the private sector and non-governmental organisations.

icipe Centre-wide programmes

Overall objective of the Human Health Theme: 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.

Overall objective of the Animal Health Theme: Contribute to the improvement of livestock health and productivity through the development of integrated strategies and tools for livestock disease vectors' control and adoption by development partners, thus leading to greater availability of meat and milk, hides and draught power and thereby assisting livestock owners to get out of the poverty trap.

Overall objective of the Plant Health Theme: Contribute to stabilising horticultural and staple food production by reducing quantitative and qualitative pre- and post-harvest yield losses due to insect pests, mites, weeds and mycotoxin-producing fungi by developing economically viable and ecologically sound production systems with low pesticide input.

Overall objective of the Environmental Health Theme: Conservation and sustainable utilisation of the agricultural production base and important natural ecosystems, by encouraging and utilising arthropod diversity, cataloguing and sharing biodiversity data, and discovering endemic wealth by bioprospecting for useful natural products.

Overall objective of Capacity Building and Institutional Development: To develop well-trained and highly motivated human capacity, and strengthen institutional and policy making capacity and capability required to respond to the arthropod-related development challenges in Africa.

Brief on *icipe*'s Results Based Management Framework

The *icipe* journey towards Results Based Management (RBM) started in early 2010, when *icipe*'s Governing Council (GC) and Management, in consultation with its core donors, agreed to develop a RBM framework to support the Centre's Strategic Priorities, Policies and Guidelines for insect science research and development. Prior to the implementation of the RBM, *icipe* used the Medium Term Plan as a reporting framework but like many other international organisations, it introduced RBM in early 2011 as its new strategic planning and management tool. Since 2012, *icipe* instituted the RBM as an operational framework that explicitly links the strategic objectives and priorities of the Centre to the various programmes and projects that it finances that collectively helps towards achieving its goals and objectives.

The RBM is useful for *icipe* in promoting efficient management techniques. The systematic approach of gathering and assessing progress of results that is measured against key objectives is a cost-effective way to diagnose early weaknesses in implementation plans. Periodic and targeted information are useful for the GC and *icipe* Management to recognise activities that generate the highest pay-offs in terms of results, or those that require support to deliver results that are aligned with strategic priorities. Using this approach, the Centre is able to track and measure progress towards objectives, and thus reach targeted decisions to improve performance on a progressive basis. Process monitoring is a critical part of the exercise to monitor whether portfolios are being implemented as intended, standards are being met, and resources are being used efficiently.

Each of *icipe's* core activity area has specific RBM framework. All projects activities go through a cycle of knowledge management and continuous learning. The Thematic Programmes and Capacity Building frameworks covers 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 programmatic and project design, and lessons learnt periodically feeds 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 has helped to increasingly expand the knowledge of each operations through learning, knowledge dissemination and feedback for decision making, project design and strategy development.

RBM is indeed a strategic management approach that ensures *icipe*'s R&D activities are implemented in collaboration with our partners to contribute to a logical chain of results that provide knowledge-based solutions aimed at equipping the communities in Africa to survive and live within a rapidly changing global environment.

In 2016, the Centre, achieved great milestones in its R&D activities as captured in the following tabular framework reports for each of the focal areas at *icipe.* During the reporting period January – December 2016, *icipe* published a total of 143 peer reviewed journal articles; another 17 were in press and three (3) books and book chapters (see annex 1).

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Section 2: Programmatic Results Based Management Reporting For 2016

1. Plant Health Results Based Management Report

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
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.				
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.				
Progress toward achieving <u>specific-objective</u> observed: Develop and implement a sustainable and eco-friendly approach for reduction of tomato losses due to T. *absoluta* infestation				
Distribution, abundance, dynamics and host plants of *T. absoluta* and their associated natural enemies established.	• The abundance, distribution and pest status established in the major tomato growing regions of the two target countries (Sudan and Tunisia) by end of 2015. • Wild and cultivated host plants of *T. absoluta* catalogued and distribution maps developed by end of 2016. • The origin and invasion pathways of *T. absoluta* established by 2016. • Colony of *T. absoluta* and at least one indigenous natural enemy species established in target countries by end of 2014.	• Percentage abundance, distribution, pest status and inventory of the host plants of *T. absoluta* established. • Number of modelling and distribution maps of the pest at country and regional levels made available. • Types of specific markers developed, and origin and invasion pathways established. • Number of vibrant colonies of *T. absoluta* and indigenous natural enemy species established.	• Study on abundance *T. absoluta* was conducted in Tunisia, Sudan, Kenya and Uganda, the result of which indicated that the pest is well established in all agro-ecological zones of these countries with up to 300 moth/trap per day. In addition to tomato several host plants belonging to different plant family such as Fabaceae and Leguminaceae have been reported. • Maps for potential invasion by and establishment of *T. absoluta* have been generated using different models, and the outcome of the same has been published in peer reviewed journal (Tonnang, et al (2015) PLoS ONE 10(8): e0135283. doi:10.1371/journal. pone.0135283. Guimapi, Ritter YA, et al. (2017) Ecological Complexity 28 (2016): 77-93E)	Captured in the publications: Tonnang, et al (2015) PLoS ONE 10(8): e0135283. doi:10.1371/journal. pone.0135283. Guimapi, Ritter YA, et al. (2017) *Ecological Complexity* 28 (2016): 77-93E.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			• COI barcode region was used to identify the pest within the target countries and beyond. The invasion pathway has been established using already developed microsatellite markers. • *Tuta absoluta* colonies have been established in the target countries of Tunisia, Sudan as well as at icipe Quarantine and Bio-containment Units at Nairobi, Kenya. • Vibrant colonies of two indigenous parasitoid species (yet to be identified to the species level) have been established in Sudan and tested for their efficacy against *T. absoluta*, with promising results by one species (up 60% parasitism) • A colony of the predator, *Nesidiocoris tenuis* was established.	
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 2015.	• 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.	• An efficient co-evolved parasitoid species *Dolichogenidea gelechiidivoris*, was introduced in 2016 from Peru into Kenya for testing and subsequent release against *T. absoluta* in Africa.	Regulatory related producers in getting export permit from Peru for introduction in to Kenya led to delay of the importation of the parasitoid into Africa.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
New technologies and already existing management tools suitable for use by small- and medium-scale tomato growers for controlling *T. absoluta* identified, tested and implemented.	• At least one new technology for *T. absoluta* suppression identified and integrated with the already existing technologies for management of the pest in one location of each target country by end 2015. • One attract-and-kill strategy developed and tested in Peru by end of 2014. • One companion crop to be used within the framework of habitat management for *T. absoluta* suppression identified and tested widely by end of 2015. • At least one virulent isolate/strain of an entomopathogen (fungi or virus) identified and field-tested by end of 2015, and discussion initiated with private partner(s) for its commercialisation by same date.	• Number of new technologies for *T. absoluta* management identified and implemented by end of 2015. • At least one attract-and-kill strategy developed and tested in Peru by end of 2014. • Types of companion crops suitable for management of *T. absoluta* identified and tested. • Types of virulent isolate/strain of an entomopathogens (fungi or virus) identified, and field-tested. • Agreement with private sector companies for commercialisation of the natural product initiated.	• Four new management technologies against *Tuta absoluta* have been identified. • One “attract and kill” product for *T. absoluta* suppression have been developed and tested both under laboratory and field conditions. • Coriander (*Coriandrum sativum*) have been identified as a potential companion crop for management of *T. absoluta* • Two entomopathogenic fungus isolates (ICIPE 18 and 20) and one Baculovirus strains (Tut 1.11) has been identified as promising candidates against *T. absoluta*. • Discussion with Private Sector partners is underway for possible commercialization of one of the fungal isolates	
Countrywide surveillance for *T. absoluta* in the high risk countries of Kenya, Republic of South Sudan and Uganda, initiated and sustained.	• Informed knowledge on occurrence of *T. absoluta* in high-risk countries of Kenya, Republic of South Sudan and Uganda established by end of 2014.	• Status of *T. absoluta* in high-risk countries of Kenya, Republic of South Sudan and Uganda documented.	• *Tuta absoluta* have been detected in Kenya, Republic of South Sudan and Uganda and currently the pest is wildly spread and well established in these countries	

Outputs Expected as per RBM framework plan	***Expected Outcomes as per RBM framework plan***	***Performance Indicator of Outcome as per RBM framework plan***	***2016 Progress Observed in Obtaining Outcomes***	***2016 Lessons Learned***
Technology transfer and training programmes initiated and implemented with stakeholders.	• At least 10 NARS in each of the target countries get acquainted with *T. absoluta* monitoring and management by mid 2015. • At least 100 growers become knowledgeable on *T. absoluta* IPM by mid 2015. • At least 3 PhD and 3 MSc students trained on *T. absoluta* IPM by 2015.	• Number of training-of-trainers (ToTs) workshops and farmer field days conducted. • Number of NARS trained • Number of growers exposed to, *T. absoluta* IPM • Number of training materials on *T. absoluta* monitoring and management developed, and distributed • Number of PhD and MSc students trained on *T. absoluta* IPM.	• A total of 6 ToTs workshops and farmer field days (3 in Sudan, 2 in Kenya and one in Uganda) were conducted. • Total number of 204 extension and quarantine officer on various aspect on *T. absoluta* management while the total number of 1107 were exposed to T. absoluta IPM. • A fact sheet and flier on *T. absoluta* management was developed and distributed to the beneficiaries in the target countries. • Four Ph.D students have been trained on various aspect of *T. absoluta* management.	
Specific objective: Development of sustainable management strategies for insect vectors of maize lethal necrosis disease (MLND) in East Africa by 2018				
Progress toward achieving <u>specific-objective</u> observed: Potent isolates of endophytes which could form part of an Integrated virus vector management strategy identified. Better understanding on the interaction between the virus – host plant – vector achieved which could be useful in management of MLN vectors.				
To identify and understand ecology of potential vectors responsible for transmission and spread of viruses causing MLN in East Africa.	• 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.	• Three endophyte isolates, *Trichoderma harzianum* (F2L4), *Trichoderma atroviridae* (F5S21) and *Hypocrea lixii* (F3ST1) were found to colonize maize plants at different phenological stages • Inoculation of maize plants with *T. harzianum* and *M. anisopliae* reduced SCMV severity by up to 1.4 folds, and its titer levels up to 2.7 folds compared to the controls. • Studies on interactions between SCMV and MCMV revealed that synergistic	Studies on field evaluation of vector management strategies could not be accomplished as funding from both CIMMYT and KALRO-KAPAP were not continuous
To develop novel, effective and sustainable seed treatment strategies for the management of MLN.				

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
To develop innovative and effective crop diversification strategies that influence both vector ecology and virus epidemiology.		• 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. • Impact of crop rotations on vector population and thereby the MLN identified by December 2015.	increase in MCMV titers was not influenced by concentration of SCMV • Significant differences in both qualitative and quantitative volatile organic compounds (VOC) profile of either SCMV-, MCMV- or co-inoculated maize plants • MCMV infection induces release of large amounts of VOCs and *F. williamsi* and *T. tabaci* are attracted to these VOCs • 2 MSc studies accomplished	
Specific Objective: Develop and implement integrated pest management strategies for production of important indigenous vegetables in Kenya and Tanzania by 2016				
Biology and ecology of major arthropod and nematode pests of amaranth, leafy cowpea and nightshades determined. Effective management tools for target pests on amaranth, leafy cowpea and nightshade developed and implemented. Available germplasms of amaranth varieties screened to identify	• 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 2015. • Variation in pheromone binding protein (PBP) and odorant binding protein (OBP) characterised in at least one AIV insect pest by 2015.	• The 2nd, 3rd and 4th seasons of population dynamic studies on amaranth pests and natural enemies were carried out in 2016. • An outbreak of *Spoladea recurvalis* was recorded from November to December 2016. • *Spodoptera littoralis* and *S. exigua* were recorded through the year but in low numbers and causing negligible damages. • In nightshade 3rd and 4th season population dynamic studies were carried out • *Aphis gossypii* was the most abundant and damaging pest on nightshade at high and mid altitude	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
source of resistance against key pests.		• The role of indigenous natural enemies against at least one AIV insect pest determined by 2015. • 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 2017. • The effect of nematophagous fungi, agro-industrial waste and intercropping on the management of at least one nematode species assessed on nightshade by 2017. • Amaranth germplasm and commercial lines assessed against at least one major amaranth insect pest by 2015.	• Nightshade was also attacked by NVMV (Nightshade Veinal Mottle Virus). The virus was also found on *Nicandra* sp. A weed commonly found around AIV fields. • The virus is not seed transmitted by *A. gossypii*. • A total of 9 populations of *S. recurvalis* were collected from Kenya and Tanzania for molecular characterization and comparison with Asian populations • Root knot nematodes (RKNs) were the key plant parasitic nematodes causing damage on African nightshades in the three seasons monitored in 2016. • Using the *de novo* transcriptome sequence assemblies of *S. recurvalis*, the full length sequences of pheromone biosynthesis activating neuropeptide (PBAN) was obtained. • The full length PBAN gene is composed of 4,295 nucleotides, and the consensus sequences for splicing junction are organized into 5'-GT-AG-3' rule exclusively. The PBAN gene is comprised of 6 exons interspersed by 5 introns. • *Apanteles hemara* caused up 50% parasitism rates on *S. recurvalis* under field conditions in Kenya. • Host acceptability and suitability studies of the parasitoid *Atropha tricolor* on its host *S. recurvalis* resulted in 30% successful oviposition and 2.81 oviposition attempts per female in 2hrs.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			• *Charop ater* caused 11% parasitism rate under field condition on *S. littoralis*. • *C. ater* displayed 70% successful oviposition, and 20.2 oviposition attempts per female on *S. littoralis* in the lab. • The new species of *Cotesia* found on *S. littoralis* and *S. exigua* caused up to 11% parasitism on *S. littoralis* in the field. • In the laboratory, *Cotesia* new sp., displayed high potentials against *S. littoralis*, with 95% of successful oviposition, and 28.6 oviposition attempts per female. • *Amaranthus dubius* reduced *Meloidogyne* spp. by 90% indicating nematode control in nightshade fields through intercropping or rotation with *A. dubius.* • *Solanum scabrum* reduced 80% of the potato cyst nematodes *Globodera* spp. in 12 weeks. Intercropping and rotation of S. scabrum with potato can therefore contribute to manage the nematode. • A total of 235 amaranth accessions were screened for their resistance against *S. recurvalis*, with 10 highly resistant and 16 resistant accessions identified	
Socio-economic constraints and opportunities for value addition of amaranth, leafy cowpea and nightshades production and protection assessed.	Develop baseline of knowledge, attitudes and practices (KAP) related to AIVs, constraints and opportunities for AIVs' production	• Baseline information on current growers' knowledge, attitude and practices (KAP) with regard to IPM and other AIVs production measures collected	• Two MSc. students graduated and produced the following papers: a) A comparative analysis of Economic returns from African Indigenous Vegetables (AIVs) in semi-arid and non-arid rural areas of Kenya	The KAP analysis show that the current level of knowledge, attitudes and practices on AIVs is not sufficient to stimulate its production

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
Capacity building and technology transfer initiated with national agricultural research partners and growers		• Constraints and opportunities for AIVs' production and marketing evaluated by 2016.	b) Farmer's knowledge, Attitude, and practices towards African Indigenous Vegetables in Kenya • The first paper (a) presented at an international conference. • Second paper (b) under review for publication. • 6 PhD students conducted their research in the project in 2016 • 3 papers published in peer reviewed journals	Lack of farm inputs and pests and diseases were identified as the major AIVs' production constraint Lessons published in: Chitambo et al. (2016), Plant Disease 100: 1954 Azandeme-Hounmalon et al. (2016), *Journal of Pest Science* 89, 137–152 Mweke et al. (2016) *African Journal of Horticultural Science* 9, 14–31 Mureithi et al. (in press) African Journal of Horticultural science (in press)
Specific Objective: Dissemination and Promotion of Mango Fruit Fly Integrated Pest Management (IPM) technologies by 2018				
Progress toward achieving specific-objective observed: Improved fruit fly management by smallholder growers in Kenya and Ethiopia				
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	• At least 5 partnerships established with national institutions and research partners relevant for implementation of fruit fly activities.	• A new agreement was signed with Hawassa University in Ethiopia. Support to the establishment of the bait production facility that is being established at the Kenya Biologics Ltd	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	implementation of the 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%.	site at Makuyu. The facility was launched on 29 March 2017 • Fruit infestation by fruit flies was 40.7% at Kitui, 17.5% at Machakos and 17.8% at Makueni. In relation to abundance, *B. dorsalis* comprised 92.7%, 90.6% and 91.2% of the flies recovered from mango from Kitui, Machakos and Makueni, respectively. *Ceratitis cosyra* comprised 7.3%, 9.4% and 8.8% of the flies recovered from mango at Kitui, Machakos and Makueni. • Trials on the efficacy of a *icipe* developed food attractant from waste brewer's yeast (Fruitfly Mania™) showed that Torula yeast and Fruitfly Mania™ were the most effective attractants capturing between 2.4-2.6 times more females and 3.4-4.0 times more males, respectively than commercially available products such as Ceratrap® • MET 69 treatment reduced *B. dorsalis* catches relative to the control by 75.2% within 4 weeks and 92.8% within 8 weeks. At harvest, the proportion of fruit infested was significantly lower in treated orchards (5.2%) compared to control orchards (52.8%). Mango yield was significantly higher in orchards assigned to biopesticide (10,652 kg ha^{-1}) compared to control orchards (3,293 kg ha^{-1}) • 1473 farms were mapped in preparation for community-based dissemination and	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			promotion of the fruit fly IPM technologies (Kitui 274), (Machakos 621) and (Makueni 578). Todate the total number of mango growers *icipe* is working with in the IBCARP programme in Kenya are 3797. From the mapping exercise in Ethiopia, 4778 growers were also mapped in preparation for dissemination of the fruit fly IPM technology	
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 native and exotic natural enemies, pest and selected host fruits. • Large-scale augmentative releases of *F. arisanus* and *D. longicaudata*. • Follow-up on establishment, colonization/dispersal of released parasitoid species and assessment of their impact on invasive fruit fly populations on cultivated and wild host-plants.	• 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. • 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 two 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	• Colonies of the two introduced fruit fly parasitoids (*Fopius arisanus* and *D. longicaudata*) are being boosted at the insect rearing facility at *icipe* Duduville campus to the level of 3,000 wasps of *F. arisanus* per week and 2,000 wasp of *D. longicaudata* per week for mass releases in Kenya and Ethiopia. • A successful parasitoid release was done in December 2016. Over 5,000 *F. arisanus* wasps were released at Wanzauni-Kakima IPM learning site at Makueni County	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
		and one wild fruit type in at least two project action sites.		
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 optimization of host 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 post harvest treatment based on hot water treatment of mango against fruit flies.	• 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 optimized for fruit fly monitoring and suppression in at least two project action sites. • At least one host marking pheromone field tested and optimized 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 characterized in at least one fruit fly species; Defensive interactions between facultative endosymbionts and the most potent fruit fly biopesticide established. • Post harvest treatments based on hot water treatment established for at least three mango export cultivars.	• The response of olfactory sensory neurons (OSNs) of B. dorsalis, *C. capitata*, *C. rosa* and *C. cosyra* to 14 candidate attractants was determined from host fruits in single sensillum recordings (SSR). A number of compounds from this work were identified for use to improve the efficacy of existing attractants as follows: ethyl acetate, 1-octen-3-ol, methyl octanoate and ethyl octanoate for *B. dorsalis*; ethyl hexanoate, ethyl crotonate and ethyl tiglate for *C. capitata*; beta-myrcene, 1-octen-3-ol, methyl octanoate and ethyl octanoate for *C. rosa*; alpha-pinene, ethyl hexanoate, 3-methyl-1-butanol, ethyl butyrate, ethyl crotonoate and methyl octanoate for *C. cosyra*. These compounds will be tested for their potential in fruit fly management • The host marking pheromones of *C. cosyra*, *C. rosa* and *C. fasciventris* have been identified. The host marking pheromone of *C. cosyra* is a tripeptide, while *C. rosa* and *C. fasciventris* share an identical pheromone identified as an amino acid. Laboratory-based assays have confirmed the broader spectrum efficacy of the host marking pheromone of *C. cosyra* in deterring itself and the	

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			heterospecifics *C. rosa* and *C. fasciventris* • *Wolbachia* was found to be the most abundant endosymbiont species infecting *B. dorsalis*. Another bacterial endosymbiont, *Spiroplasma*, was also detected in some field samples of *B. dorsalis*. This is a first report of this endosymiont in *B.dorsalis*. The detected *Spiroplasma* was characterized as similar to *S.ixodetis*, a major endosymbiont of *Ixodes pacificus* ticks. Screening is ongoing to determine the prevalence of this endosymbiont in local populations of this fruit fly. Knowledge of endosymbionts will inform the field application of biological control agents against *B. dorsalis*. • Infested mangoes of "Apple" variety harbouring the different immature life stages of *B. dorsalis* were subjected to hot water treatment of 46.1°C. Immersion time of 84.47 minutes (95% CL 75.77-87.18) was the time required to achieve the Probit-9 requirement of 99.9968% mortality (i.e. 3 survivors in 100,000 individuals). In validation trials, there were no survivors from 44,651 third instar larvae exposed at 46.1°C for 68 minutes	
Specific Objective: Dissemination and Promotion of Mango Fruit Fly Integrated Pest Management (IPM) technologies by 2018				
Socio-economic impact of the introduced fruit fly IPM and classical biological	• Develop baseline of knowledge, attitudes and practices (KAP) related to	• Baseline on KAP related to mango production and IPM technologies	• Baseline data collected from 370 mango growing households in Arbaminch,	Baseline study in Ethiopia show fruit fly is the most important pest

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
control technologies assessed.	mango production and IPM technologies using complementary methods including focus group discussions and household surveys with data disaggregated by sex and age. • Undertake an ex-ante impact assessment to assess economic impact of IPM implementation. • Conduct a follow-up expost impact assessment of IPM up scaling on smallholder farms with data disaggregated by sex and age	developed in at least two project action sites. • At least one ex-ante study undertaken 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.	Ethiopia and 300 mango growers in Makueni county, Kenya • One *ex-ante* study on mango IPM research and outreach in Kenya based on expert opinions completed, and paper submitted for peer review • Data collected from 400 mango growers in Meru, Embu and Machakos, Kenya for an *ex-post* impact assessment of mango IPM packages	contributing about 28% of total fruit loss The ex-ante analysis of the economic and poverty impacts of fruit fly IPM research revealed that the strategy can derive economic surplus benefits of about $19 million, which would lift about 1.7million poor people out of poverty over the period 2007-2030
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 pre-harvest management packages. • Conduct Farmers' Field School (FFS)/IPM technology learning hands-on training. • Carry out public awareness to facilitate large-scale adoption. • Advanced level training.	• 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 pre-harvest 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	• 8 partners from Machakos, Kitui and Makueni were trained by *icipe* on various aspects of fruit fly taxonomy, monitoring and management. Todate a total of 14 partners have received training as Trainers of trainers. • Through mass campaigns, sensitization and trainings on fruit fly IPM, 34 farmers' groups comprising 852 males and 614 females were reached in Makueni, Machakos and Kitui. Fourteen (14) field days were also held at the programme action sites where 874 males and 733 females participated and received basic knowledge on fruit fly IPM. A partners'	

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		least 6 farmers' field days conducted in the project action sites. • At least 60,000 fruit flies 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 sites; 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.	linkage meeting was also held for all stakeholder involved in fruit fly IPM and attended by 40 participants (29 males and 6 females). • The Fruitfly team distributed more fruit fly IPM starter materials to enhance technology uptake. These included 637 traps, 1440 ME blocks, 20 pieces of 200ml bottles of biopesticide and 40 Augmentorium in Kenya and 2500 traps and 5000 ME blocks to Ethiopia. Additionally, 12 IPM learning sites in Makueni, 12 in Machakos and 16 in Kitui were fully established and labelled.	
Specific Objective: Fruit fly IPM technology up-scaling and dissemination among smallholder fruit growers in East Africa by 2018				
Progress toward achieving specific-objective observed: Fruit fly IPM technology up-scaled and disseminated among smallholder fruit growers in Kenya and Ethiopia				
To conduct baseline assessment of fruit flies composition and damage caused by different fruit fly species on mangoes in the new project action sites in Kenya and Ethiopia.	• Carry out regular and systematic fruit sampling of mango in the target locations to ascertain the damage, abundance, and fruit fly composition in the two countries. • Catalogue and establish the host range of major fruit infesting fruit flies in the locations.	• The direct damage caused by fruit infesting Tephritids on mango and other key fruits and vegetables in Kenya (Meru, Tharaka Nithi and Kitui) and Ethiopia (Arba Minch) quantified by December 2016. • Host plant range of fruit infesting fruit flies established by December 2017. • The population dynamics of fruit infesting fruit flies established in the target locations by December 2017.	• Fruit fly damage levels on mango in Kitui, Meru and Tharaka Nithi were assessed and the infestation levels were at 40.7%, 65.5% and 35.9%, respectively. In all the benchmark sites *Bactrocera dorsalis* was the most dominant species followed by *Ceratitis cosyra* on mango. In Kitui, the abundance of *B. dorsalis* was 92.70% and *C. cosyra* 7.30%, while in Meru *B. dorsalis* was 80.78% and *C. cosyra* 19.22%. In Tharaka Nithi the trend was the same, with *B. dorsalis* being most dominant with 72.5% abundance and *C.*	The dominant fruit fly species in the project benchmark sites is *Bactrocera dorsalis.*

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	• Establish the seasonality of the major mango infesting fruit flies in the target locations.		*cosyra* 27.5% of fruit flies recovered from incubated host fruits collected from this locality. • In Tharaka Nithi, mango, water melon and butternuts have been established as the major hosts of key fruit fly species. Additional surveys are ongoing to establish the host range of major fruit fly species. • Preliminary results from fruit flies monitoring data showed that fruit fly population increase gradually as the fruits increase in size, at maturity and ripening stage of the fruits (peak harvesting period), the population builds up rapidly with high levels of infestations and significant yield loss. Furthermore, orchards with IPM components, the fruit fly population dropped drastically at the centre and periphery of the orchards compared to orchards with no fruit fly IPM application in all the benchmark sites.	
To conduct on-farm demonstration, adaptation and validation of existing and novel fruit fly IPM technologies (based on baiting and male annihilation techniques, use of biopesticides and orchard sanitation) in the target locations.	• Identify suitable and easily accessible site in consultation with NARS, growers and farming communities. • Establish IPM learning sites jointly with NARS partners. • Mobilize model farmers and other growers in collaboration with NARS partners. • Set up demonstration activities that encompass	• One suitable and easily accessible site identified in consultation with NARS and the farming communities in each of the project benchmark sites of Meru, Kitui, Tharaka Nithi and Arba Minch by July 2016. • At least one fruit fly IPM technology learning sites established in each of the project benchmark site in Kenya and Ethiopia by July 2016.	• A total of 8 suitable and accessible orchards: 4 in Kitui (Wikililye, Mwanyani, Itoloni and Kwaciku), 2 in Meru (Gakuri and Gikuuru) and 2 in Tharaka Nithi (Keeria and Rukurani) have been established as learning sites. These sites were jointly selected in consultation with the NARs, growers and farming communities. In Ethiopia, a total of 8 sites have been selected for IPM activities namely: Chano, Zeyise Elgo, Shelle	Cooperation between model farmers and NARS is a key to successful implementation of the IPM technologies since there exist a trust base relationship with local growers in the villages.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	various IPM management options and assess the impact jointly with NARS and growers.	• Identification and recruitment of at least 5 model farmers in each project benchmark site willing to be engaged in the application of fruit fly biological control and IPM technologies for implementation in Kenya and Ethiopia by July 2016. • Carry out at least one demonstration session that encompass various fruit fly IPM management options to growers jointly with NARS in at least two benchmark sites, one in each country by December 2016.	Mella, Shara, Chano Mile, Kola Shele, Lante and Chano Cheliba. • Eight IPM learning sites were identified and established in all the benchmark sites in Kenya. Four of these sites are in Kitui (Wikililye, Mwanyani, Itoloni and Kwaciku villages), 2 in Meru (Gikuuru and Gakuri villages) and 2 in Tharaka Nithi. (Rukurani and Keeria) In Arba Minch, Ethiopia, the main IPM learning sites are in Chano, Chano Mile, Lante and Chano Cheliba villages. • In Kenya, a total of 8 model farmers have been recruited from the three benchmark sites (Kitui, Meru and Tharaka Nithi). • 11 fruit fly IPM demonstration activities were undertaken in Kitui, Meru and Tharaka Nithi for NARS, CESPS and growers in these regions. During this period, 45 NARS and CESPS (80% males and 20% females) as well as 1322 growers (59.4% males and 40.6% females) were trained.	
To carry out large-scale releases of fruit fly parasitoids (*Fopius arisanus* and *Diachasmimorpha longicaudata*) and monitor for establishment and colonization in the new project actions sites in Kenya and Ethiopia.	• Catalogue and assess the level of parasitism by native natural enemies attacking major fruit fly species in various locations in Ethiopia. • Apply for and obtain import permits for introduction of *F. arisanus* and *D. longicaudata* into Ethiopia.	• The native natural enemies of fruit flies attacking major fruit species and their level of parasitism in the project bench mark site in Ethiopia quantified by December 2017. • Apply and obtain import permit for the introduction of at least one parasitoid species into Ethiopia by July 2017. • At least 5 NARS personnel trained on natural enemy production, releases and	• Establishing native natural enemies of fruit flies and their level of parasitism is on-going in Ethiopia. • A dossier has been compiled and shared with the Ethiopian partners for submission of application for import permit for the parasitoid species. • Training of NARS personnel is being organised at *icipe*, with subsequent training to be undertaken in Ethiopia.	The trust-based networks amongst scientist–extension workers-farmers' group alliance ensured a successfully flow of reliable information and supports participatory testing and usage of fruit fly IPM

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	• Carry out ToT workshop on parasitoid rearing at *icipe* for Ethiopian NARS on natural enemy production, releases and assessment of impact. • The two parasitoid species (*F. arisanus* and *D. longicaudata*) mass produced in large-scale and released at learning sites and selected grower's fields in Ethiopia. • Initiate and maintain laboratory colonies of *F. arisanus* and *D. longicaudata* in Ethiopia. • Follow up on establishment, colonization and impact in target locations.	assessment of parasitoids' impact by August 2016. • Large cultures of the two parasitoid species (~10,000/week) in place by end of December 2017 for mass releases in the project benchmark site in Ethiopia. • A starter colony of at least one parasitoid species established in the Ministry of Agriculture laboratory in Ethiopia by December 2017. • Establishment and colonisation of the two parasitoids documented for at least 2 sites in terms of percent parasitism by July 2018.	• Process is underway to sequre an importation permit from Ethiopian regulatory authority. • Production of the two parasitoid species stable at ~ 12,000/week in the rearing facility in Kenya; for pupae importation to Ethiopia for mass releases to be carried out at the learning site and in over 5 growers' farms in the project bench mark site in Ethiopia by end of 2017.	technologies in the various benchmark sites especially the release of parasitoid. It is with this approach that the Ethiopian partners are following up with importation permit for introduction of the parasitoid into Ethiopia.
To develop capacity to support up-scaling of fruit fly IPM technologies while strengthening the mango value chain through good agricultural practices (GAP).	• Training of trainers (ToT) workshop on fruit fly biological control and IPM technologies conducted for extension officers (NARS) and community extension service providers (CESPs) in the project benchmark sites. • Awareness campaigns and sensitization on technology availability for fruit fly management technologies in project benchmark sites in Kenya and Ethiopia conducted for farmers, farmer	• At least 10 NARS and 5 CESPs personnel recruited and trained on fruit fly IPM technologies and use of parasitoids by August 2016 in each country (Kenya and Ethiopia). • At least 2 awareness campaigns on availability of fruit fly management technologies and application and conservation of parasitoids conducted at IPM learning sites in both countries by end of August 2016. • At least 1000 fruit fly extension and training materials (manuals, flyers, posters, Farmer Field School curriculum) distributed to growers and	• Throughout the first year of the project, 45 extension officers (30 NARS and 15 CESPS) were sufficiently trained on fruit fly IPM technologies as well as good agricultural practices in the three benchmark sites (Kitui, Meru and Tharaka Nithi). Among the extension officers trained, 80% (36) were male and 20% (9) females. • A total of 11 awareness campaigns of the NARS, CESPS and growers on the availability of fruit fly management techniques and application of parasitoids were conducted in all the new project benchmark sites in Kenya.	For project sustainability beyond the project lifespan, a knowledge base is to be built through training workshops and training materials distribution to NARS, CESPs and growers.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	groups and the community at large at the newly established IPM learning sites. • Fruit fly extension and training materials (manuals, flyers and posters) produced and distributed to growers and extension officers in the project benchmark sites. • Contract and engage NARS partners, growers and other development partners in resource mobilisation for testing and sharing of the fruit fly IPM technologies.	extension officers at each of the selected benchmark sites in both countries by December 2016. • Collaborate with NARS and identify farmer groups in community that will help in fund raising and assist the growers in accessing fruit fly IPM products as well as market accessibility.	• Following the workshops and farmers' field days organized in Kitui, Meru and Tharaka Nithi, a total of 45 fruit fly IPM manuals were distributed to the participants. A total of 4398, 2670 and 1134 flyers were distributed in Kitui, Meru and Tharaka Nithi, respectively, to the NARS, CESPS and growers.	
Specific Objective: Develop IPM tools and strategies for major coffee pests in East Africa based on a better knowledge of their bioecology.				
Development of laboratory rearing methods for major coffee pests in East Africa	• Colonies of *Hypothenemus hampei*, *Monochamus leuconotus* and *Antestiopsis thunbergii* continually maintained in the laboratory.	• Living insects available for experimentation. • Rearing methods published.	• Colonies of *Hypothenemus hampei*, *Monochamus leuconotus* and *Antestiopsis thunbergii* provided living insects for the period 2014-2016. • Rearing methods and life table studies published for *Monochamus leuconotus* and *Antestiopsis thunbergii* in 2016	Inbreeding issue observed for *Monochamus leuconotus* as soon as the 3rd laboratory generation. Issue of artificial diet infection by spider mites. Low fecundity for *A. thunbergii* in reared colony, which requires frequent field collection.

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				Two publications in International Journal of Tropical Insect Science and Journal of Economic Entomology
Thermal requirements characterization 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.	• Thermal requirements published. • Set of phenological models available for further demographic simulations	• Life table study at 7 constant temperatures completed for *A. thunbergii*. Phenological models and thermal requirements available for *A. thunbergii*. • Life table study initiated for *M. leuconotus* and *H. hampei*, in 2016.	*Antestiopsis thunbergii* showed thermal requirements closer to those of Pentatomids from temperate countries when compared to tropical Pentatomids. The length of *M. leuconotus* life cycle (≈1 year) is a challenge in life table study. One publication submitted to Annals of Applied Biology in 2016
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 coffee industry.	• Distribution mapping for *A. thunbergii* completed in 2016 for two elevation transects located on Mount Kilimanjaro, Tanzania, and in Jimma area, Ethiopia. A publication in preparation. • Similar mapping work initiated for the Kenya Central Province, with a focus on Murang'a county.	

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
Characterization of major coffee pest population dynamics in coffee farms and of agroecological factors impacting the dynamics.	• Networks of smallholding coffee 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 characterized 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 solutions developed based on these models.	• Data sets available for modelling work. • 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.	• Monthly monitoring of *H. hampei*, *A. thunbergii* and *M. leuconotus* completed for two years (2013-2015) in 24 coffee farms, over an elevation transect on Mt. Kilimanjaro. • Agroecological factor characterization completed for the coffee farms. • Modelling work in progress and publication in preparation. • A new network of 30 coffee farms in Murang'a county implemented in 2016. • Monitoring of the three target coffee pests initiated in 2016. • For *Hypothenemus hampei*, a set of 70 Brocap traps implemented in coffee farms for assessment and monitoring.	
Identification and utilization of semiochemicals 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.* • 1 publication for promising pheromones for the control of *A. thunbergii*.	• Behavioural assays with coffee berries at different maturation stages completed. • Headspace volatile collection and identification for coffee berries completed. • Electrophysiology for coffee berry 90% completed. • Behavioural assays with bioactive standards 80% completed. • Work on pheromones in progress	A publication on kairomones from green coffee berries in preparation.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
Specific Objective: Promote adoption of push-pull technology for effective management of striga and stemborers infesting cereals through collaboration with international and national partners by 2018.				
1. Push–pull technology implemented by over 120,000 farm households, and indirectly benefit over 1.5 million people in East Africa.	Food sufficiency and household incomes of 120,000 push–pull farmers increased by at least 50% by 2018 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.	• A total of 16,985 new farmers (7,669 males and 9,316 females) adopted push-pull technology in 2016. Cumulatively 139,635 farmers have so far adopted the technology, surpassing the target of 120,000 farmers. This translates to over 1,117,080 direct beneficiaries having improved food sufficiency, nutrition and incomes. It also translates to approximately 69,818 acres under push pull. • Based on the case studies undertaken, technology beneficiaries experienced at least 2.5 times higher grain yields, and significant increases in fodder, milk, soil fertility and incomes. • Ninety percent of push-pull farmers are utilizing fodder from push–pull plots in their dairy production, translating to 15,287 farmers in 2016 and cumulating to 125,672 farmers. • 66,049 farmers were trained on push-pull technology through 1641 training events that were delivered through farmer field days, farmer teachers, farmer research networks and agricultural shows. Use of comic books was also explored where production of 3000 copies of the second edition of Swahili and English versions of the push-pull comic book was completed and used to disseminate push-pull among	• More female farmers are adopting push-pull technology because it is gender-friendly and reduces drudgery, and time spent on looking for animal fodder. • Integration of cereal and livestock production improves the demand of push-pull as a multi-functional technology since farmers in Africa traditionally practice mixed agriculture • Working closely with grassroots institutional collaborators such as local chiefs, churches, private sector and Community Based Organizations' (CBOs) increases the level of ownership of push-pull technology. • Use of farmer based communication

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			1430 school pupils. Two farmer groups in Bungoma and Vihiga in western Kenya were also trained on drama and video as a means of disseminating push-pull • Technology up-scaling options were expanded through training of 419 extension personnel from various partner organizations (Send- a- cow, One Acre Fund in Kenya and Uganda, and CABI Plant wise project, World Vision and Project Concern International in Kenya and Tanzania) and 40 peer farmer trainers from Kenya, Uganda and Tanzania.	channels is sustainable in the long term as it is based on local networks and social capital, and can be used as an innovation platform. • Building strong partnerships with the farming communities, national extension networks, NGOs, and the private sector players remains key in scaling up Push-pull technology. Their involvement also enhances impacts of the technology on beneficiary livelihood
2. An integrated management approach for Napier stunt disease	Improved incomes and livelihoods of at least 5,000 Napier farmers in Western Kenya by at least 50% through adoption of an integrated Napier stunt disease management strategy, characterised by increased fodder and milk production by 2016	• Quantity of Napier grass and milk produced • Number of alternative fodder grasses in use • Number of farmers using the integrated disease management approach • Number of partnerships formed • Number of peer-reviewed publications	• Resistant Napier grass cultivars (Ouma 2 and South Africa) were multiplied in western Kenya and distributed to and planted by at least 53,518 farmers in the region. Additionally, 14,913 farmers planted alternative fodder grass, *Brachiaria mulatoII* within the climate smart push-pull in drier parts of Kenya, Tanzania, and Ethiopia. • A total of 2,667 farmers have established bulking sites for disease resistant cultivars	• Alternative foder grass, brachiaria cv mulato is preferred to Napier grass by female farmers since it is relatively easier to handle thus facilitating uptake. • Phytoplasma infection improves attractiveness of Napier grass to

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			Napier grass (Ouma2 and South Africa). There are also community-based resistant Napier multiplication and distribution systems established through 5 principal stakeholders (KALRO, Heifer, Send-a-Cow and Ministries of Livestock in Kenya Agricultural Training Centres) and over 92 farmer groups in Nyanza and 96 farmer groups in western Kenya. • Three scientific publications on various aspects of Napier stunt disease transmission and management were published in 2016	*Maiestas banda* and improves the vector's population build-up • Napier stunt research needs an expanded partnership, with partners of varied competencies if an effective management approach is to be efficiently implemented.
Specific Objective: Integrated Biological Control Applied Research Programme (IBCARP) – Push-Pull Research Component				
1. Push-pull technology further adapted to climate change, through new science, optimized for different agro-ecosystems and smallholder cereal-livestock farming systems, and scaled up in eastern Africa.	Food sufficiency and household incomes of 30,000 additional smallholder farmers in drier areas vulnerable to effects of climate change increased by at least 50% by 2016, through adoption and practice of climate-smart push-pull	Acreage of farmland under climate-smart push-pull Number of farmers practicing climate-smart push-pull Cereal and fodder yields and incomes among target farmers in drier agro-ecologies	A total of 14,913 farmers (8123 females and 6790 males) adopted the climate-smart push-pull technology in 2016 in drier parts of Kenya, Tanzania, and Ethiopia (translates to about 104,391 indirect beneficiaries). The technology beneficiaries experienced at least 2.5 times higher grain yields and significant increases in fodder, milk, soil fertility, and income.	• Increased fodder due to good leaf establishment properties exhibited by both Brachiaria cv Mulato and greenleaf desmodium has resulted in increased feed availability. This has led to a substantial increase in the number of push-pull female and male farmers who are keeping

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
				dairy cattle, in the target areas. • Climate-adaptation of Push-pull has expanded the ecological range of its application, enabling farmers to obtain cereal and milk yields in place where they otherwise would not produce a crop.
2. Additional drought-tolerant African desmodium species identified, tested and incorporated into the climate-smart push-pull technology	At least four drought-tolerant African desmodium species as outcomes of the technology adaptation process utilised by scientists, policy makers and other stakeholders by 2016	• Number of drought-tolerant African desmodium species incorporated into climate-smart push-pull technology • Number of farmers utilizing these desmodium species • Improvements in yields of cereal crops, fodder and milk • Number of stakeholders trained • Number of partnership formed • Number of publications on the performance of the optimized push-pull technology	• Four drought tolerant *Desmodium* spp. were further evaluated: *D. intortum*, *D. repandum*, *D. incanum*, and *D. ramossisimum*. Field evaluation results effective control of striga by the drought tolerant *Desmodium* spp. These have now been incorporated into the climate adapted push-pull, with *D. incanum* and *D. ramossisimum* currently under farmers' evaluation. • A total of 14,913 new farmers adopted use of *Desmodium intortum* in 2016, bringing the total number of farmers practicing climate-smart push-pull to 61,246. Additionally, *D. incanum* and *D. ramossisimum* are currently being tested by 15 famers in western Kenya	• All the highly drought tolerant desmodium species were found to possess the same biochemical potential for striga control previously reported in other desmdium species, albeit through different allelochemic modes of action. • *D. incanum* and *D. ramossisimum* are highly prolific in terms of seed production,

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			• Use of drought tolerant *Desmodium* spp. effectively controlled striga resulting in at least 80% yield increases in sorghum. • Partnerships have been formed with National and County governments, Send-a- cow, One Acre Fund, CABI Plant wise project, World Vision and Project Concern International to help disseminate the climate-smart push-pull in the region • 12 peer-reviewed papers were published, deepening and expanding scientific knowledge and capacity development.	representing an opportunity for income generation for the farmers
Specific objective: **Strengthening citrus production systems through the introduction of IPM measures for pests and diseases in Kenya and Tanzania by 2018**				
Progress toward achieving objective : Development and dissemination of IPM measures for ACT and associated HLB disease, and FCM that is less reliant on synthetic pesticide applications on citrus				
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 populations of ACP and FCM conducted by mid 2017.	• 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. • 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.	• *Stephania abysinica*, *Murraya koenigii*, *Clausena anisata*, *Vepris* sp. and Teclea nobilis found to be hosts of T. erytreae. • Triozids were more abundant between 1500-2000masl and . more abundant on shaded trees as measured by the number of ACT stage per tree (34.4, 37.0 and 0.7 for eggs, nymphs and adult, respectively) than those exposed to sunlight (11.5, 15.8 and 0.5, for eggs, nymphs and adult, respectively). • FCM was reared from, okra, sweet pepper, egg plant with percentage infestation of 3, 9 and 2% respectively. • Insect colony for both ACT and FCM have been established and the life table studies at different temperature regimes	

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		• Vibrant colonies of ACP and FCM established by end of 2015.	(10, 15, 20, 25, 30 and 35°C) been initiated, for predictive phenology modelling • The first DNA barcode reference library for the Trioza erytreae has been unveiled. We have constructed for the first time, a barcode reference library for T. erytreae as a means of rapid identification of the pest • Different endosymbiont species were detected in T. erytreae from different populations using Universal Eubacterial primers 27F/1492R. A new alien invasive psyllid, Diaphorina citri was detected and reported for the first time in Kenya and Zanzibar. The insect identity was confirmed using DNA barcode. *D. citri* was sympatric with *T. erytreae* at mid elevations.	
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	• 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.	• DNA extracts from plant and insect samples were analyzed using PCR to detect the presence of CLaf and/or CLas genes. There was a high level of bacterium detected in plant tissues compared to insect tissues. • The A2/J5 primer was more reliable and precise for indexing greening disease in plant tissues whereas OI1/OI2c was more robust in insect tissues. BLAST hits of the amplified samples linked them to CLaf and CLaf subspecies clausena with identity of 98-100% confirming the species.	Unavailability of large size citrus orchards sufficient for landscape modelling. Prolonged drought spells hinder this activity, as it causes symptoms that mimic *HLB*

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	spread of HLB disease by end of 2015. • HLB disease distribution and potential implications on citrus industry on a regional scale assessed using Earth Observation tools by end of 2017.	• Hyperspectral pattern of disease spread and regional distribution established using remote sensing tools by end of 2017.	• Candidatus *Liberibacter*' africanus' (Laf), was found to be the main causal agent of greening disease. Sequences from samples testing positive for Las in the Las-specific real-time PCR were homologous to 'Ca. Liberibacter africanus subsp. clausenae' (LafCl), identified from an indigenous Rutaceae species in Africa. Additionally, LafCl was also detected in *D. citri* and *Trioza erytreae*, suggesting that both species can vector the bacterium. This is the first report of a subspecies of Laf being associated with greening symptoms of citrus	
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.	• 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 2017. • 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.	• Chemical analysis isolated five antennally-active compounds using antennae of both sexes of the insect, the identities of which are being confirmed. • *Metarhizium anisopliae* ICIPE 62 (Met 62®), ICIPE 78 (Achieve®) and ICIPE 7 (Tickoff®) were tested on ACT egg and adult. Only Met 62® was found to be promising, inducing up to 70 and 88% mortality on eggs and adults, respectively. On FCM, Met 69® was evaluated for soil treatment against pupating larvae. Adult emergence was reduced by 86% following application of a standard concentration of 1 x 108 conidia ml-1 in the laboratory. • Insect proof screenhouse has been established at icipe field station, Muhaka,	Regulatory challenges have had an influence on introduction of virus-based pesticides from South Africa into Kenya for testing

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	• Citrus plant materials/root stock for HLB resistance 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.	• At least 20 citrus genotypes screened for tolerance/resistance to HLB by mid 2017. • At least two insect-proof nurseries established and 500 HLB-free clean stock, produced by mid 2017. • 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.	Kenya. Citrus materials (10 cultivars) are being sourced from South Africa	
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 for target pests and disease conducted by end of 2017.	• Baseline data on farmers' knowledge and management practices (KAP) 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. • At least one *ex-post* assessment of implemented IPM management interventions conducted by end of 2017.	• Data collected from 350 citrus producing farms in Machakos and Makueni counties, Kenya. • ACT, HLB and FCM were reported to be imajor constraints among citrus growers, with 62, 75 and 75% of respondents respectively citing them as major problems. The main control method for these pests is the use of synthetic pesticides by over 70% of respondents. • Orchard sanitation was the most widely utilized (>60% of the respondents). Growers were also aware of bio-pesticide and pheromone traps (>40%), but only a few used them (<10%).	

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			• About 58% and 60% respondents cited they were willing to pay for the ACT/HLB and FCM IPM packages respectively if their income from citrus farming would increase, with majority (over 60%) citing they would adopt the packages	
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 2017. • At least 3 PhD and 3 MSc students trained on bioecology and management of the target pests by 2017.	• A workshop was held in Tanzania to create awareness about the alien Asian citrus psyllid (ACP), *D. citri* in the country in addition to training on ACT and FCM identification and management. An action plan for containment and prevention of spread of *D. citri* in Tanzania was agreed upon. • 23 NARS were trained on identification and management of ACT, the greening disease (symptoms and damage) • 5 PhD and two MSc students continue to make good progress on their respective areas of research.	
Specific Objective: Emergency assistance for the control of Potato Cyst Nematode (PCN)				
Progress toward achieving specific-objective observed: National and county governments in Kenya capacitated to effectively respond to Potato Cyst Nematode				
Develop capacity of Government Laboratory Technicians on soil sampling techniques for PCN prevalence; morphological and	• Capacity built in Kenya for detection of PCN	• Training of 20 staff from KEPHIS, KALRO, PPSD and universities	• 21 staff were trained in a Training of Trainers (ToTs); on sampling procedure (survey) and analysis of samples. • 12 participants received advanced training in PCN morphology and 5 in molecular techniques for identifying PCN	Hands-on training is an effective method for achieving more than one goal. The trainers were trained and the

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molecular identification methods enhanced				project achieved valuable results.
Soil samples from georeferenced potato growing areas of Kenya collected and analysed for PCN prevalence, severity and species identification	• Collection and analysis of soil samples to determine the PCN species present in Kenya	• Collect 1, 200 soil random samples in the 20 potato growing areas of the country. • GPS coordinates data collected in the 20 potato growing areas where samples are collected • Analyse the 1 200 samples to identify the species	• 1,250 farms were visited and 1250 soil samples collected in 20 potato productive counties • 1,250 GPS coordinates were collected in 20 potato productive counties. • 1,236 soils samples were analysed for PCN cysts • 1,014 samples were positive for PCN infestation (indicating a prevalence of 82%). • 2 nematode species were identified at the morphological and molecular level.	Good team work is vital to achieving the targets with good coordination at the different levels. Open and honest communication with donors is also valuable for achieving the targets
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.				
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 targ communities by 2019 At least 30% increase in yield (fr the baseline) in target communiti by 2019 At least 30% reduction in frequency pesticide applications 2019 Atleast 20% increase in household incomes from adoption of IPM practices by	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	Integrated management of chickpea whilst using two improved varieties: Habru and Arerti combined with seed dressing using Lamdex and with occasional spray with Karate against pod borer, planted on raised bed and furrow (farmers' practices) had shown considerable level of resistance to the wilt diseases and pod borer and shown high acceptance by demonstrating farmers in Ethiopia.	Farmers perceive non-pesticide maize pest control methods to be effective and cheaper but they also believe that pesticides are effective. Other benefits of IPM such as health, environmental safety and effect on beneficial insects should be

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	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 application Six PhD/MSc students trained Over 800 farmers and extension agents trained by 2019 (200 a year for 2016, 2017, 2018 & 2019)			emphasized to enhance IPM adoption. Women should be empowered through trainings to participate in all activities of maize production especially on maize pest and disease control decision making. Discussions with farmers during the survey indicated that most of them lack knowledge of causes and transmission of rice blast disease in their fields in Tanzania. Farmers use rice straws as a mulch for horticulture production. There is a possibility that this situation contributes to persistence of rice blast disease inocula in the field if infected rice straws are used.
Key partners identified, IPM technologies developed and	Identify key stakeholders and develop implementation strategy by mid 2016	Number of stakeholders participated	Integrated termite management trails were conducted in maize by using cropping system as a major component.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
implementation strategies defined for sound sustainable intensification along the maize, rice and chickpea value chains	Problem identification and prioritization 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 pest problems identified and prioritized 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	The components were maize intercropped with desmodium, or soybean or maize mulched with stover and manure. Total number of damaged plants, number of harvested plants, root and stem damages were less in maize intercropped with desmodium, or soybean or maize mulched with stover and manure compared to maize planted sole in Ethiopia	
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	Number of scientists/institutions engaged Number of pests, diseases and weeds identified and prioritized 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)	Push-pull technology targeting management of maize stem borers was implemented in Hawassa area district of Ethiopia. This study evaluated farmers' perception of push-pull technology based on their experiences and observation of demonstration plots established at farmers' farm in two villages of the district in 2016. Majority (89%) practicing farmers have rated the technology better than their own maize production practices on major	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	Communication and data-network systems with partners by end of 2019	Number of pests, diseases and weds diagnosed Number of people accessing data	attributes such as access to new livestock feed and control of maize stem borer damage. As a result, about 96% of interviewed farmers were interested to adopt the technology starting in the 2017 crop season.	
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 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	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 Number of people accessing the web-interface Number of documents downloaded Types of training needs assessed Number of farmers and extension workers trained	The push-pull was planted in Nakuru and Naivasha in 2016 in Kenya to control stem borers in maize and create awareness and disseminate the technology. The number of exit holes and tunnel length in the push-pull demos showed reduction in tunnel length and exit holes which most probably contributed to the yield increases observed.	

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	Conduct training need assessments and educate farmers and extensions agents by end of 201			
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	Evaluation of biopesticides, *Beauveria* and *Metarhizium* against rice stem borers and Trichoderma and *Bacillus subtillis* against rice blast in Tanzania has shown considerable control of the pest. This results will be consolidated and communicated to policy makers	
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 2017.				
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 groups as well as to wider audiences.	Integration, synthesizing, and reporting of results from different WPs and within WPs from CHIESA by mid 2016. Integration of scientific capacity at institutional level built to achieve overall objective of climate change adaptation by end of 2016	• Effects of climate change on biodiversity and habitats disseminated • Species distribution maps for pest insects for maize, crucifers, avocado and coffee imparted.	• Results were synthesized and shared with the stakeholder organizations and farmers. • 1 climate change (CC) adaptation intervention map was developed and updated localized action plan for each of the four target areas were produced, 9 scientific articles were published in international scientific journals.	• Joint planning with stakeholders and active participation from onset is key for project success and sustainability of technologies introduced.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	Synthesized 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		• 2 horizontal capacity building events were organized in Kenya (KE) and in Ethiopia (ET). • 2 workshops on long-term impacts of CC organised; 1 in KE and 1 in ET . • 3 PhD students who started under CHIESA but did not finalize their research work by the end of the project graduated in 2016. • 2 target areas (ET and Tanzania (TZ)) implemented the action plans to support their existing national CC adaptation strategies.	
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 utilization of the GeoNetwork platform and weather monitoring infrastructure by mid 2016 Strengthen capacity of providers of extension service by end of 2016 Improved access to appropriate and affordable technologies by mid 2017	• GIS platform established for sharing geospatial datasets among at least 25 East African stakeholder organisations regularly utilized. • No. of participants at trainings that showcase the utility of geospatial products. • No. of new local and regional products derived. • Geospatial datasets in use. • Number of Community training events.	• 100% of participatory GIS data on prioritized action sites collected from the AFERIA workshops in the four target areas visualized and uploaded to the data sets for MALM development.75% of the geospatial and quantitative outputs for scenarios of Climate Change and land use and cover change was finalized and is to be uploaded on the webserver. • 30% increase in CC adaptation technologies (modern beehives, drip irrigation kits, roof rain water harvesting systems, modern nursery	• Individual ownership of the introduced technologies, verses core ownership, and the core livelihood activities of the individual are important considerations when selecting locations for the demonstration sites of the

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	Implementation of community adaptation plans, including linking with the existing government planning processes by end of 2017		techniques and soil erosion control approaches) • 4 indigenous tree and disease-resistant coffee nurseries were established in ET, trainings for 4 nurseries in TZ were finalized, demonstration site locations indicated and material purchase has started for drip irrigation kits and roof rainwater harvesting systems, beekeeping trainings for youth in 3 sites in ET.	various technologies.
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 2016 Increased knowledge and information about climate, technology and markets by end of 2016 Adequate use of information dissemination pathways by mid 2017 Appropriate political support for communication and dissemination by end of 2017	• 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.	• 2 new sets of training materials available from horizontal capacity building training courses organized at Jimma University, ET and KALRO Food Crop Centre in Kabete, KE. • 3 awareness-raising campaigns in TZ, and 3 in ET; 4 workshops organized (one in each target area). • In Jimma area, 172 women participated in 6 training events on disease-resistant coffee nurseries and bee keeping. In Mt. Kilimanjaro area, 83 women participated in 9 training events training on drip irrigation, and indigenous tree species nurseries.	• Awareness creation on best practices available has been welcomed due to the continuous changes in rain partners and thus frustration among the farmers as their activities are hampered with and fail to produce any results.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			• 2 new videos available on the project website (CHIESA project summary and Tree planting with School children),CHIESA information on WeADAPT platform, and YouTube platform for all videos.	
Specific Objective: Responses of tropical insects to global changes				
Progress toward achieving specific-objective observed: Baseline information of plants - Lepidoptera stemborers – parasitoids interactions generated				
Baseline information on influence of temperature on intra- and interspecific resource utilization within a community of Lepidopteran maize stemborers, host plant selection mechanisms by Lepidoptera stem borers (Noctuidae), host selection mechanisms by parasitoids (Braconidae). Genome sequencing of *Busseola fusca*. Genetic of host acceptance of the larval endoparasitoid, *Cotesia sesamiae.*	• At least four study outcomes utilized by scientists and students by 2017.	• Identification of a new parasitoid species associated to *Sesamia nonagrioides* in Kenya. • Initiation of a study to control biologically *Sesamia nonagrioides* in France by a new parasitoid species. • Identification of a specific natural enemy (a stem borer species) of Guinea grass. • Prediction of the spreading of different species of Lepidoptera stemborers caused by climate change.	• 1 *ex ante* PhD studies completed (name of the PhD student: Eric Ntiri) • 1 *ex ante* MSc studies completed (name of the MSc student: Elijah Njuguna) • Isolation of the kairomone(s) for further identifications and participating in the genome sequencing of *B. fusca* ongoing (PhD scholar Gladys Bichanga) • Study on chemical ecology mechanisms underlying oviposition choice in maize Lepidoptera stemborers ongoing (PhD scholar Mawuko Sokame) • Biological control (BC) intervention done by *icipe* has contributed to an aggregate monetary surplus of US$ 1.4 billion to the economies of the three countries with 84% from maize production and the remaining 16% from sorghum production. • The estimated number of people lifted out of poverty through the BC-programme was on average 57,400 persons (consumers and producers) per year in	Training and education are key ingredients for success. A close relationship of scientists with biological materials is a key ingredient for success. Need for increased investment in biological control research to sustain cereal production and improve poor living conditions. 8 publications in peer reviewed journals: -Badshah et al. 2016. *Biocontrol Science and Technology 26, 1605-1616.*

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
Exploration for natural enemies of Guinea grass in Kenya. Baseline information on maize stem borer communities densities along altitudinal gradients, on soil and plant silicon levels influencing the stem borer density and communities, stem borer competitions, soil characteristics along altitudinal gradients, farmer practices and their impacts on agro-ecosystem. Assessment of the long-term welfare effects of the biological control of cereal stem borer pests in East and Southern Africa: Evidence from Kenya, Mozambique and Zambia.			Kenya, 44,120 persons in Mozambique, and 36,170 persons in Zambia, representing an annual average reduction of poor populations, respectively of 0.35, 0.25 and 0.20% in each of the three countries	-Calatayud et al. 2016. *Entomologia Experimentalis et Applicata 159, 354–361.* -Calatayud et al. 2016. *Agriculture, Ecosystems & Environment 224, 95–103.* -Calatayud et al. 2016. *International Journal of Insect Science* 8, 95–103. -Calatayud et al. 2016. *Entomology, Ornithology & Herpetology 5: e125. doi: 10.4172/2161-0983.1000e125.* -Juma et al. 2016. *Journal of Chemical Ecology 42, 394–403.* -Ntiri et al. 2016. *PLoS ONE* 11(2), e0148735. -Ntiri et al. 2016. *Entomologia Experimentalis et Applicata. doi: 10.1111/eea.12514.*
Specific objective: Determine the contribution of organic agriculture to sustainable development in the tropics by 2018				
Effect of organic and conventional farming systems on pest and	• Long-term organic and conventional farming systems compared and their effects on	• At least one major pest and one major disease of maize assessed under the two different farming systems by 2016.	• Potato was evaluated during vegetable season that ended in February 2016 while maize was assessed during the	Adamtey et al. (2016) *Agriculture, Ecosystems*

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
disease incidence, severity and damage determined and documented by 2017. Effect of organic and conventional farming systems on soil biodiversity assessed, and documented, by 2016. Effect of organic and conventional farming systems on soil fertility and safety evaluated, and documented, by 2018. Yields and incomes generated through organic and conventional farming systems compared. Participatory on-farm research (POR) conducted for wider result dissemination and adoption.	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 vegetables assessed under the two different systems by 2016. • 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 2017. • 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 2016.	long rainy season from March to September 2016 • Soil hydraulic conductivity, bulk density and sampling for soil moisture curve determination were conducted • Weed biomass, seed bank and diversity were assessed • During the potato season, the predominant pests identified were termites, white flies, aphids, *Spodoptera* spp. and potato tuber moth. • During the maize cropping season, the major pests identified were aphids, stemborers and beetles. • PhD study on N dynamics revealed that N leaching was similar between organic and conventional systems. • PhD study on termites revealed that termite abundance, diversity and foraging activity were highest in organic systems compared to conventional systems. • PhD studies on microbial diversity showed that Thika site had higher microbial diversity compared to Chuka. • MSc nematode studies revealed that plant parasitic nematodes were more abundant in organic systems compared to conventional • On farm trials were carried out at Kangari, Chuka and Kianjugu • 1 peer reviewed paper was published	*& Environment* 235, 61–79

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
Objective: 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: Assess the effect of hermetic storage on mold and aflatoxin contamination of stored maize.				
Effect of hermetic storage on mold and aflatoxin contamination of stored maize assessed.	• At least five (5) village communities in Makueni (Kenya) are aware of the effect of hermetic storage on mold and aflatoxin contamination of stored maize by early 2018.	• At least one (1) study on mold and aflatoxin contamination of stored maize conducted by end of 2017. • One scientific publication by end of 2016.	• Field trials conducted in 9 rural villages in the aflatoxin belt of Machakos County, Kenya • 703 households reached and educated on safe storage of grains using hermetic storage bags. Among individual persons reached, 59% were women and 41% were men. • Field demonstrations and "open-the-bag ceremonies" conducted in 9 villages. • 27 extension officers, community leaders and government officers trained to offer technical backstopping at rural level. • Two (2) articles published in peer reviewed journals. • One (1) MSc trained; completed in Nov. 2016.	Community altitudes and inadequate prior sensitization affect mobilization of target groups and reaching out to beneficiaries. Involving grass root government administrative and extension officers improved outreach
Specific objective: Evaluate qualitative changes in grain legumes during hermetic storage.				
Qualitative changes in grain legumes during hermetic storage evaluated	• Qualitative changes in at least two (2) grain legumes during hermetic storage known by early 2018.	• At least one (1) research report and one draft journal article produced by end of 2016.	• One (1) laboratory trial involving common beans conducted and data collection completed. • One (1) research report • One (1) MSc being trained	Field trials need to be conducted to validate laboratory findings.
Objective: 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: 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*				

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
Acoustic profiles of *Prostephanus truncatus, Sitophilus zeamais, Sitophilus oryzae, Acanthoscelides obtectus, Tribolium castaneum* developed.	• Acoustic profiles developed for at least five (5) storage pests by end 2018.	• At least one (1) research report and one draft journal article produced by end of 2016.	• Acoustic profiles of *Prostephanus truncatus, Sitophilus zeamais* and *Acanthoscelides obtectus* developed • Two (2) articles published in peer review journals. • One (1) PhD being trained.	Broadened collaboration with global institutions that have undertaken similar work in the past was necessary to be able resolve signal interpretation challenges, as well as gain exposure to more simplified but robust methods of data acquisition and processing
Specific objective: To undertake the selection of specific unique frequency identifiers for *Prostephanus truncatus, Sitophilus zeamais, Sitophilus oryzae, Acanthoscelides obtectus, Tribolium castaneum* using sound characteristics				
Unique frequency identifiers for *Prostephanus truncatus, Sitophilus zeamais, Sitophilus oryzae, Acanthoscelides obtectus, Tribolium castaneum* selected.	• At least five (5) unique frequency identifiers selected for at least five (5) storage pests by end 2018.	• At least one (1) research report and one draft journal article produced by end of 2016.	• Five (5) unique frequency profiles of *P. truncatus* and *S. zeamais* identified. • Four (4) unique frequency profiles of *A. obtectus* identified. • Two (2) articles published in peer review journals. • One (1) PhD being trained.	Broadened collaboration with global institutions that have undertaken similar work in the past was necessary to be able resolve signal interpretation challenges, as well as gain exposure to more simplified but robust methods of data acquisition and processing

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
Specific objective: To assess the preference for acoustic early warning system in bulk storage warehouses in Kenya				
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 2018.	• At least one (1) research report and one draft journal article produced by last quarter of 2016.	• One (1) study involving commercial managers of store completed. • One (1) working paper produced	Warehouse managers highly willingness to cooperate, and support development of a tool that can offer early detection of noxious insect pest species in stores.
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				
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.	• 18 species in six major cricket consumption areas in the coast and Lake Victoria region of Kenya found. *Acheta domesticus* was the most dominant species accounting for 30.3 – 50.5% of the total catches across the studies areas. • Mass rearing systems for two cricket species *Acheta domesticus* and *Gryllus bimaculatus* has been established and boosted to produce 40,000 – 50,000 crickets per week. • Evaluation of oviposition devices for egg laying by *A. domesticus* and *G. gryllus bimaculatus* has shown that the blue and green egg collection devices increase oviposition by 15-20%. Moist cotton wool was the most efficient in term of hatching rates (83% and 92% for *A. domesticus* and *G. bimaculatus*, respectively)	At least more than 80% of farmers considered crickets as an alternative source of protein.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			followed by moist saw dust (82% and 77% for *A. domesticus* and *G. bimaculatus*, respectively). • Wheat bran supplemented with kale enhances productivity of *A. domesticus* - mean weekly production of adults per egg crate stand at 116.8 ± 22.4 adults with percentage adult emergence of 72%. • *A. domesticus* and *G. bimaculatus* successfully developed within the temperature range of 20°C to 35°C. No egg of both crickets hatched at 15°C.	
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 the key insects as food in Kenya identified by end of 2016.	• Microbial characterization of bacterial and fungal loads in different cricket species (*A. domesticus* and *G. bimaculatus*) is ongoing	
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 2016.	• Entomopathogens (*Beauveria* spp., *Entomophthora* spp. *Metarhizium* spp., cricket paralysis virus (CrPV), microsporidia, nematodes, mites documented in laboratory colonies of crickets at *icipe* • *Apergillus flavus* detected in cricket colonies, which constitute a possible threat to cricket rearing and colony growth. • Differential susceptibility of *Beauveria bassiana* and *Metarhizium anisopliae* as potential threat to *A. domesticus* and *Gryllus bimaculatus* production has been established. Out of the 15-species screened Kapiti S3 was the most	There exist several entomopathogens that pose a threat to cricket production and urgent measures should be taken to prevent colony contamination.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			pathogenic *M. anisopliae* with mortality rates of 60 – 80%, while Caterp B recorded the highest mortality (70 – 90%) among the *B. bassiana* isolates. • The susceptibility of cricket species (*A. domesticus* and *G. bimaculatus*) to four species of entomopathognic nematodes (Mw8A, Naivasha, Palm and Yatta) at different temperature regimes has been established. The percent mortality of both cricket species ranged between 22 – 78% across the different temperature regimes for the different nematodes.	
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 2016.	• Evaluation of fresh, processed and stored crickets showed no evidence of aflatoxins and pesticide residues as contaminants. Commonly observed pathogens included *Escherichia coli*, *Salmonella typhi, Staphylococcus aureus* and faecal coliforms. The fungus *Apergillus flavus* has also been detected. • Post-harvest processing revealed that boiling at 96°C for more than 5 min or toasting at 150°C for 2 minutes was sufficient to eliminate all possible bacteria and fungi contaminants found in the processed insect.	Microbial contaminant in cricket can easily be overcome using appropriate postharvest handling procedures
Recommendations for enhancing food safety and quality control of edible insects in Kenya, and for international trade provided.	• Information to enhance policy regulations and legislations governing the use of insects as food and feed available.	• Workshops to provide recommendations to inform policy for development of standards for use of insects as food and feed conducted by end of 2016.	• GREEiNSECT project jointly organized an International Conference on Legislation and Policy on the Use of Insects as Food and Feed in East Africa, with 105 participants from 13 countries. The project continues to strengthen	There is technically no policy and legislation governing the use of insects as food in Kenya

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			legislation and policy with several workshops and meetings held with relevant bodies.	
Specific objective: Develop and promote insect feed for poultry and fish production in Kenya and Uganda (INSFEED) by 2018				
Socio-economic surveys carried out on the use of insects for feed in poultry and fish farming.	• Farmers and feed producers invest more in insect based feed production and use, and increase adoption by 2017.	• At least 3 focus discussions per target country. • At least 500 small-scale farmers surveyed per target country. • At least 100 livestock feed processors surveyed per country.	• One MSC thesis under review by University supervisor " Acceptance of Insect based feed among female and male farmers in Kenya" • One manuscript developed and under review	The results show that more than three quarters of poultry and fish farmers are willing to use insect based feed. More female farmers are willing to use insects that male farmers. Insect based feed, will thus be a great boost for livestock production if they prove cheaper than the conventional feed.
Market demand analysis for insects as feed ingredient for poultry and fish conducted.		• Market demand and cost benefit analysis conducted for at least one insect based feed by 2017. • Key market segments described.	• One MSc student successfully defended at University of Nairobi on "gendered analysis of demand for poultry feed in Kenya" • A manuscript (gendered analysis of demand for poultry feed in Kenya) was generated from the above thesis, and was presented in the 2016 AAAE Fifth International Conference, September 23-26, 2016, Addis Ababa, Ethiopia 249279, African Association of Agricultural Economists (AAAE)	Findings suggest higher poultry farmers responsiveness to feed prices and the effect is greatest among female farmers.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
Economic performance of insect-based feed assessed	•	• Comparative costs of at least 3 insect based feeds. assessed by end 2016 • Cost efficiency studies of poultry and fish reared on insect based feed evaluated by 2017.	• One graduate student recruited to work on economic viability of insect based feed in Kenya; • Draft MSc. Thesis proposal developed, • Collection and analysis of data on inputs and cost of insect rearing in progress	
Rearing techniques for key insects suitable for use as feed developed and adapted. Wild harvesting techniques for swarming insects developed and adapted. Chemical and microbial contamination determined and protocol developed for safe rearing and handling. Nutritive profile of key insects assessed. Insect based feed formulated and tested.	• Efficiency improved in insect, poultry and fish rearing for low cost production and high profit margin by 2017.	• Rearing techniques developed and optimised for at least 3 insect species. • 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 2016. • Entomopathogens affecting at least 3 insect species colonies documented by 2016. • Wild harvesting techniques developed or adapted for at least 3 species by September 2016. • Effect of trap and post-harvest 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 2016.	• Rearing techniques for *Hermetia illucens*, *Gryllus bimaculatus* and *Acheta domesticus* optimized in Kenya and Uganda in 2016 • Microbial levels and effect of different processing techniques on insect based feed safety established • Chemical contamination in insect mass reared assessed and result indicated that the most important aspect affecting safety is the post-harvest handling. • Various insect based feeds were developed and tested on Tilapia, Cat Fish, Broilers and layers • The nutritive profile of 15 different feed formulations were assessed • Effect of insect based feeds at varying rates of insect inclusion was evaluated on layers of improved local chicken breed. Egg production level and egg quality were higher on insect based feed than conventional feed while feed intake and egg weight were similar • Insect based feed tested on Tilapia and cat fish resulted in higher growth rates compared to conventional feed	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
		• Effect of at least two insect based feeds on fish and poultry growth assessed by end of 2016. • Storage techniques developed for at least 3 insect based feeds by September 2016.	• Broilers fed on insect based feed had same feed intake and growth rate as those fed on conventional feed • A total of 5 insect species were tested as fish and poultry feed • Dry insects were conserved for 3 months with no deterioration of quality	
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 2016. • At least 10 media coverage stories on the INSFEED project by December 2016. • At least two policy briefs documented by December 2016. • 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 2016. • Documentation of processed feed leading to national and international standards (Codex) developed by December 2016.	• A total of 4 stakeholder workshops were in 2016. • The project achievement was reported on 15 web links • An insect based feed standard was developed in Kenya • The Ugandan insect based feed standard draft was initiated in 2016 • One situation paper was developed and submitted to peer reviewed journal • The process for standard development was developed for each country	
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.				
Pilot production and demonstration facilities established at *icipe* 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.	• Pilot production facility and feed sources for rearing BSF that is culturally and environmentally acceptable in Kenya documented by end of 2017.	• Mass rearing systems for black soldier fly (BSF) has been established and boosted to produce 80,000 – 120,000 4^{th} and 5^{th} larvae per week accounting for approximately 50 - 55 kg of frozen materials per week.	BSF can be reared on many waste streams to produce high quality protein.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			• *Beauveria* spp., *Metarhizium* spp., nematodes and mites documented in laboratory colonies of BSF in *icipe* • Differential susceptibility of BSF to *Beauveria bassiana* and *Metarhizium anisopliae* has been evaluated. ICIPE 32 was the most pathogenic isolate of *M. anisopliae* followed by ICIPE 69 while ICIPE 35 (cbb6) recorded the highest mortality among the *B. bassiana* isolates followed by ICIPE 35 (cbb15), ICIPE 620 and ICIPE 676. Mortality varied between 40 – 70 %. • Larval stages of BSF were the most susceptible (10 - 80%), followed by the prepupa (10 – 55%) to four entomopathogenic nematodes (EPNs) isolates (Mw8A, Naivasha, Palm and Yatta) • The effect of temperature on the development and survival BSF reared on agro-industrial waste supplemented with either water or brewer's yeast has been established at 8 constant temperatures (10, 15, 20, 25, 30, 35, 37 and 40°C). • Developmental and reproductive fitness of BSF reared on agro-industrial waste streams (Tusker, Guinness, Senator and Pilsner beer bi-products) have been established. The survival of the larval (85.6±3.78 - 99.2±0.80%), pre-pupa (70.6±3.64 - 95.4±3.63%) and pupa (65.4±5.41 - 90.8 ± 2.92) stages varied significantly across the different substrates.	Several threats can affect colony maintenance of BSF
Socio-economic surveys carried out on the use of insects for feed in poultry, fish and pig farming.	• Farmers and feed producers invest more in insect based feed production and use, and increase adoption by 2017.	• At least 500 small-scale farmers surveyed by end of 2017. • Comparative costs of at least 1 insect based feeds assessed by end 2017	• From 878 respondents, vegetables and floating pellets were the most common fish feed, and mixed feeds and home-grown grains for poultry. Pig production depended on purchased feeds and household food remains.	Farmer are willing to accept insects as alternative protein ingredients in poultry, fish and pig feeds

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
Market demand analysis for insects as feed ingredient for poultry, fish and conducted.		• Market demand and cost benefit analysis conducted for at least one insect based feed by 2017.	• More 70% of the farmers were aware and willing to buy insect-based feeds as an alternative to replace fishmeal and/or plant protein sources, and showed willingness to rear insects for sale to commercial feed manufacturers/processors. • 668 consumers (66.02% males and 33.98% females) revealed that >90% were willing to buy and consume animal products when reared on insect-based feeds.	
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	• At least 10 awareness stakeholders meeting organized • 5 radio spots realized • At least 30% of farmers attending awareness meetings consider insect as an alternative source of feed for poultry, pig and fish farm enterprises	• 4 awareness campaigns and 24 farmer groups visits were organized to sensitize farmers on the potential of insect as feeds for poultry, pig and fish. • 95 County policy makers were trained from Uasin Gishu, Kakamega, Nyeri and Kiambu Counties, respectively, to ensure buy-in and ownership of the project • Three media houses (NTV, KTN and Nation Newspaper) created awareness about insect based feed (https://www.youtube.com/watch?v=PrCz3fkF_HQ and https://www.youtube.com/watch?v=jSj8VQEaNeE). • Following the awareness campaigns, additional 214 young entrepreneurs (36.92% females and 63.08% males) have been trained in *icipe*.	Sensitization of farmers is very crucial in establishing insect-based enterprise The media plays a crucial role in the visibility of project activities
Capacity of youth and women farmers (small-scale and commercial) in mass-production, harvesting and primary processing of BSF (Black Soldier Fly) protein built	• Youth and women farmers (small-scale and small commercial) engage in mass-production, harvesting and primary processing of BSF	• At least 10 youth and 10 women groups trained in mass-production, harvesting and primary processing of BSF protein • At least 30% of the group members produce, harvest and process BSF	• A total of 24 model farmers from 24 different groups visited the *icipe* insect rearing facility for training on mass-production, harvesting and primary processing of BSF protein. • 24 farmer groups (100%) engaged in the application of insect-based technology are still at their early stage of production but are supplementing the diet of the free-range chickens with BSF	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
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	• At least one formulation for insect-based feeds for poultry, pigs and fish established and tested • At least two commercial small scale feed companies willing to take the nutritious insect based feed formulation for mass production	• Feed formulation for poultry and fish with inclusion of BSF larval diet has been established while formulation of feeds for weaning and starter pigs is currently being analyzed. • A total of eight small scale feed manufacturers are willing to take up production of insect-based feed for mass production after the training awareness campaigns across the different counties	
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	• At least one feed formulation is tested free from microbial pathogens and toxins, and can be proposed for mass production • At least two commercial small scale feed companies willing to take the safe insect based feed formulation for mass production	• Feed formulations with BSF have been tested and shown to be free of aflatoxin and pesticide residues. • Commonly observed pathogens on the black soldier fly larvae include *Escherichia coli*, *Salmonella typhi, Staphylococcus aureus* and faecal coliforms. • Postharvest handling measures have been established to sufficiently eliminate all possible bacteria and fungi contaminants rendering them safe for use in feeds.	
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	• At least one protocol and tool for production of safe insect-based feeds available • At least two small-scale feed processors use the protocol and tools for feed formulation	• Protocol for the producing safe insect-based feeds for poultry, pigs and fish have been established.	
Youth and women farmer groups linked to profitable markets e.g feed	• New sector for employment, value chain for insect protein created in Kenya	• At least 10 youth groups and 10 women groups	• Activities on trainings on marketing and marketing access as well as linked farmers to profitable markets for insect based feeds has been scheduled for 2017.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
companies for the insect-based protein products		linked to profitable markets for insect based feeds • At least 20% of the farmer group members are selling insects to small-scale feed processors		
Specific objective: Development and implementation of insect-based products to enhance food and nutritional security in sub-Saharan Africa (EntoNUTRI) by 2019				
Insect farming and harvesting techniques for edible saturniids, grasshoppers and crickets developed and production systems optimised using locally available substrates. The nutritional attributes of target insect species (fresh, stored and processed) established and appropriate post harvest technologies for preservation tested and implemented Food safety (chemical and microbiological) and regulatory requirements to inform policy on the use of insects as food established	• 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 Dec 2017 • Improved postharvest handling techniques for at least 2 edible insects developed by Dec 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 5 species of saturniid caterpillars and their natural enemies in Kenya identified. • Molecular characterization of the saturniid caterpillars and their natural enemies undertaken. • Stable colonies of at least 3 edible saturniids established at *icipe* laboratories • Improved mass rearing diets for *Scistocerca gregaria* and crickets, *Gryllus bimaculatus* developed • *Carotenoids, vitamins and proteins* are limiting nutrients in the development of a diet for *Scistocerca gregaria* and crickets, *Gryllus bimaculatus* identified • Nutritive profile of edible Saturniids established and they are found to be rich in crude proteins, limiting amino acids such as tryptophan and threonine, vitamin E, and flavonoids • The saturniid caterpillars stored under clean conditions were mostly free of harmful pathogens and aflatoxin producing fungus	In the first year of implementation the project has successfully initiated most of the activities Synergies with other on-going project initiatives in the Insects for Food and Feed program have been established to achieve the project outputs and outcomes.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			• Simple post harvest treatment technologies such as boiling for 5 min or more or toasting for 2 min can clear harmful pathogens • New strain of entomopathogen *Bionectria cf. ochroleuca* isolated from the cabbage tree emperor moth, *Bunaea alcinoe*	
Socio-economic assessment – 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		• 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 Dec 2018 • Economic situation of edible insects value chain actors assessed in 1 of the target countries by Sep 2018	• Activity in progress	
Innovations on insect farming and utilization as food transferred to beneficiaries and R&D capacity and entrepreneurship in the field disseminated		• ToTs on insects to enhance food and nutritional security undertaken for at least 40 stakeholders (20 each for Kenya and Uganda) by Dec 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 Mar 2019 • A project website established by Mar 2017 • Advanced level training of at least 4 PhD and 5 MSc students, especially	• Increased awareness among various stakeholders especially policy on the potential of edible insects were created through the international conference on *Legislation and Policy on the Use of Insect as Food and Feed in East Africa* and mass media communications. • 3 PhD and 2 MSc studies on-going	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
		women, from Africa and Germany accomplished by Mar 2019		
Specific Objective: Establishment of pilot commercial processing plant for food bait production for the management of fruit flies in Kenya by 2017				
A pilot-bait production facility with the capacity to produce 1000 litres of food bait built and operationalised.	• A pilot food bait production facility for fruit fly suppression and demonstration to private sector entrepreneurs, government representatives, and interested horticultural growers established in Kenya.	• Increase in food production and income generation of smallholder farmers • A protein pilot facility established and operational by December 2017	• The food bait production facility commissioned on 29 March 2017. • The product “Fruitfly Mania™” will be 70% cheaper than other commercial products. • The facility will produce 2,000 litres of food bait daily	Partnerships with the private sector are a good avenue to take technologies out to the growers who need them
Effective food attractants identified and developed through appropriate formulation for the management of fruit flies.	• Effective food attractants identified and developed from waste brewers yeast	• At least one effective fruit fly bait identified from waste brewer’s yeast • An effective locally-produced fruit fly bait available by December 2017	• Different waste brewer’s yeasts were screened to test their efficacy. Waste brewers yeast from senator and tusker beers performed best, capturing 4.8 and 3.6 flies/trap/day, respectively, compared to standard commercially available products such as Ceratrap®.	
Capacity of national systems and entrepreneurs in using facility to mass produce food bait transferred to the private sector	• Capacity of national systems and entrepreneurs enhanced	• At least 5 private sector entrepreneurs and government representatives trained on use/bait production by December 2017	• Softer bacterial based biopesticides (Venerate™ and Grandevo™) have been identified, and are being tested and validated as killings agents, to be an alternative to the use of synthetic chemical insecticides used bait spray for suppression of fruit flies	

2. Animal Health Results Based Management Report

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
Objective 1: To develop attractive and effective killing and repellent system for control of vectors of camel trypanosomiasis (surra) and to reduce vector and disease levels by 50% by 2020.				
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.	In 2016 the following were achieved: • Major surra target vectors identified • The diverse trypanosomes species affecting camel health identified • Potential attractant Semio-chemicals identified • Visual bait for biting flies identified • Larger Field trials are underway • Farmers training is planned	• Diverse biting flies and more complex trypanosomes species are responsible for camel trypanosomiaisis. • The impact of surra on Camel mortality, milk production, abortion and cost of treatment is significant. • The developed technology has to be broad based to target major surra vectors. • Community awareness and participation is very important.
Objective 2:- To upscale and adapt tsetse repellent technology in partnership with the private sector and to reduce trypanosomosis risk by 50% by 2020				
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*	This is on track, with the evaluation possible despite the drought, because of the Lake Victoria island location.	The drought in 2016 affected most of the filed implementation activities.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
		• At least 50% decrease in fly catches in presence of repellents.		
Integrated 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 and tsetse-free 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.	Evaluation of barrier system was very much dependent on large fly populations, but these were affected by prolonged drought. Upscaling has taken longer than anticipated because of prolonged drought, which slowed down field evaluation, and the slower than expected development of repellent release devices.	Registration of a product by regulatory authority takes time.
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.	Current dispensers are made by the private sector. The cost is adjudged to be higher than would be viable for smallholder farmers ~($50). New dispensers using durable synthetic materials are being tested.	
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	• No. of agreements signed. • No. of meetings held. • At least one design prototype tested for upscaling.	Market-ready dispenser not yet available, but under development with private sector under an agreement with the partner.	

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
	commercialisation of tsetse repellent technology • At least one local entrepreneur identified for manufacturing/ distribution of repellent collars.			
Business plan for commercialisation, packaging, product registration, marketing and dissemination for rollout of the technology developed. Advocacy of the repellent technology enhanced.	Business plan developed for commercialisation, dissemination, registration and roll out. Advocacy of repellent technology enhanced in collaboration with stakeholders.	• Business plan developed. • At least one P-P-P partner using the business plan. • At least 3 advocacy events undertaken.	• *icipe* project reports providing details on progress. • Business plans largely developed. • Additional Public–Private–Partnership established.	
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 with progress details. • Peer-reviewed publications.	
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	• Socio-economic impact study reports. • *icipe* project reports and M&E report available.	
Objective 3: A novel tsetse management strategy that is based on the use of bio-insecticide, and semiochemicals, developed and implemented by 2018.				
A novel approach to tsetse control based on bio-insecticide developed.	A novel tsetse control strategy based on bio-insecticide developed by 2019.	At least 3 fungal isolates screened for virulence, and efficacy in field application.	• Project reports providing progress with the field applications.	• Integration of technologies is critical for sustainability.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			• Scientific publications produced. • Theses completed. • Documented collaboration with veterinary services in place.	• Participation of stakeholders provides a valuable community of practice in IVM.
Biopesticide technology field tested and incorporated in integrated tsetse management program.		Combination of fungal pathogen and semiochemicals tested.		

3. Human Health Results Based Management Report

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
Objective 1: Contribute towards malaria elimination through the development of effective vector control strategies and public health initiatives by 2020.				
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	• Comprehensive evaluation reports of icipe IVM projects in Kenya and Ethiopia published. • New IVM proposal documents	An external evaluation report of the malaria IVM project phase 2013-2015 was completed and submitted to icipe and the funding agency – Biovision during 2016. Implementation of a new malaria IVM project phase 2016-2018 commenced at the field sites in Kenya and Ethiopia in January 2016, funded by Biovision. *icipe* was invited by WHO-AFRO to submit a proposal for a regional project to evaluate the feasibility of IVM in six southern African countries still using DDT for malaria control including Botswana, Swaziland, Namibia, Mozambique, Zambia and Zimbabwe.	IVM is now widely viewed as a pathway to sustainable malaria control and elimination due to its capacity to address ecological, social and institutional issues related to the disease. Past and ongoing IVM research at *icipe* provides the institution with comparative advantage to explore further funding on implementation research for IVM.
Implementation of integrated vector management (IVM) promoted to improve health	• At least 60% increased awareness among communities on IVM	• Number of community members trained.	Investigations on existing and new community structures and networks with capacity to help	IVM is feasible at community level and will also get support from policy makers when there is

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
and livelihoods of communities in malaria-affected areas of Kenya and Ethiopia.	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 combinations of vector control methods (non-chemical/chemical) being used by national programmes. • 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. • Improvement in socio-economic status of households. • Number of articles published in peer reviewed journals.	sustain IVM for malaria control continued to be undertaken in all the three project sites during 2016. Community health workers (CHWs) were recognized as being particularly strategic in view of the nature of their routine work. Systematic training of CHWs in malaria control and IVM was undertaken as a pilot activity in Malindi. An estimated 34,400 people at project sites in Kenya and 7,140 in Ethiopia were reached with IVM awareness messages through different means including community meetings, door to door visits and school malaria and health clubs. Approximately 50% of those receiving the awareness creation messages were females. Villages implementing IVM involving use of long-lasting insecticide-treated nets (LLINs), larviciding with *Bti* and community education and mobilization in Tolay, Ethiopia	operational research evidence to demonstrate its effectiveness and impact in clearly defined settings, and is accompanied by continuous capacity-building and advocacy among all relevant stakeholders. IVM interventions need to be carefully selected so as to take account of geographic, environmental and seasonal variations likely to influence distribution of vector breeding sites and disease transmission. This will help in optimizing the interventions and minimize wastage of resources. Studies to evaluate feasibility of IVM require substantial funding in view of the need to have them include detailed epidemiological, entomological and socio-economic assessments.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			were found to have less than 50% the number of *Anopheles* (malaria) mosquitoes compared to those with only the conventional usage of long-lasting insecticide treated nets. A 40-70% reduction in malaria parasite prevalence was similarly associated with the integrated combination of interventions in Tolay, but not at the other two IVM project sites – Malindi and Nyabondo in Kenya. The IVM research, therefore, demonstrated that integration of interventions leads to further reductions in malaria, than is normally achieved with LLINs only, especially in settings of low disease prevalence. Settings with high disease prevalence may require correspondingly more comprehensive suite of mosquito control methods, directed at both larval and adult mosquito populations in order to significantly reduce both vector populations and malaria.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			Using analyses of house-hold socio-economic data malaria was found to negatively affect agricultural productivity in Tolay due to reduced crop yield and labour productivity. During 2016, Uzimax - the plant-derived mosquito larvicide developed by the project during the previous research phase was found to have no toxicity against non-target organisms (insects and mammals). It was shown to be eco-friendly and safe for handling during application at the recommended and even higher dosages. Samples of *Uzimax* were produced and submitted to the Pesticide Control Products Board (PCPB) for independent efficacy and safety testing before registration.	
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.	Ten-day IVM training course conducted for participants from Ethiopia, Eritrea and Madagascar in July 2016. *icipe's* participation as a co-executing partner in	Key milestones achieved at the national level included the upgrading of the multi-sectoral IVM steering committee in Kenya to an inter-agency coordinating committee hosted by the Vector-Borne Disease	*icipe* is strategically placed to serve as the leading institution for capacity building in IVM for control/elimination of malaria and other vector-borne diseases in eastern and southern African region.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	• *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	October/November 2016 during the launching of the Global Environment Facility (GEF)/UNEP-funded AFRO-II project whose main Executing Agency is WHO-AFRO	Control Unit. In Ethiopia, the Ministry of Health formally recognized the IVM working group as an entity within the vector control department. In Kenya, 20 policy makers benefited from being facilitated to exchange updated information on the potential of IVM towards elimination of multiple vector-borne diseases including malaria and arboviruses such as dengue. Participants from different sectors contributed practical ideas for inter-sectoral action needed for a pilot MOH IVM project to control of multiple vector-borne diseases (malaria, filariasis, schistosomiasis) in Kwale County in coastal Kenya. In Ethiopia, ten participants shared with another ten the knowledge and experience they had gathered during a two-week IVM training course organized by *icipe* and WHO-AFRO in Nairobi in July 2016.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			At the regional level, the invitation of icipe by WHO-AFRO to lead in the evaluation of IVM in six DDT-using countries in southern Africa was a significant achievement towards IVM capacity-building and scaling out in Africa.	
A potent synthetic lure derived from screening three mosquito-preferred plants developed.	Scientists' use of synthetic lure in at least one malaria endemic site in Kenya.	• Number of peer-reviewed publications. • Number of proposals. • Graduate student thesis. • Availability of lure.	• 3 more natural host plants for the malaria vector, *Anopheles gambiae* sl identified using molecular methods • 1 Ph D thesis produced • 2 oral presentations at International Conferences	DNA barcoding useful in identifying host plants for other disease vectors
At least two chemical-based technologies for surveillance and/or disruption of malaria transmission developed.	• Odour-baited traps used for malaria control in at least one community by 2015. • 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	• 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	• In 2015 the SolarMal project was completed where over a period of 5 years odour-baited traps were used on community level (covering 25,000 people) to protect households from malaria. The results were published in The Lancet Volume 388, No. 10050, p1193–1201, on 17 September 2016. The results have shown moderate impact on	• Calibration of semi-field systems and human landing catchers used for mosquito collections is vital prior to implementing main experiments to establish the natural baseline variability in data. • Natural data variability must be used to calculate sample sizes for experiments in order to generate robust data on mosquito behaviour towards odour sources.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	government and/or non-governmental agencies by 2020.	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.	malaria transmission highlighting several areas for improvement of an attract and kill strategy towards push-pull strategies. • To address outstanding questions, this objective has been extended in in 2016, and two new projects are currently implemented to develop novel oduor-based push-pull strategies by end of 2019. • Two large semi-field systems built at ITOC and calibrated for experimental use by end December 2016. • Odour-baited traps used in various research projects for mosquito sampling and routine surveillance in 2016. • Traps further developed to improve catching efficiency by testing alternative chemicals to CO_2, combinations with visual cues. This work is still ongoing.	• Basic research required to develop functional push-pull concept, this includes the identification of odour-oriented behaviour of malaria vectors to spatial repellents, replacement of CO2 in traps, placement of traps in space for optimal interaction, airsampling to better understand diffusion of chemicals in space and over time. • Optimization of lure required for multi-site use

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			• Small pilot field study implemented in Ahero Rice irrigation to test push and pull strategies for malaria vector control. Data collection will be complete by end June 2017, when data will be analyzed. • 1 PhD student enrolled in study (2017-2019) to implement basic research to inform key determinants of push-pull systems. PUBLICATIONS: • Hiscox et al. 2016. Mass mosquito trapping for malaria control in western Kenya: study protocol for a stepped wedge cluster-randomised trial. Trials. DOI 10.1186/s13063-016-1469-z • Homan et al. 2016. Spatially variable risk factors for malaria in a geographically heterogeneous landscape, western Kenya: an explorative study. Malaria Journal.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			DOI 10.1186/s12936-015-1044-1 • Homan et al. 2016. The effect of mass mosquito trapping on malaria transmission and disease burden (SolarMal): a stepped-wedge cluster-randomised trial. The Lancet. doi.org/10.1016/S0140-6736(16)30445-7 • Silkey et al. 2016. Design of trials for interrupting the transmission of endemic pathogens. Trials. DOI 10.1186/s13063-016-1378-1 • Menger et al. 2016. Eave screening and push-pull tactics to reduce house entry by vectors of malaria. American Journal of Tropical Medicine and Hygiene. doi:10.4269/ajtmh.15-0632	
The symbiotic microbes harboured by mosquitoes as potential tools to control malaria transmission investigated.	• Detailed survey of the symbiotic microbes associated with vector mosquitoes.	No. peer-reviewed publications.	• Survey of the symbiotic microbes associated with Anopheles vector mosquitoes complete. A novel strain of Spiroplasma	• Experiments to determine the effect of *Spiroplasma* on Plasmodium transmission required approvals from KEMRI ethics committee. This was a

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	• Experimental investigation into the effects of harbouring symbiotic microbes on mosquito vector biology. • Investigation into the potential of using microbial symbionts to block disease transmission.		found in *Anopheles* mosquitoes. • An experimental investigation into the effects of harbouring *Spiroplasma* on mosquito vector biology has been carried out and it has been found that *Spiroplasma* affects mosquito fertility. • Experiments to determine the effect of *Spiroplasma* on Plasmodium transmission are ongoing.	critical but long process that requires about 12 months.
Innovative application strategies of novel, persistent insecticides for *An. gambiae* developed.	• Optimum concentration of insecticides for malaria control used by the communities in western Kenya by 2020. An 'attract-and-kill' strategy adapted by combining oviposition attractants with long-lasting larvicides developed and used by communities by 2020.	• Increased interest in larval source management by national malaria control programmes (NMCPs). • Rationalised larval source management strategies for malaria control. • Use of novel insecticides in national programmes. • No. peer-reviewed publications. • Books. No. theses produced.	• Insect growth regulators were tested for attract and kill approaches in semi-field settings will limited success. One manuscript is currently drafted to be submitted by July 2017. • Another manuscript is currently drafted to highlight the potential of using insect growth regulators for the control of immature tsages of mosquitoes by targeting the intervention in time, manuscript to be submitted by July 2017.	• Insect growth regulators (pyriproxyfen) might be an excellent tool for vector control, it persists over 3 weeks in aquatic environment requiring only monthly application. • Targeting larval control in time for 3-4 months per year is an effective way to integrate this tool with personal protection measures. • Horizontal transfer of larvicides seems not a very effective way for larval control.

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
			• Increased interest of governments to use larval control tools for malaria control has been indicated by their inclusion of the tool in national strategy guidelines and also increased interest at RBMs Larval Source Management work stream.	
Objective 2: Preventing and controlling Rift Valley fever in Kenya: An Eco-health approach by 2018.				
Progress towards achieving the following specific objectives observed: **Specific Objective 2.1: To develop a cost-efficient sampling and effective project implementation strategy that is feasible among remote pastoral communities in North Eastern Kenya by 2016.** **Specific Objective 2.2: To better understand changing risk pathways and vulnerabilities related to RVF (vectors, pathogens, livelihoods) in the context of climate change and agro environmental transformations by 2016.** **Specific Objective 2.3: To understand the impact of the current mode of communication and infrastructure development on access and barriers to the use of human and animal health care for pastoral communities by 2016.** **Specific Objective 2.4: To identify and test feasibility for possible multi-stakeholder development modalities that translate into enhanced prevention and control of RVF by 2016**				
2.1 Pastoralists and stakeholders in NE, Garissa County engaged, to understand pastoral system dynamics.	• Project team understands the nomadic pastoral system (NPS) and decides on sampling plan.	• Meeting with community and stakeholders to discuss project and pastoral system.	• The project team gained a better understanding of the dynamics that contribute to the decision making and process in movement of livestock in a nomadic pastoral system and how this can be put to use to guide farmers on avoidance of disease risk areas and in	• Through scientific mapping, data collection and participatory mapping with the community, we learned that the livestock movement in search of pasture and water in a nomadic pastoral system is not random and

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			tracking herds to facilitate vaccination when outbreak alerts are issued.	haphazard but are guided by well structured community traditions and processes that should be well captured and documented to be able to support communities in disease prevention and control
2.2. . Circulation of RVF virus in animals, vectors and humans within the nomadic pastoral system (NPS) determined.	• Research team identifies evidence of virus activity and/or transmission potential within the NPS.	• Publications. 1. Arum SO, et al. Plant resting site preferences and parity rates among the vectors of Rift Valley Fever in northeastern Kenya. Parasit Vectors. 2016 May 31;9(1):310. 2. Arum SO, et al. Distribution and diversity of the vectors of Rift Valley fever along the livestock movement routes in the northeastern and coastal regions of Kenya. Parasit Vectors. 2015 May 28;8:294. 3. Owange NO, et al. Perceived risk factors and risk pathways of Rift Valley fever in cattle in Ijara district, Kenya. Onderstepoort J Vet	• The research team has gained an understanding of the circulation of RVF virus in livestock, human population and vectors that can be associated with the nomadic pastoralists system and the movement of animals through diverse ecologies. The knowledge gained and shared in public domain through publications will influence future decisions on RVF control and prevention	• The research team has a clear understanding of the extent and seasonal circulation of the RVF among the diverse host systems and the areas within the livestock movement routes that present more risk to the animals and herders in terms of exposure to disease. The information will improve perspective of animal and public health authorities in terms of approach to disease prevention

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
		Res. 2014 Nov 20;81(1). doi: 10.4102/ojvr.v81i1.780. PubMed PMID: 25686079. • Reports. Final technical report submitted to IDRC, who funded the project. • Stakeholder farmer meetings. Meetings and workshops held with farmers to provide lessons from the project		
2.3. The impact of developmental change on RVF control determined.	• Awareness on use of infrastructural development to prevent/reduce RVF outbreaks.	• Reports. • Publication: 1. Muga GO, et al Sociocultural and economic dimensions of Rift Valley fever. Am J Trop Med Hyg. 2015 Apr;92(4):730-8 2. Abdi IH, et al Knowledge, Attitudes and Practices (KAP) on Rift Valley Fever among Pastoralist Communities of Ijara District, North Eastern Kenya. PLoS Negl Trop Dis. 2015 Nov 13;9(11):	The team gained knowledge on the socio-cultural dimensions that influence community vulnerability to disease impact and their coping mechanisms. The knowledge is now available in public domain for application.	That pastoral nomadic communities hold hard to their practices and beliefs and we must work hard to changes some of the practices that predispose them to disease.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
2.4 Potential opportunities for RVF control identified.	Awareness about RVF community based preventive measures.	• Community and stakeholder meetings. • Publications. • Reports.	• 1 feedback workshop on RVF organized involving 29 participants- farmers, CHWs, MOH, from Ijara subcounty, Veterinary and Public Health, DVS and and Zoonotic Disease Unit (ZDU). • 24 CHWs mobilised to conduct awareness campaigns on RVF preventive strategies through monthly community dialogue days in Ijara sub-County, impacting on about 250 households. • 10 enumerators trained to collect data using questionnaires, a skill they can apply to other projects in their areas. • 10 awareness campaigns on RVF preventive strategies conducted monthly through community dialogue days in Korisa and Bulagolol Hologho, subcounty, Ijara County, Kenya • 1 manuscript submitted	Communities can be trained and empowered to reduce their risk of exposure to RVF infection

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
Objective 3: Epidemiologic assessment of risk of yellow fever (YF) and dengue (DEN) transmission and outbreaks in Kenya				
Progress toward achieving specific objectives observed: **Specific Objective 3.1. To determine existence and locality of YF, DEN transmission foci in Northern Kenya at border with endemic countries.** **Specific Objective 3.2. Assess vector species presence and their YF/DEN vector potential in the selected areas.** **Specific Objective 3.3. To assess the potential for urban *Aedes* vectors to sustain an outbreak in major urban centers in Kenya** **Specific Objective 3.4. To develop trapping tools for conducting vector surveillance to improve surveillance of YF and dengue**				
3.1. 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.	• The research team has established by serologic surveys, the presence and extent of YF and DEN activity among primates and human population in West Pokot (Kacheliba) site at the border with the Uganda. • That there is movement of primate troupes across the two borders but to a limited extent	• Work is still on-going
3.2. 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.	• The research team has observed the presence of potential vectors of YF and DEN in West Pokot (Kacheliba) site at the border with the Uganda which would possibly lead to transmission if the virus was to get there through travel and/or	• Work is still ongoing on the same.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			movement of infected people and primates. • However, the study has also observed that the vector population has low vectorial capacity in transmitting YF.	
3.3. 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. Submitted to PLOS NTD for consideration *Assessment of Risk of Transmission of Dengue and Yellow Fever viruses in major cities in Kenya based on Stegomyia indices Sheila B. Agha1,3, David P. Tchouassi1, Armanda D.S. Bastos3, Rosemary Sang1,* • Donor reports. Annual donor report has been submitted to NIH. • Stakeholder information sharing meetings	• The research group has established risk levels for transmission of YF and DEN in major cities in Kenya using the stegomyia indices determination with low risk for YF in all the cities and medium to high risk for DEN in Kisumu and Mombasa and low risk for Nairobi. • Further, the research has shown low vectorial capacity of mosquitoes from Mombasa, Kisumu and Nairobi for YF transmission. More data is being collected.	• Work still ongoing.
3.4 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.	• An odor bait screened for forest dwelling Aedes mosquito species	Previously established protocol(s) provide useful framework for developing

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			• Chemical profile differences established for different primates and humans	improved disease surveillance tools

4. Environmental Health Results Based Management Report

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
Objective 1: Survey, inventory, and description of new species of East African insects published and data made internet-accessible by 2020.				
1. At least 10 taxonomists agree to study and publish results of examination of insects collected in Burundi and Kenya.	Taxonomists agree to study East African specimens.	Number of taxonomists agreeing to participate.	Expansion of collaborators as follows: Michael Engel and Zachary Falin, Kansas University, USA. Lynn Kimsey, Univ. California Davis, USA Scott Shaw, University of Wyoming, USA Simon Van Noort, Iziko Museum, Capetown, South Africa (SA) Jason Londt, KwaZuluNatal Museum, Pietermaritzburg, SA Gerard Delvare, CIRAD, Montferier-sur-Lez Cedex, France Celso Azevedo, Universidade Federal do Espirito Santo, Brazil Volker Lohrmann and Michael Ohl, Museum für Naturkunde, Berlin Val Korneyev, Schmalhausen Institute of Zoology, Kiev, Ukraine	Many taxonomists are identified who are interested in studying the East African insect fauna. Collaborators include scientists from5 continents.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			Matt Buffington, Scott Miller, David Adamski, and Elijah Talamas, US National Museum of Natural History, Washington DC Ashley Kirk-Spriggs, National Museum, Bloemfontein, South Africa Massimo Olmi, Tropical Entomology Research Center, Viterbo, Italy Ulrike Aspöck, Naturhistorisches Museum, Vienna, Austria Geoff Hancock, The Hunterian (Zoology Museum), Glasgow, Scotland Alain Roques, INRA, Orleans, France Gary Gibson and Lubo Masner, CNCI, Ottawa, Canada Norm Johnson, Ohio State University, USA Chang-Jun Kim, Yeungnam University, Gyeongbuk, Republic of Korea Marc De Meyer, MRAC, Tervuren, Belgium	
2. At least 10 manuscripts produced by 2015 exclusively devoted to, or incorporating significant numbers of, East	Taxonomists study and publish on East African insect taxa.	Number of manuscripts published on generic revisions, species descriptions, and regional checklists.	Buffington, M.L. & R.S. Copeland. 2016. Redescription of *Helorus ruficornis* Förster (Hymenoptera: Heloridae) with a new synonymy and new Afrotropical specimen	Taxonomist colleagues continue to collaborate on new manuscripts.

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
African insect taxa.			records. Proceedings of the Entomological Society of Washington 118: 330-344. De Meyer, M., M. Mwatawala, R.S. Copeland & M. Virgilio. 2016. Description of new *Ceratitis* species (Diptera: Tephritidae) from Africa, or how morphological and DNA data are complementary in discovering unknown species and matching sexes. European Journal of Taxonomy 233: 1–23. Copeland, R.S., Q. Luke, and J.W. Muriuki. A Natural History of the Wild Fruits of the Taita Hills, Kenya. 2016 an online book. http://chiesa.icipe.org/index.php/news-events/147-a-natural-history-of-the-wild-fruits-of-taita-hills-kenya. pp. 421. Roques, A., R.S. Copeland, L. Soldati, O. Denux & M-A. Auger-Rozenburg. 2016. *Megastgimus* seed chalcids (Hymenoptera, Torymidae) radiated much more on Angiosperms than previously considered. 1. Description of 8 new species from Kenya, with a key to the females of Eastern and Southern Africa. ZooKeys 585: 51-124. Talamas, E.J., I. Mikó & R.S. Copeland. Revision of *Dvivarnus* (Scelionidae: Teleasinae) 2016. Journal of Hymenoptera Research 49: 1-23.	

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
Objective 2: Collection of one-year Malaise trap sampling in climate-change threatened coastal forest (Kaya Kinondo) made as part of International Barcode of Life's Global Malaise Project and delivered to University of Guelph by 2016.				
1. One years' worth of preserved insect samples sent to University of Guelph for processing and barcoding by 2017.	Data on threatened insects published online and made available to conservation biologists, taxonomists and interested parties	Number of barcodes generated.	52 one-week samples were sent to the International Barcode of Life project, Guelph, from Kaya Kinondo Forest, a near sea level site threatened by rising ocean levels due to global warming. To date 7599 specimens have been barcoded.	IBOL has encountered some difficulty in securing funds to support their Global Malaise Trap project. Nonetheless, good progress has been made to date on the Kinondo samples. Hymenoptera continue to be difficult subjects for generating barcodes with currently used general insect primers, a situation that has persisted for several years now.
Objective 3: Taxonomic information on African insects including major African pests and vectors used by scientists, students and public by 2020.				
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.	The total number of specimens with successfully generated barcodes has passed 10,000. This number includes the specimens barcoded in the Kinondo Forest Project (IBOL's Global Malaise Trap Project) as well as specimens collected earlier during the Kenya Node IBOL-funded barcode projects on Kenyan Hymenoptera, Diptera and Lepidoptera, among others.	IBOL continues to have problems with a general primer for use in Hymenoptera. Consequently, more family specific primers need to be developed.

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2. Three trainings 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.	Fourteen ICIPE doctoral students completed a 2-week training in insect morphology and identification. By the end of the course students were able to identify most of the families of Chalcidoidea, the most family-rich group of parasitoids. Considering that the majority of students have not had an introductory Entomology course as undergraduates this was quite an accomplishment.	
3. African Insect Taxonomy Toolkit continuously updated (http://taxonomy.icipe.org)	• Scientists and others make periodic use of taxonomic literature and tools.	• External access rates are monitored.	The resource will be re-activated on ICIPE's new website, reviewed for utility and compliance with copyright laws.	
4. At least four donor-funded projects with relevant taxonomic perspective request and receive taxonomic support from the Biosystematics Support Unit by 2017.	• Scientists incorporate taxonomic information into planning and carrying out of projects.	• Number of projects funded that incorporate taxonomic data.	Projects from all 4 ICIPE health themes utilized the taxonomic and/ or photographic services of the Biosystematics Unit during 2016 and included; 1. AIV-IPM: Enhancing the livelihood opportunities of smallholder African indigenous vegetable (AIV) producers through the development and implementation of IPM measures for arthropod and nematode pests. 2. Development and implementation of a sustainable IPM and surveillance programme for the invasive tomato leafminer, Tuta absoluta, in North and sub Saharan Africa. 3. Strengthening Citrus production systems through the introduction of IPM measures for	BSU has provided support services to a wide spectrum of ICIPE projects from the 4H themes. The unit has concerns that the implementation of monetiziation of the institutes service units might lead to a reduction in demand which could impact negatively on project outputs.

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			pests and diseases in Kenya and Tanzania (SCIPM). 4. AFS4FOOD - Enhancing food security and well-being of rural African households through improved synergy between agroforestry systems and food-crops 5. INSFEED: Insect feed for poultry and fish production in sub Saharan Africa 6. ILIPA: Improving livelihood by increasing livestock production in Africa 7. Development of low cost, low environmental impact surra control technologies and strategies developed for camel diseases vectors (within the Integrated Biological Control Applied Research Programme -- IBCARP) 8. Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA) 9. Development and evaluation of nectar-based lures for the management of selected mosquito disease vectors.	
5. Aquatic insects of streams in East Usambara area of Tanzania are identified and local groups are	• Local groups of farmers are capable of identifying these insects, and can monitor the quality of streams.	• Number of community members trained.	1386 members of farming communities in the East Usambara (Tanzania) and Kakamega Forest (Kenya) areas were given sensitization training on environmental conservation through training in water quality evaluation using aquatic	The continued interest showed by school children has led to the funding by BIOVISION for a 2nd phase of the project. This new

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trained in their identification by 2014.			macroinvertebrates. During this training participants learned to identify higher taxonomic units. The gender breakdown of participating farmers was 720/666 (m/f), approaching parity.	phase will concentrate on schoolchildren and integrate the conservation theme into the school curriculum.
Objective 4: At least 6 new eco-friendly nature-based products for pests and vector control adopted for improvement of livelihoods of rural and wider community members by year 2020				
4.1.1 At least 4 new potential products for mosquito control identified from plants based on efficacy, safety and ease of application. 4.1.2 Atleast 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. Atleast 2 PhD and 2 MSc students trained.	• Two plant-derived insecticidal product adopted for use in mosquito control by a local community by 2019. • Three papers or patents on potential mosquito control products published by 2018.	• Number of products produced and used. • Number of community members using the mosquito control products. • Number of reports and publications. • Number of students trained.	• Through toxicity evaluation on non-target organisms (insects and mammals) and evaluation of its physical and chemical properties, the mosquito larvicide, *Uzimax*, has been shown to be eco-friendly, biodegradable, stable and safe for handling during application at the recommended and even higher dosages. A registration dossier was compiled which contained detailed data on efficacy, toxicity and physical properties of *Uzimax*, including its mode of action and application. It was submitted to the Pest Control Products Board (PCPB) of Kenya for registration. Following review of the dossier by PCPB, the dossier was approved for the second phase of the registration process. For the second phase, the project was issued with 3 test permits by PCPB to undertake independent evaluation of efficacy, toxicology, physical and chemical properties of Uzimax as a requirement before registration. The tests were to be undertaken by PCPB appointed institutions that included the following:	• There is a major potential for use of plants in vector control particularly with rural Community participation.

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4.1.6. At least three papers prepared and submitted to international journals.			• Studies on physical and chemical properties of UZIMAX EC, to be undertaken by the Chemical and Industrial Consultancy Unit at the Department of Chemistry, University of Nairobi; • Acute toxicity tests for UZIMAX EC including: Acute oral toxicity, acute dermal toxicity, eye irritation, acute inhalation, skin irritation and skin sensitization tests, to be undertaken by Department of Anatomy and Physiology, Faculty of Veterinary Medicine, University of Nairobi; • Efficacy trials at semi-field and field level, to be undertaken by the Malaria Control Unit, Ministry of Health. • So far, independent studies on physical and chemical properties, and acute toxicity tests have been undertaken and those of physical and chemical properties submitted to PCPB. Those of efficacy trials at semi-field and field level have not yet been undertaken. • A water soluble formulation of an additional insecticidal and medicinal plant named *icipe*-MedPlant-31 was developed that was very effective as a larvicide against the larvae of the 3 mosquito species, *A. gambiae*, *A. arabiensis* and *C. quifasciatus* in the laboratory and under semi-field	

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			conditions. The results indicated that the *icipe*-MedPlant-31 formulation had great potential for practical application in the control of mosquito larvae. • Community-based cultivation of 2 insecticidal plants ongoing. • 5 Ph.D. and 2 M.Sc. students trained. • Patent: 1. Lwande W., Ochola J. B., Marubu R. M., Moreka L., Nduguli F.W. and Ligare J., Composition and Method for Controlling Larvae. Patent No: KE/UM/2015/00569. Manuscripts: 1. Obare B., Yole D., Nonoh J., Lwande W. (2016). Evaluation of cercaricidal and miracicidal activity of selected plant extracts against larval stages of *Schistosoma mansoni*. *Journal of Natural Sciences Research.* 6 (22): 24-31. 2. Obare B., Yole D., Nonoh J., Lwande W. (2016). Molluscicidal activity of selected plant extracts against adult and juvenile *Biomphalaria pfeifferi. Journal of Biology, Agriculture and Healthcare*. 6 (22): 31-38.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
			3. Mutero C.M., Mbogo C., Mwangangi J., Imbahale S., Kibe L., Orindi B., Girma M., Njui A., Lwande W., Affognon H., Gichuki C. and Mukabana W.R. (2015) An assessment of participatory integrated vector management for malaria control in Kenya. *Environmental Health Perspectives*, 123(11):1145-1151. (http://dx.doi.org/10.1289/ehp.1408748). 4. Moghadam S. E., Ebrahimi S. N., Gafner F., Ochola J. B., Marubu R. M., Lwande W., Haller B. F., Salehi P., Hamburger M. (2015) Metabolite Profiling for Caffeic Acid Oligomers in *Satureja biflora. Crops and Products.* 76: 892-899.	
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.	• One plant-derived product for honeybee pests/diseases control adopted for production and in use by 2018. • Two publications/utility model/patent on potential honeybee pest control products published by 2018.	• Number of products produced and used. • Number of reports and publications.	• *Apicure,* a shelf-stable plant-based fumigant biopesticide product that was developed for control of bee pests in beehives was further validated in Burkina Faso under semi-field and field conditions, where it was shown to be effective in killing varroa mites and repelling hive beetles in bee colonies. • Compilation of a registration dossier for *Apicure,* a shelf-stable plant-based fumigant biopesticide product that was developed for control of bee pests in beehives was completed. The process of its submission to the Pest Control Products Board (PCPB) of Kenya was initiated. It will subsequently be	• There is a major potential for use of plants in vector control particularly with rural Community participation.

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4.2.4. Protocols for production of the bee pest/disease control product established.			modified for submission to other African countries. • Production of *Apicure* biopesticide was initiated with 18,000 pieces produced for validation in other African countries; • Community-based domestication and cultivation of one repellent plant, *Ocimum kilimandcharicum,* continued to be undertaken by over 1000 households in Kenya and Tanzania. • Two community-based facilities for processing the repellent plant continued to operate in Kenya and Tanzania. • Over 20,626 pieces of products products produced by participating community members. Patent: • Lwande W., Marubu R. M., Ochola J. B., Nguku E. and Raina S., Composition and methods for controlling a bee pest or disease, Patent No: KE/UM/2015/00554 • An international patent application on *Apicure* was filed at the World Intellectual Property Organisation (WIPO): PCT/IB2016/055576.	

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Objective 5: Geographic information systems are fully integrated as a strategic research tool for *icipe* by 2020.				
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 2016. • Number of peer reviewed papers on the use of GIS and remote sensing in insect science and climate change studies published.	• Three GIS and RS training courses were given; ARPPIS and DRiP student training was given in February (14 participants), a ICIPE-WHO AFRO Regional IVM Training course was given in July (20 participants being various backgrounds), and a Thrive Training course was given in Mbita in March (14 participants). • More than 3 ARPPIS students used their GIS and RS knowledge to produce maps showing their results in various publications and the thesis itself (i.e. Yvonne Ajamma Ukamaka,) • 2 key note presentations were given, one to the AFRIGEOS Symposium (Zimbabwe) and another one to the Global Research Council's meeting in Maputo (Mozambique). Another invited talk was given to staff members of the University of Nottingham (UK) at the launch of their AgriGIS crop project. • Two new papers were published that included GIS and RS variables from the GI-Unit (Dubovyk et al., 2016; Mosomtai et al., 2016)	• Icipe colleagues and ARPPIS students need more specific training and self-help knowledge so that the knowledge gained can be self-sufficiently used (without further help from the GI-Unit).
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.	• In 2016 one new project was granted in which GIS and RS plays a pivotal role (push-pull scaling Southern Africa). • Proposals within icipe that included a GIS and RS part in icipe rose significantly	• Although many proposals were written, only one was funded., thus more specific and smaller grant

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			• Over 12 proposals were written that included a GIS and RS component (donors/programme; AU, GIZ, EU, BIOVISION, GCRF, NIH, GCE, etc.). • The unit an award from the European Space Agency (ESA) for the best paper given at the ESA Living Planet Symposium in Prag, May 2016 (http://www.icipe.org/news/icipe-mln-research-recognised)	programmes with fewer consortium members and less overall grant sizes need to be targeted.
3. Remote sensing (ecological) variables are derived and used for disease mapping.	• Disease assessments are localized/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.	• A data portal that collates ecological variables from remote sensing and other variables for mapping RVF in central and north-eastern Kenya (Lamu to Baringo County) was improved by adding new RS-derived vegetation seasonality variables and the results published. • Several proposals were made to NIH and GCE on ecological mapping of Malaria and Leishmaniasis to improve disease transmission risks assessments in Kenya.	• Disease mapping is a very competitive field and thus more publications and staff development is needed.
4. Operational species diversity mapping framework developed.	• *icipe* can use operational shared decision making (SDM) framework for enhanced decision making in IPM and as a marketing tool for funding.	• Number of ecological and remote sensing models available and significantly understood.	• Innovative seasonality variables were derived from satellite time-series data and a publication was submitted that shows the pest model improvements using RS variables. The SDM framework is set up for Kenya and Ethiopia	• The GI Unit should develop a continental (Africa) SDM-based bee pest distribution product to maximize visibility and impact
Objective 6: Increasing honey and silk production by 20% in selected African farming communities by 2020.				
1. Potential and healthy silk and bee races identified for enterprise	60% of the farmers use improved bee and silk races.	• Number of farmers using improved races. • No. of races produced.	• 1.18million silkworm eggs (59boxes) distributed to 3 Silk Farmers' Associations in Uganda and Madagascar; and 17 house hold based silk farmers in Kenya. These eggs	• Encourage beekeepers to work with locally available races to

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development in Africa by 2017. 2. Healthy silk and bee races are distributed to 3000 trainers for the farmer groups. 3. At least 15 PhD and 10 MSc. students trained. 4. At least 50 peer reviewed papers and 5 books/proceedings published in international journals.		• No. of manuscripts published.	support rearing and cocoon production enterprises. • Efficacy trials on eri silkworm *Samia cynthia ricini* Boisduval undertaken with the aim of introducing the silkworms and in addition contribute towards use of the castor plant in Kenya to produce eri silk for cottage industries in the country. • Two (2) new papers published that highlight properties of selected *Bombyx mori* strains, and processing techniques (Nguku et al, 2016; Ngoka et al, 2016).	minimize introduction of pests and pathogens.
5. Training material developed. Training sessions held for 2000 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.	• A total of 3,030 farmers trained in modern beekeeping techniques ○ Ethiopia: 523 (86 Female & 437 male) ○ Liberia 465 (150 Female & 315 male ○ Madagascar: 86 ○ Kenya: 303 ○ 5 Island Nations: 1,653 (575 Female & 1,078 male) • At least 1,483 beekeepers practicing modern beekeeping using moveable frames hives. • At least 107 silkworm farmers applying rearing techniques to support cocoon production.	• Farmer to farmer extension model needs to be explored to supplement government extension services. • There is need to adapt training materials to address site specific challenges.
6. Business model developed using value chain approach.	Business model and business responsibility adopted by at least 400 farmer groups.	Number of enterprises registered.	Twenty (20) beekeeping associations registered in nine (9) countries, involved in training, product bulking, value addition, organic certification and marketing of hive products.	• There is need to link associations with the private sector for capacity building and

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				market/business opportunities.
7. 16 to 20 marketplaces (honey and silk harvesting, processing and selling units) established.	35% increase in honey and silk quantity by 2017.	• DC registry. • Production records.	Nine (9) new honey marketplaces established in seven (7) countries. Annual honey volumes being documented by respective marketplaces.	• For successful operation of marketplaces, there is need to engage with the private sector for marketing linkages. • The established marketplaces offer farmers the much-needed central point to sell their hive-based products.
8. Modern beehives supplied to farmers and rearing houses (silk moth) established.	500 beehives supplied to farmers by 2017.	Project records.	3,248 Langstroth hives, 200 Top bar and 415 Dadant hives distributed to beekeepers.	• Provision of modern hives requires to be accompanied by adequate training and continuous extension programmes • Indigenous beekeeping knowledge needs to be built into the modern practices
9. Internal control system (ICS) training for 3000 trainers conducted.	Percentage of communities producing honey and silk to European Union (EU) standards increases from 20 to 40% by 2017.	Honey and silk quality assessed and certified.	Internal Control Systems trainings were organized for different countries and undertaken by 166 Field Officers, who are facilitating internal inspections for twelve (12) beekeepers' associations.	• Designing and implementing an effective internal control system for certification of hive based products can be challenging, and therefore calls for collaboration among

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				different stakeholders and players along the value chain. • Government programmes can promote (for example legislation/policies) or derail (for example free fertilizer and pesticide programmes) certification. • Organic certification is a viable though costly form of honey value addition due to the annual certification renewal.
Objective 7: Improve bee products and pollination services by 30% through reduced incidence of bee diseases and pests, enhanced markets access, and bee health policy and institutional environment by 2020.				
1. Bee health facilities for innovative technologies and provision of pest risk analysis, baselines and benchmarks established.	Documentation of honeybee pests, maps available and utilised by 40% of stakeholders for training beekeepers by 2020.	• Number of stakeholders using maps. • Peer-reviewed publications.	• Diagnostic manual for bee pests developed for use by beekeepers to identify bee pests. • Three (3) publications addressing honey bee pests diversity (Ayuka et al 2016a; Ayuka et al 2016b; Bobadoye et al, 2016).	• Regular and continuous monitoring to document seasonal variations in infestation. • Need to train the beekeepers on pests' diagnosis, and develop a platform for pest and disease reporting.

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2. Development of validated bee disease and pest management modules with efficient field based diagnostic tools.	Honeybee–pest interactions understood and applied by 30% of bee extensionists by 2017.	• Number of bee extensionists applying new knowledge. • Peer-reviewed publications.	• The entomology unit in Mauritius have adopted use of screen boards in hives. • Forty (41) key country NARS representatives (Kenya, Cameroon, Liberia, Burkina Faso & Kenya) trained in bee disease and pest management.	• Need to develop farmer friendly modules in local language.
3. Innovative integrated honeybee pest control strategies developed.	Use of honeybee integrated pest control strategies increased by 20% by 2017.	• Number of beekeepers trained. • Number of beekeepers applying new knowledge. • Peer-reviewed publications.	• 200 beekeepers trained on integrated honey bee pests control in the Island Nations. • 100 beekeepers applying the new technology. • Two (2) publications on residue analysis.	• Chemical use in control of honey bee pests to be highly regulated. • Awareness creation on natural resistance as the first line of defense. Not every pest needs to be controlled using chemicals.
4. Improved awareness of honeybee health and favourable environment for enhanced bee disease control, access to markets and consumer safety.	Effective multi-stakeholder partnerships and mechanisms for the development of policy, institutional and market options for bee health and pollination services established and functional by 2017.	• At least 75% of participating countries have formulated/reviewed their policies on honeybee health for hive products.	• Reviewed and Validated of 3 regional policy frameworks and three working groups established (Bee health; Pollination Services & biodiversity conservation; and Production, Marketing and Technologies). • Inventory of Apiculture policy and regulatory completed in 33 Member States (MS) and 2 Regional policy and regulatory frameworks drafted. • Continental guideline to minimize the impact of Pesticides on honey bees pollinators validated.	• In order to get political support/goodwill, there is need to document the contribution of beekeeping to the National GDP.
5. Capacity of beekeeper/farmers' federations, Regional Economic Communities	• At least 20 beekeepers' associations' supported/strengthened by the end of 2017.	• Project and policy activities report. • Farmers' Federations reports.	• Eleven (11) producer organizations strengthened for input supply management and cooperative marketing.	• Need for diverse membership/skills in the formation of beekeepers

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(RECs) and NARS on bee health management systems and policy options strengthened.	• 80% of the beekeepers' associations actively engaged in bee health policy processes at national level.		• Five (5) Regional Training on beekeeping technology, honey production & postharvest handling of beehive products organized and 128 ToTs representatives for National Beekeepers Associations • 74 Extension Workers & NARs ToTs trained on beekeeping technology, honey production & post-harvest handling of beehive products. • 3 Bee modules in ARIS2 developed (Bee Health; Production, Marketing Technologies and Pollination Services & biodiversity conservation). • Reference database on bee health and pollination services accessible on ARIS 2 developed. • Interactive online platform (Bee Net Africa - d-group on honey production, bee health & pollination services) is active	associations bring in all the stakeholders.
Objective 8: Promote knowledge and technology-based entrepreneurship through training in beekeeping and silk farming for youth employment in Ethiopia (YESH Project) by 2020				
1. In-depth value chain analysis of beekeeping and silk production in the targeted project zones undertaken.	• At least two (2) value chain analysis reports produced and shared with donors and partners by end of 2016. • One (1) scientific publication by end of 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 2016	Two value chain analysis reports produced – one on apiculture and another on sericulture – and were under internal review by end of 2016. Both reports mapped main actors and the flows of products in the value chain. Baseline production levels quantified as part of the M&E framework. Bottlenecks in the value chains identified.	(too early to draw lessons in this area in just the first year of the project)

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	• Gender mainstreaming strategy designed by 2016	Identify the flows of products as well as information flow and knowledge in the value chain by 2016 Quantify the volume of different products in the value chain by early 2017 Identify relationships and linkages between value chain actors by 2016 Identify the bottlenecks within the supply chain and where possible identify/refine interventions by 2016	Gender mainstreaming strategy drafted.	
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 during the period 2016 – 2020 • Gender mainstreaming strategy designed by 2016	Identify, profile and select youth to form groups with a good balance in gender by 2016 Establish training Centres for beekeeping and silk farming activities by 2017 Build capacity through training (technical, business and life-skills), provision of starter kits and material support to improve beekeeping and	By end of 2016, a total of 500 YESH project beneficiary youth were selected, engaged and trained in entrepreneurship and technical skills development. Preparations underway to receive six suitable public structures to establish training and demonstration facilities, one facility by each project district. Business and life skills development training was provided to a total of 493 youth.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	• Support at least one (1) egg production facility by 2016 • Develop at least two (2) training manual by end of 2016	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	Technical skills training workshops were attended by 474 project beneficiary youth, who then received the starter kits for apiculture and sericulture. Each of the 33 youth enterprises were allocated suitable land to develop their feed base and nurseries, and about half of these have initiated work on their nurseries by end of 2016. A private silkworm grainage was identified for technical support and was used to deliver a Training-of-Trainer workshop on the set up and maintenance of a grainage scheme.	
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 2018	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	By end of 2016 a total of 33 youth led and owned enterprises were established from the Year 1 cohort of the YESH project, with 22 in apiculture sites and 11 in sericulture sites. Each of the enterprises have opened savings accounts with local microfinance institutions in preparation to gain access to their credit services but none have taken loan by end of 2016. Arrangements were made with local key institutions for availing business development services and mentoring in the coming production season.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
		advisers as well as 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 information by providing technical training by 2020		
4. Market opportunities for youth in beekeeping and silk value chains created	• At least 70% of youth in the project areas employed in the beekeeping and silk farming value chain in the period 2017 - 2019 • Youth led cooperatives established within the period 2017 – 2019 • 25% increase in honey and silk production by end of 2017 of the initial enterprises established	Facilitate the establishment of legalized Cooperatives and Unions that are youth-led by early 2017 Develop youth-led marketplaces for harvesting, bulking, processing (value addition) and packaging of quality honey and silk products by mid 2016 Work with relevant Ethiopian Government organizations and NGOs to increase honey and	Preparations underway to establish one training and demonstration facility (marketplace) for each of the six project districts to promote product aggregation, quality control and value addition on key products.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
	• At least two (2) by products introduced by end of 2019	silk market opportunities – import substitution and export promotion by end of 2020 Facilitate the use of by-products of the silk and honey industries to benefit youth and their associations by end of 2020		
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 2016 • 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 2016 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	Comprehensive M&E framework and plan developed, reviewed and adopted, with key strategic learning questions of the project incorporated. Baseline and target production levels quantified based on data generated during baseline surveys.	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	2016 Progress Observed in Obtaining Outcomes	2016 Lessons Learned
		Monitor different partners (NGOs and Government Ministries) in order to document the extent to which beekeeping and silk farming are used for solving youth unemployment problem by 2020		
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 • Annual workshops for dissemination of reports • A communications plan developed by end of 2016	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 2016	Project website initiated within the main *icipe* website, with scope to expand it during Year 2 of the project when project activities gain full momentum. Project communication plan developed and arrangements made to enroll a communication officer with the project core team to move the implementation forward.	

5. Socio-Economic R&D Cross-Cutting Activities Results Based Management Report

i. **NAME of Project:** **The African fruit fly programme: Spillover effects assessment**

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
Overall objective:	**Assess the spill over effects of Mango IPM fruit fly control technology on farm productivity and environment in Kenya**			
Objective 1: Collect data for the spillover effects assessment				
1. Information and data needed for IPM spillover effects assessment collected	At least 400 households applying IPM technologies interviewed, 40 market survey questionnaires administered and 4 focus group discussions conducted.	• One household-level survey, one market-level survey and at least 4 focus group discussions conducted	• Data analysis for MSc. thesis and for peer review article completed	
Objective 2: Evaluate the spill over effects of Mango IPM fruit fly control technology on farm productivity				
2. Economic spillover effects of Mango IPM fruit fly control technology on farm productivity evaluated	At least 3000 households are aware of the spill over effects of Mango IPM fruit fly control technology on farm productivity Kenya (Embu, Meru, Kilifi) and the results disseminated to other Countries' project's sites and project partners	• One field survey conducted in one of the Kenyan sites • One MSC thesis produced by April 2015 • At least one article produced by end of 2015	• 1 MSc. thesis developed, under review by university supervisors (Economics analysis of spillover effects of integrated pest management strategy for suppression of mango fruit flies in Meru County, Kenya) • Above paper developed, presented in international	Our analysis show positive and significant cross-commodity spillover effects of the fruit fly IPM strategy on pawpaw and oranges.

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
			conference and under revision for publication	
Objective 3: Evaluate the environmental benefits of Mango IPM fruit fly control technology				
3. Economic analysis of environmental benefits of Mango IPM fruit fly control technology evaluated	At least 3000 households are aware of the spill over effects of Mango IPM fruit fly control technology on environment in Kenya and the results disseminated to other Countries' project's sites and project partners	• One field survey conducted in one of the Kenyan sites • One MSC thesis produced by end 2015 • At least one articles produced by end of 2015	• One thesis submitted to the university department for marking (Assessment of health and environmental effects of mango integrated fruit fly management in Meru County) • Above paper presented at an International conference, and under revision for publication	The analysis show that adoption of IPM strategy reduced environmental impact quotient (EIQ) field use by 6.81%, implying the strategy improved human health and reduced damage on the environment.

ii. **NAME of Project: Integrated Vector Management (IVM) for Sustainable Malaria Control in Eastern Africa**

Outputs Expected as per RBM framework plan	**Expected Outcomes as per RBM framework plan**	**Performance Indicator of Outcome as per RBM framework plan**	***2016 Progress Observed in Obtaining Outcomes***	***2016 Lessons Learned***
Objective 1: Assess the impact of the IVM strategies on communities' health, and livelihood				
Impact of IVM strategies on communities' health, and livelihood assessed	At least 3000 community members are aware of the impact of the IVM strategies on health and livelihood in Nyabondo	1. At least one (01) research report produced by end of 2015	We have produced a manuscript " Malaria Risk and Agriculture Productivity in Boter Chora district, Ethiopia: The Mitigating effects of Integrated	Our analysis of the impact of IVM strategies on malaria reveal that, in Tolay, use of Bacillus thuringiensis israelensis (Bti) for mosquito

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
	(Kenya), Malindi (Kenya) and Tolay (Ethiopia) and results of impact study disseminated to project's partners		Vector Management Interventions" with a component on the role of IVM on malaria in Tolay We also have two KAP reports (Tolay and Nyabondo) showing the perceived effects of IVM strategies on community knowledge and adoption of practices for malaria control in Tolay and Nyabondo In 2016, we published a paper " The role of gender on malaria preventive behaviour among rural households in Kenya" in malaria journal from the baseline data collected in 2014.	larval control is effective in reducing malaria in households, but can be enhanced by integrating it with house screening. Integrating house screening in the current IVM package for malaria control may strengthen effective malaria control. The KAP reports show that the IVM has helped to increase the community knowledge on malaria transmission, symptoms, and preventive measures in Tolay and Nyabondo.
Objective 1.1: Collect baseline data for the impact assessment exercise				
2. Information and data needed for IVM impact assessment collected	At least 1000 households in each project site Nyabondo (Kenya), Malindi (Kenya) and Tolay (Ethiopia), 3000 in total get to know the IVM Malaria project and are	• At least one (01) survey conducted in each study site by end of 2014	In April 2016, we collected a comprehensive household survey in Tolay (540 households) and Nyabondo (from 260 households) to understand the burden of	Based on the experiences of not getting expected results on impact if IVM in Tolay and Nyabondo data, decided to change strategy of implementing survey and tools to analyse the data. We would like to focus more on

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
	enrolled in the baseline study by 2014		malaria and the role of the IVM interventions.	rounds of focus group discussions to tease out the attribution and contribution of the IVM program as we did for the multi-interventions analysis. A tool for focus group discussion is ready and the exercise is underway to assess the community perceptions of the impact of IVM project in Malind
Objective 1.2: Evaluate the impact of the IVM strategies on communities' health, and livelihood.				
Objective 2: Assess the Economic Importance of Malaria in East Africa				
3. Impact of Malaria on agricultural productivity and income evaluated	At least 1500 community members are aware of the impact of malaria livelihood in Nyabondo (Kenya), Malindi (Kenya) and Tolay (Ethiopia) and results of economic importance of malaria study disseminated to partners in malaria control and prevention	At least one (01) research report produced by end of 2015	We have produced a manuscript " Malaria Risk and Agriculture Productivity in Boter Chora district, Ethiopia: The Mitigating effects of Integrated Vector Management Interventions."	IVM 's Bti intervention can reduce malaria prevalence; We further note that malaria still places a major economic burden to smallholder farmers in Tolay: In particular, we found that a one percentage point in intensity of malaria in a household leads to about 1,400birr (US$66.7) loss in annual crop yields (per hectare);

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
				Our results reveal heterogeneous effects of malaria burden (by age and sex of sick member); (i) A one percentage point in intensity of malaria among children below 14 years reduces annual crop yields by 1,102.5 birr (US$52.5); the yield loss is about 1,963.5birr (US$93.5) per hectare when productive members of a household fall sick. (ii) Productivity effect of malaria is significant when women in a household fall sick, but not significant for men: the loss is about 1,919 birr (US$91.4) per year due to malaria sickness among females.
4. Effect of agricultural Practices on malaria prevalence in Kenya and Uganda evaluated	At least 1500 community members are aware of the impact of malaria livelihood in mwoya (Kenya), Lango subregion and Bugiri district (Uganda); Results study will be	At least one (01) research report produced by early 2016	This objective was not undertaken due to lack of adequate funds	

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
	disseminated to partners.			

iii. **NAME of Project:** **Multi-Intervention Impact Assessment 4-H Project (H for Health) in Tolay (Ethiopia)**

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
Objective 1: Assess and compare the impact of combined 4-H interventions to single H or 2-H or 3-H interventions on household income per capita in Tolay (Ethiopia)				
The impact of multi interventions on household income per capita in Tolay (Ethiopia) evaluated	One impact assessment report utilised by donor by end of 2014	• At least one (01) research report and one draft journal article produced by end of 2014	A manuscript produced " economic benefits of multi-intervention in Ethiopia using multi-period linear programming approach" that reveals total income and per capita income effect of multi-interventions.	Framers livelihood and resilience can substantially improved if icipe can promote its technologies in an integrated manner in a community.
The impacts of combined 4-H, single H, 2-H and 3-H interventions on household income per capita in Tolay (Ethiopia) are assessed and compared.	One impact assessment report utilised by donor by end of September 2014.	• At least one (1) research report and one draft journal article produced by end of 2014.	The same paper above demonstrates the impact of individual and combination of interventions on household per capita income..	Framers livelihood and resilience can substantially improved if icipe can promote its technologies in an integrated manner in a community.

iv. **NAME of Project:** **Impact of biological control of stem borer on maize and sorghum production in East and Southern Africa**

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
Objective 1: **Assessing the ex-post impact of the biological control programme on productivity, household welfare and environment**				
Objective 1.1: Analyze the spread of stem borers and its biological control agents and farmer's knowledge and perceptions on the biological control				
1. The spread of stem borers and its biological control agents known, and farmer's knowledge and perceptions on the biological control documented	• The percentage (%) area infested by stem borers and area covered by its biological control agents in Kenya, Mozambique and Zambia known by the end of 2016 • At least 500 maize and sorghum farmers are enrolled in the study by 2014 and their perception documented	• At least one (01) study on the spread of stem borers and its biological control agents conducted by end 2016 • One scientific publication by end 2016	• A household survey of 600 households on farmer's knowledge and perception on biological control collected, analysis completed.	
Objective 1.2: Assessing the impact of the BC program on productivity, food security, poverty and environment at household level				
2. Impact of the biological control programme on productivity, household welfare and environment assessed	At least one (01) impact assessment report produced and shared with donors and partners by end 2016	• At least one (01) impact study conducted by end 2016 • One scientific publication by end 2016	• Paper on welfare-effect of biological control in Eastern and Southern Africa published in peer-reviewed journal. • Ex-post impact of Biological control on household's income, expenditures and poverty indicators: analysis	We note that the icipe program of biological control (BC) of cereal stemborer contribute to an aggregate USD 1.4 billion to the economies of Kenya, Mozambique and Zambia and results in an attractive

Outputs Expected as per RBM framework plan	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome as per RBM framework plan	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
			completed and draft manuscript produced awaiting submission for peer review • Draft manuscript on productivity-effect of biological control in Kenya developed and being fine-tuned. • Draft manuscript on ex-post impact of biological control on food security in Kenya developed and being fine-tuned	internal rate of return of 67%. Findings from poverty impact analysis indicate that each percent increase in BC intensity is associated with a US$ 1.15 increase in household expenditures and a 0.5% reduction in poor households. The implementation of the BC program has resulted in improving food security in Kenya. A one percent increase in BC level increases the per capita food expenses by US4 1.24, the per capita calorie intake by 6.94 Kcal, and reduces the number of food-insecure households by 0.16%.

6. Capacity Building and Institutional Development Results Based Management Report

Outputs Expected as per RBM framework plan	*Expected Outcomes as per RBM framework plan*	*Performance Indicator of Outcome as per RBM framework plan*	*2016 Progress Observed in Obtaining Outcomes*	*2016 Lessons Learned*
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, 60 PhD and 150 MSc postgraduates complete their training in arthropod and related sciences with icipe	• At least 75% of PhD students who complete their training 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 (NARS), sub-Regional Organisations (SROs), International Research Centres (IRCs), and the private sector in Africa. • At least 75% of MSc students who complete their training progressing to careers in research,	• 12 PhD and 30 MSc students complete their training each year during the 2014-2020 period. • By 2020, 45 PhD level scientists (33% women) trained in insect and related sciences working in NARS, SROs, IRCs, Universities and the private sector in Africa. • Number of new research and development activities/projects implemented and/or led by trained PhD level scientists at NARS, SROs, CGIARs, universities and the private sector in Africa. • At least 75% of MSc students who complete	• During 2016, icipe had 70 PhD fellows and 68 MSc fellows at various stages of their postgraduate programmes. • In 2016 17 PhD students completed training. Currently, 10 (58%) are in research, development and higher education in Africa; 4 (24%) are applying for postdoctoral positions; records are not available for 3 (18%). • We do not have complete records of the number of new research and development activities/projects implemented and/or led by trained PhD level scientists, but this data is being collected as part of routine alumni follow-up	We still lack some data on icipe MSc and PhD alumni, e.g. current positions of alumni, and number of projects initiated/led by alumni. However, in 2016 we began an internet survey of icipe alumni, and completed the survey for the icipe ARPPIS PhD programme. This has proved to be an efficient method for collecting basic data on alumni, and will be followed up in 2017 by email requests for further information. Although we have surpassed our target of 33% women in the postgraduate programmes, we are confident that gender equity could be reached if more women applied to the programme. To make the programme more attractive to young women scientists we will seek additional funding to create postgraduate programmes that pay special attention to the needs of early-career women scientists.

	development and higher education in Africa. • The postgraduate programme contributes to addressing the lack of women in research, development and higher education in Africa. At least 33% of PhD and MSc students who complete their training are women. • The postgraduate programme has a continent-wide reach, with at least 20 countries in SSA represented by students, including at least 35% of PhD students from Southern, Central and West Africa.	their training progressing to careers in research, development and higher education in Africa. • Number of women in the postgraduate programmes • Nationalities of students in postgraduate programmes.	for the icipe capacity building database. However, a tracer study of alumni from the icipe ARPPIS PhD programme has shown that 80% of all alumni are engaged in R&D and higher education in Africa. • 24 MSc students completed their training in 2016. 16 (66%) are pursuing careers in research, development and higher education (including 3 doing PhD studies in Africa and 2 in Europe); 4 (17%) are currently unemployed; we do not have records for 4 (17%). • In 2016, 43% of all postgraduate and postdoctoral fellows are women. • In 2016, 19 African countries were represented by postgraduate students at icipe; and 37/138 (30%) of postgraduate students were from Southern, Central and West Africa.	To ensure we reach our target of at least 20 countries in SSA represented by students, including at least 35% of PhD students from Southern, Central and West Africa we must expand our reach, especially to countries that are under-represented in our PhD programme. To help increase country diversity, in 2017 we will reduce the number of scholarships that are available to Kenyan nationals, who traditionally occupy a significant proportion of postgraduate positions at icipe.

			(Note: 10 new ARPPIS PhD fellows started in October 2016. With 8 African nationalities represented (Burkina Faso, Cameroon, Ethiopia, Kenya, Nigeria, Rwanda Tanzania, and Togo) the new cohort represents significant country diversity entering the ARPPIS PhD programme.	
2. Dissemination of research results by postgraduate students (including theses, book chapters, peer-reviewed papers, conference abstracts and proceedings, training brochures and manuals, policy documents, print and online media)	• Research results disseminated in relevant formats at scientific community and policy maker levels	• 58 publications each year during the period 2014 - 2020 (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.	• In 2016, of 149 peer-reviewed papers published by *icipe*, 68 (46%) were authored by postgraduate students (53 (36%) as lead authors). *We do not have any citation metrics for publications, but this will be measured from 2017 for papers published since 2014.* • 17 PhD and 24 MSc theses were completed in 2016.	From 2017, we will obtain citation metrics for papers published to assess their impact/quality.

		• Number of students participating in scientific meetings/conferences	• In 2016, 17 postgraduate students participated in 13 international/regional scientific meetings & conferences and 8 local scientific meetings & conferences.	
3. 200 mid-level practitioners and extension workers (at least 33% women) from at least 20 national systems in Africa trained in non-degree professional development courses each year	• At least 50% of trained middle-level practitioners applying their knowledge and expertise in NARS in Africa each year during the period 2014–2020.	• Number of mid-level practitioners and extension workers trained • Number of women trainees • Number of training courses • Number of countries represented • Number of trained middle-level practitioners applying their knowledge and expertise in NARS countries	• 385 mid-level practitioners and extension workers trained (37% women) • 45 training courses • 20 countries in Africa (The number applying their knowledge and expertise in NARS countries is incomplete).	We need to apply consistent, in-depth M&E to determine the number of trained middle-level practitioners applying their knowledge and expertise in NARS countries.
4. 250 undergraduates trained over 5 years in insect and related sciences through short-term internships	• At least 50% of trained undergraduate interns progressing to research, development and higher education careers in Africa	• Number of interns trained • Number of internship reports • Follow up information from interns for 1 year after internship	• 35 interns were trained in insect and related sciences in 2016. Average duration of an internship was 3.3 months. • No data is currently available on follow-up of interns.	We will strengthen our data collection in 2017 to facilitate monitoring and follow up of interns. We will also develop a database of interns.
5. Research and training capacities in insect and related sciences strengthened at national and regional research and		• Signed MoUs and collaborative agreements • Exchange visits between icipe and national/regional institutions	• In 2016 visits to ARPPIS sub-regional centres at Addis Ababa University and University of Zimbabwe were made.	Managing a network for capacity strengthening in Africa will require a full-time Network coordinator. Funds should be raised in 2017 to support

higher education institutions through the development of an icipe Alumni Network. Institutions will include three ARPPIS sub-regional centres at Addis Ababa University, University of Ghana-Legon, University of Zimbabwe.		• Number of new networks established • Number of scientists and students from selected institutes attending training courses. • Number of capacity building or research projects funded at the strengthened institutes	MoU with each centre are under development. • Tracer study of icipe Alumni in ARPPIS programme completed. New tracer study of DRIP PhD and MSc programme alumni begun, and will be completed in 2017. • A new website and social media for an icipe Alumni Network was started in 2016, and will be completed in 2017. • New online database of all icipe postgraduate and postdoctoral fellows and alumni was developed and is continually updated with new information. Data from the database will support the Alumni Network.	institutional development through an Alumni Network.
6. 5 new career development opportunities (short-term visiting scientists and post-doctoral fellows [PDF]) each year.	• At least 75% of PDFs and visiting scientists on completion at icipe proceed to contribute to research, development and higher education in Universities, NARS, SROs, IRCs, and the private sector in Africa each year during the period 2014–2020.	• Number of postdoctoral fellows and visiting scientists trained. • Number of grants received by PDFs each year. • Number of research publications in peer-reviewed journals.	• 17 postdoctoral fellows (PDF) were engaged in research at various stages of their tenure at icipe in 2016. • Two new postdoctoral scientists were recruited in 2016. • We did not host any visiting scientists in 2016.	Additional funding is required to maintain 5 new career development opportunities (short-term visiting scientists and post-doctoral fellows) each year. From 2017, we will obtain citation metrics for papers published to assess their impact/quality.

	• At least 50% of fellows attract competitive research grants during their tenure at icipe or within 1 year of leaving *icipe*.		• 37 peer-reviewed articles were published by postdoctoral fellows in 2016 (12 as lead author). • 11 postdoc fellows (65%) applied for 17 research grants. Four grant applications were successful. Awaiting outcome of three applications. • 5 postdoctoral fellows completed in 2016. All (100%) are engaged in research/ higher education in Africa, 1 as a scientist with icipe and 4 as scientists/senior scientists/lecturers in national systems and universities.	

Section 3: List of Refereed Journal Articles

Annex 1: January – December 2016 Publications List

2016 Published (143)

1. *Abonyo E.A.*, *Maniania N.K.*, Warui C.M., Kokwaro E.D., Palmer T.M., Doak D.F. and Brody A.K. (2016) Effects of entomopathogenic fungus *Metarhizium anisopliae* on non-target ants associated with *Odontotermes* spp. (Isoptera: Termitidae) termite mounds in Kenya. *International Journal of Tropical Insect Science* 36, 128–134. doi: 110.1017/S1742758416000114.

2. Abtew A., Niassy S., *Affognon H.D.*, *Subramanian S.*, *Kreiter S.*, Tropea Garzia G. and *Martin T.* (2016) Farmers' knowledge and perception of grain legume pests and their management in the Eastern province of Kenya. *Crop Protection* 87, 90–97.

3. *Achinko D.*, Thailayil J., Paton D., Mireji P.O., Talesa V., *Masiga D.* and Catteruccia F. (2016) Swarming and mating activity of *Anopheles gambiae* mosquitoes in semi-field enclosures. *Medical and Veterinary Entomology* 30, 14–20. doi: 10.1111/mve.12143.

4. Adamtey N., *Musyoka M.W.*, Zundel C., Cobo J.G., *Karanja E.*, *Fiaboe K.K.M.*, Muriuki A., Mucheru-Muna M., Vanlauwe B., Berset E., Messmer M.M., Gattinger A., Bhuller G.S., Cadisch G., Fliessbach A., Mäder P., Niggli U. and F. D. (2016) Productivity, profitability and partial nutrient balance in maize-based conventional and organic farming systems in Kenya. *Agriculture, Ecosystems & Environment* 235, 61–79.

5. Affognon H.D., Njoroge A.W., *Mutungi C.M.*, *Manono J.*, Baributsa D. and Murdock L.L. (2016) Storage of pigeonpea grain (*Cajanus cajan* (L.) Millsp.) in hermetic triple-layer bags prevents losses caused by *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). *Acta Horticulturae* 1120, 245-252. doi: 210.17660/ActaHortic.12016.11120.17637.

6. Agboyi L. K., Ketoh G. K., *Martin T.*, Glitho I. A. and Tamò M. (2016) Pesticide resistance in *Plutella xylostella* (Lepidoptera: Plutellidae) populations from Togo and Benin. *International Journal of Tropical Insect Science*, doi:10.1017/S1742758416000138.

7. Ahmed A.G., *Murungi L.K.* and *Babin R.* (2016) Developmental biology and demographic parameters of antestia bug *Antestiopsis thunbergii* (Hemiptera: Pentatomidae), on *Coffea arabica* L. at different constant temperatures. *International Journal of Tropical Insect Science* 36, 119–127. doi:110.1017/S1742758416000072.

8. *Ajamma Y.U.*, *Mararo E.*, *Omondi D.*, *Onchuru T.*, Muigai A.W.T., *Masiga D.* and *Villinger J.* (2016) Rapid and high throughput molecular identification of diverse mosquito species by high resolution melting analysis. *F1000Research* 5, 1949. doi: 1910.12688/f11000research.19224.12681.

9. *Ajamma Y.U.*, *Villinger J.*, *Omondi D.*, *Salifu D.*, *Onchuru T.O.*, Njoroge L., Muigai A.W.T. and *Masiga D.K.* (2016) Composition and genetic diversity of mosquitoes (Diptera: Culicidae) on islands and mainland shores of Kenya's lakes Victoria and Baringo. *Journal of Medical Entomology* 53, 1348–1363.

10. *Akutse K.S.*, *Maniania N.K.*, *Ekesi S.*, *Fiaboe K.K.M.*, Van den Berg J., Ombura O. L. and *Khamis F.M.* (2016) Morphological and molecular characterization of *Vicia faba* and *Phaseolus vulgaris* seed-borne fungal endophytes. *Research Journal of Seed Science*, doi: 10.3923/rjss.2016.

11. *Arum S.O.*, Weldon C.W., *Orindi B.*, *Tigoi C.*, Musili F., *Landmann T.*, *Tchouassi D.P.*, *Affognon H.D.* and *Sang R.* (2016) Plant resting site preferences and parity rates among the vectors of Rift Valley fever in northeastern Kenya. *Parasites & Vectors* 9, 310. doi: 310.1186/s13071-13016-11601-13077.

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