2015 *icipe* CORE ANNUAL REPORT

BASED ON

RESULTS BASED MANAGEMENT REPORTING

30 April 2016

International Centre of Insect Physiology and Ecology

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icipe

African Insect Science for Food and Health

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2015 *icipe* INSTITUTIONAL RBM ANNUAL REPORT

SECTION 1: 2015 *icipe* Institutional RBM Achievements

INTRODUCTION

The focus on insect-based research and capacity building to address the challenges of poverty, food security, and the health status of people in Africa, while preserving the natural resource base, is the mission *icipe* ascribes to.

In 2015, we made strides in delivering against *icipe*'s mandate as exemplified by the various research, development and capacity building activities undertaken.

The first major event of 2015 was a review of the DFID Performance Management Funding Mechanism (PMFM) of International Agriculture Research Centre's under which *icipe* has received core funding since 1st October 2011. The DFID PMFM program ended in March 2015 and the review team was tasked to provide input into the future of the scheme. The review program included presentations from *icipe* senior management, key *icipe* scientists as well as from key beneficiaries of *icipe* technologies and discussion groups involving *icipe* staff and stakeholders. Whilst our scientists represented the Centre and its achievements well the highlight for all was the testimonies provided by our key stakeholders and the life changing stories they provided. The week after the review team's visit following an invitation by DFID, *icipe* lodged a request for a one year extension of our core funding under the scheme pending the outcomes of the review and the future of the PMFM program. The request was granted and the Centre received support for the fiscal year that ended March 2016.

On 19th - 20th of February 2015, *icipe* had the honor of hosting the Annual Steering Committee Meeting of the Association of International Research and Development Centers for Agriculture -AIRCA, of which *icipe's* Director General is currently the Chair. Membership of AIRCA allows *icipe* an opportunity to benchmark and share learning's with similar organizations.

New initiatives such as the European Union funded Integrated Biological Control Applied Research Programme (IBCARP), which aims to increase the adoption of the push-pull technology, fruit-fly integrated pest management, and tsetse control programmes in East African countries, are examples of our contribution to research and development. The programme also aims to adapt the tsetse fly repellent technology to control camel diseases that biting flies transmit. An estimated 350,000 additional farmers and pastoralists in Kenya, Ethiopia, and Tanzania will be beneficiaries of *icipe*-developed technologies as a result of the 4-year programme.

A publication arising from our new area of research on insects for food and feed, published in *PLOS ONE* that *icipe* scientists and collaborators wrote, showed that the desert locust contains compounds known as sterols, which have cholesterol-lowering properties, with the potential to reduce the risk of heart disease. This finding was highlighted in the local and international print, electronic, and TV media.

We continue to solidify our niche in the fight against malaria through *icipe*'s research on 'Studying the oviposition behavior of *Anopheles gambiae*: the development of novel tools for the surveillance and control of this major malaria vector (OviART project).' In a world first, the OviART research group, a multinational team that includes *icipe* scientists, published in the *Malaria Journal* that a naturally occurring chemical, cedrol, attracts pregnant malaria mosquitoes. The paper was rated in the top 10 publications of 2015 by the journal. This discovery could boost the worldwide malaria control efforts. Further, three PhD students graduated in the OviART project, all were registered at the prestigious London School of Hygiene & Tropical Medicine. A comment from one of the students' (Oscar Mbare) thesis examiners is pertinent: *"Without a doubt, his thesis was one of the most interesting, comprehensive and thought provoking bodies of work I have examined."*

Another significant finding, and publication, of our malaria team focused on the invasive American weed that is now found across large areas of Africa, *Parthenium hysterophorus. icipe* scientists found that the weed is able to sustain the malaria-transmitting mosquito, *Anopheles gambiae,* extending its lifespan in the absence of a blood meal, which has a negative impact on malaria control efforts. These findings were featured in journals such as *New Scientist* and *Scientist*.

Commercialisation of tsetse-repellent collars, in partnership with the private sector, continues. Five different new design prototypes are being evaluated in the field for their robustness and constant release rates. In parallel, farmers in Shimba Hills have registered their own community-based organisation for selling the repellent dispensers and compounds, including the servicing and maintenance of the dispensers. This is an encouraging trend, and a step towards adopting the technology and up-scaling it.

icipe taxonomists, in collaboration with colleagues from the Tropical Entomology Research Institute and University of Tuscia (both in Italy), published the discovery of 14 never before identified wasp species from Kenya and Burundi. Many wasps are beneficial to humankind, because of their ability to control agricultural pests.

During the reporting period *icipe* staff were the recipients of a number of prestigious international awards including Prof. Zeyaur Khan received the Louis Malassis International Scientific Prize for an Outstanding Career in Agriculture in March 2015. In July 2015, the World Academy of Sciences Regional Office for Sub-Saharan Africa (TWAS-ROSSA) selected Dr David Tchouassi, a Postdoctoral Research Fellow with the Chemical Ecology Group, as a TWAS Young Affiliate. Dr. Sunday Ekesi, leader of our Plant Health Theme was elected a Fellow of the African Academy of Sciences in 2015. Section 1.1.7 contains a full list of the awards and recognitions.

Towards the close of the year in November 2015 *icipe* held its Science Day events, which provided an opportunity for a diverse range of our stakeholders to hear about the Centre's world-class science and our contributions to food and nutrition security, health improvement and poverty reduction in Africa. Over 200 dignitaries, including ambassadors and high commissioners, government ministers and other officials, members of the Centre's Governing Council, investors, partners including farmers, representatives of the general public and journalists attended the events. The *icipe* science days included a mix of scientific presentations and exhibitions. In addition, the *icipe* science day demonstrations enabled guests to view the Centre's research outputs up close, and to interact with researchers, students and partners. They included exhibition booths illustrating topics such as push-pull, fruit fly integrated pest management (IPM) technologies, tsetse repellent technology, our private sector partner Real IPM also demonstrated technologies arising from our partnership, beekeeping technologies including crop pollination, and the silk value chain among others. Eight institutions hosted by *icipe* also exhibited their research outputs.

Postgraduate and postdoctoral fellows make a significant contribution to the research output of *icipe*. Of the 151 peer-reviewed papers published by *icipe* between April 2015 and March 2016, 74 (49%) were attributed to postgraduate and postdoctoral fellows, who were lead authors on 58 (38%) of these papers. Research findings by postgraduate students have been highlighted by the international media, and a number of *icipe* fellows are recipients of prestigious international awards and other recognitions. Postgraduate students also participate in a large number of national, regional and international scientific conferences to gain experience in communicating research findings, to learn about the most recent advances in their fields, and to establish contacts with other scientists. In 2015, 35 postgraduate students participated in 30 scientific meetings and conferences.

icipe INSTITUTIONAL ACCOMPLISHMENTS IN 2015

1.1. Centre Achievements

During 2015, *icipe* continued to make significant advancements in its chosen field of entomology and related sciences, publishing in high impact journals and adopting technologies in areas as diverse as attractants for malaria mosquitoes, tsetse repellent collars, and integrated pest management of crop pests. We continue to enhance our broad programme of capacity development for staff, students and stakeholders. In addition, Thomson Reuters 2015 Journal Citation Reports® published the first impact factor for the institutional journal, *International Journal of Tropical Insect Science* (JTI) in June 2015. The allocated 2014 IP is 0.419, which is a good start; and so we celebrate this milestone.

icipe continues to strengthen its media relationships, evidenced by continued coverage by CNN International, the *New Scientist*, National Geographic, *The Guardian*, *SciDev.Net*, *The Scientist*, *The Washington Post*, *CBS News*, Al Jazeera, the BBC and *Fox News*. The Director General's participation in Trieste Next 2015, and strong support from TWAS-The World Academy of Sciences led to extensive coverage in the Italian and other European media.

icipe's library was granted free access to Science Direct and Scopus through the Library of Alexandria Access Program; in addition, the Centre was granted full access to journals and books available through Reserach4Life, a public-private partnership of WHO, FAO, UNEP and others. *icipe* has free access to more than 20,000 unique e-journals and 30,000 e-books.

The Centre continues to implement its upgrades of facilities, infrastructure and equipment. To-date, we have completed the water-harvesting project on our main campus at Duduville, renovated our Nguruman field station, and custom-built our Arthropod Containment Level -2 (ACL-2) facility at *icipe* Thomas Odhiambo Campus (ITOC) in Mbita, at the shores of Lake Victoria, Western Kenya.

1.1.1. Resource mobilisation

icipe continues to perform well in mobilising resources. The Centre's strategy is to increase both the level of restricted funding and to diversify the range of donors. The latter shall serve to reduce our risk profile should one or more donors have a change in investment priorities. Diversifying our donors also serves to reduce the risk associated with currency fluctuations, as observed with the Euro and other European currencies in 2015. A major achievement in meeting this strategic goal was the establishment of a collaborative arrangement with the MasterCard Foundation in the form of a 5-year US$ 10.35 million project to reduce youth unemployment in rural communities in Ethiopia through development of honey and silk value chains signed in November 2015. Seven (7) new donors joined *icipe* during the reporting period and include: The MasterCard Foundation (discussed above); L'Oreal Corporate Foundation; Stichting Katholieke Universitiet, Netherlands; Virginia Tech Management Entity of the Feed the Future Collaborative Research on Integrated Pest Management Innovation Lab (IPM IL); Sir Henry Wellcome Postdoctoral Fellowship" from the Wellcome Trust; SWITCH Africa Green; and Partnerships for Enhanced Engagement in Research (PEER) programme.

The Centre has made significant progress in securing funds for a wide range of research areas during this reporting period as detailed in the report and financial statements for the year ended 31st December 2015 that accompanies this report as a separate document.

1.1.2. Infrastructure Upgrade and Construction Projects

icipe undertook the following infrastructure upgrades and construction projects in 2015:

icipe Nguruman and Muhaka Field Stations: During May to June 2015, *icipe* commissioned its Facilities staff to refurbish Nguruman field Station. The work was completed in July 2015, and now we have improved laboratories, offices, and guesthouse. The field site is open for research, and scientists have been encouraged to make maximum use of it. The tendering for a contractor to refurbish *icipe* Muhaka field site has been completed, and work will commence soon. Works include refurbishing of the laboratories, providing water storage, and upgrading the generator, gate and perimeter fence as well as animal shelters.

Construction of an *Arthropod Containment Level -2 (ACL-2) facility at icipe-TOC in Mbita* was completed, and a USA Centers for Disease Control (CDC) expert has conducted an audit for biocontainment and regulatory compliance. Plans are underway to apply for commissioning of the facility by the Kenya National Biosafety Authority. The facility features mosquito-proof state-of-the art insectary and laboratory space, attached to a large double-walled screen house, which can be used for research on conventional mosquito control strategies, as well as potentially novel genetic approaches to control vector mosquitoes.

icipe's new confocal microscope: The Cellular Imaging Facility of the Lausanne University Hospital (Switzerland) made a donation of a Leica SP5 confocal microscope to *icipe*. The donation was mediated through TReND Africa. This microscope will enable users to acquire optical sections of specimens without background noise and image degradation. Confocal microscopes have become popular, and are found in most biological research departments and research institutes. They allow stacking of sections and creation of 3-D images of specimens. The Leica SP5, installed in *icipe*'s Emerging Infectious Diseases (EID) laboratory, is the first operational confocal in the East African region. There are many benefits to having such an instrument for *icipe* research staff.

*Water Tanks and LED Lighting***:** Water tanks will allow the Centre to benefit from rainwater harvesting. The Centre installed ten 24,000-litre plastic water tanks (total 240,000 litres) and gutters in Duduville in August 2015. Further efforts are underway to more than double our rainwater harvesting capacity to half a million litres. The Centre's activities under this initiative are not only expected to offer positive environmental outcomes but to also save the Centre significant resources in utility bills.

Reducing the Centre's Environmental Foot Print: During the reporting period the Centre undertook a number of construction projects aimed at reducing our water and electricity use including the installation of water tanks and energy saving lighting systems. We also signed an agreement in early 2016 with Solar Century East Africa for an expansive solar powered renewable energy project. Replacement of the *fluorescent tubes with LED lights* across the Centre will promote savings on electricity. Indeed, we have observed a drop in energy consumption in May and July 2015 following this exercise. To further improve energy consumption, LED tubes were fitted in the Caroll Wilson building in September/October 2015

1.1.3. Endorsement to continue operations as a Stockholm Convention Regional Centre

icipe's role as a Stockholm Convention Regional Centre was formally endorsed to continue operations for a further 4 years (2016 to 2019) by the more than 160 countries that are members of Stockholm Convention, following the evaluation of the performance of the regional centres. In May 2015, *icipe* SCRC-Kenya participated in the 2015 Meetings of the Conferences of the Parties to the Basel, Rotterdam and Stockholm conventions. *icipe* SCRC-Kenya performed well where it scored a mark of 94%, based on the 2013-2014 evaluation report that *icipe* submitted to the Stockholm Convention Secretariat in December 2014. The Stockholm Convention aims to reduce the use of Persistent Organic Pollutants (POPs). The *icipe* Centre is focused on finding alternatives to chemicals for controlling pests and promoting integrated control methodologies for crop and livestock insect pests and other related arthropods, and insect vectors of tropical diseases and the strengthening of scientific and technological capacities of the developing countries in insect science and its application through training and collaborative work.

In this capacity, *icipe* was engaged in the regional promotion of IVM for malaria control through the organization of a workshop on DDT and alternatives in November 2015. The workshop was held at *icipe's* Nairobi campus and involved participation by countries that still use DDT for malaria control.

1.1.4. Key staff recruitments and other staffing

icipe has made considerable progress in appointing a number of strategic science and administrative positions in 2015. These include the Head of *icipe* Ethiopia Country Office, Head of Social Science and Impact Assessment Unit, Internal Auditor among others. Although a number of key positions were filled during the year, recruitment of high calibre international scientists still remains a challenge, and the Centre is still looking to appoint a Senior Gender Specialist and Senior Modeller, among others. Additionally, *icipe* undertook a number of major recruitment initiatives including the appointment of staff associated with the IBCARP programme as well as the MasterCard Foundation supported Ethiopia based Honey and Silk Value Chain project.

1.1.5. Director General's strategic global and regional engagement

The Director General made a number of official trips to engage with key stakeholders, current and potential donors, and key government agencies, and to represent *icipe* at significant scientific events. Some highlights include:

a.) Examples of engagement with key donors

- Discussions with Mirko Giulietti, Deputy Head of Mission – Deputy Permanent Representative to UNEP, Embassy of Switzerland (9th December 2015)
- Interview by Ms. Annemarie Kruse, SYSPONS GmbH, Germany on Potentials of technology transfer for East African-German research cooperation (2nd December 2015)
- Discussions with Centre for International Migration and Development (CIM) - Dr. Johannes Schilling (Programme Coordinator), Ms. Bianca Kunz (placement officer) and Mrs. Kokebe Hailegabriel (Advisor Ethiopia Programme) (1st December 2015)
- Discussions with Dr Yves Guinand, Senior Thematic Advisor, Rural Development Federal Department of Foreign Affairs (FDFA), Swiss Agency for Development and Cooperation (SDC) (16 November 2015)
- Dr Claes Kjellström, Director, Regional Research Cooperation Department, Sida: Discussions on BioInnovate Phase II Africa Programme (October 2015).
- Dr Gity Behravan, Dr Seyoum Leta, Dr Allan Liavoga, Mr Abel Anyolo, BioInnovate Africa programme: Meeting to discuss Bioinnovate Phase 2 hosting arrangements (August 2015).
- Teleconferences with Dr Jeffrey Ehlers, Programme Officer, Bill & Melinda Gates Foundation: Discussion on Legume IPM ideas (July 2015).
- Science meeting, partnerships and fundraising at Cornell University (July 2015).
- Discussions with Prof. Achim Dobermann, Director and CEO, Rothamsted Research and Dr Mike Birkett, Head of the Chemical Ecology Group and Deputy Head for the Biological Chemistry and Crop Protection Department: To explore more collaborative opportunities with *icipe* (June 2015).
- Dr Christina Owen, Programme Officer, Agricultural Development, Bill & Melinda Gates Foundation: To explore funding opportunities (June 2015).
- Discussions with the President of Alliance for a Green Revolution in Africa (AGRA) (April 2015).

b.) Representation at key policy and science fora and media coverage

- Sida Science Day. Invited to make a presentation at the Women in Science – Does it matter? Plenary session. Title of presentation –"The Role of Women in Science for Development". (12 – 17 December 2015), Stockholm, Sweden.
- Filming of an International Science TV series called "The Mind of the Universe" by The Dutch Public Broadcasting Company VPRO. (23 – 24 November 2015), Nairobi and Mbita.
- Invited steering committee member for the 2nd International Food Security Conference held in Cornell University - Ithaca, New York, USA (October 2015).
- Invited presentation and roundtable discussion at the Trieste Next Science festival by The World Academy of Sciences (TWAS) - Trieste, Italy (September 2015).
- Invited presentation at the Women's Forum Italy as part of the Universal Exhibition (Milan Expo) - Milan, Italy (June/July 2015).

- Invited presentation at a plenary session at the ILSI Health and Environmental Sciences Institute (HESI), Annual Meeting - Washington, DC, USA (June 2015).
- Invited presentation at a plenary session on Innovations from *icipe* - Valagro Global Conference 2015, Milan, Italy (May 2015).
- Keynote talk at the Advancing Pest and Disease Modelling Workshop in Gainesville, Florida (Feb., 2015).
- Meeting of International Jury for the 2015 edition of the Louis MALASSIS International Scientific Prize for Agriculture and Food hosted by Agropolis Fondation and the Olam Prize.
- Meeting at the Cirad Lavalette Campus, Montpellier, France with Cirad officials to discuss current and potential collaboration.
- Award Ceremony for L'Oréal UNESCO Regional Fellowships for Women in Science in Sub-Saharan Africa (November 2014).

1.1.6. Key visitors to *icipe*

In 2015, visitors to *icipe* have included representatives from donor organisations such as Biovision Foundation; Bill & Melinda Gates Foundation; as well as science partners (including visits from Wageningen University Netherlands; Imperial College, London; Swedish University of Agricultural Sciences (SLU), Sweden; Millennium Institute; Department of International Agricultural Development at Tokyo University; and Rothamsted Research (UK). Discussions included current and future collaborations in malaria research, push-pull, and other key *icipe* thematic areas, as well as emerging opportunities with delegations from the University of Helsinki, Finland, representatives from Government agencies and universities, as well as the private sector.

1.1.7. Staff Awards and Recognition

icipe and *icipe* staff members have been the recipients of external awards for many years, and even more opportunities for staff to be recognised than ever before exist. In 2015, *icipe* recognised the contribution of its staff, teams and partners.

a.) Internal icipe staff awards and recognitions

I. Outstanding Research Publication of the year Award (ORPA)
Recipient - Dr. Michael Okal et al., for their publication:
Lindh J.M., *Okal M.N.*, *Herrera-Varela M.*, Borg-Karlson A.-K., *Torto B.*, Lindsay S.W. and *Fillinger U.* (2015) Discovery of an oviposition attractant for gravid malaria vectors of the *Anopheles gambiae* species complex. *Malaria Journal* 14, 119. doi: 110.1186/s12936-12015-10636-12930.
New strategies are needed to manage malaria vector populations that resist insecticides and bite outdoors. This study describes a breakthrough in developing 'attract and kill' strategies targeting gravid females by identifying and evaluating an oviposition attractant for *Anopheles gambiae s.l.* In a world first the team found that a naturally occurring chemical attracts pregnant malaria-transmitting mosquitoes – a discovery which could boost malaria control efforts. The paper was rated by the journal as one of the top 10 (ranked 9th) papers of 2015.

II. Outstanding Professional Staff of the year Award (OPSA)
Recipient - Annah Njui:
In recognition of the significant contributions that Annah has made over the years, during which time she has developed enduring relationships with donors, partners and staff alike. Her efforts ensure that *icipe* is viewed by the Centre's partners in the most positive manner, and that their needs are met in a timely and efficient way. She provides high quality relationship and contract management to *icipe* and its partners.

III. Outstanding Support Staff Contribution Award (OSSCA)
This year the panel felt that the contributions of two staff members were worthy of recognition: *Recipients - Brian Mwashi and Syprine Amolo*

Brian Mwashi: In recognition of Brian's high level of professionalism and commitment to ensuring that *icipe* is always represented with a professional corporate image through his work on poster, banners, displays and the design of the Centre's new web site, amongst other things.
Syprine Amolo: In recognition of Syprine's efforts in leading the cleaning and gardening team at *icipe* and in doing so supporting the transformation of the Duduville campus.

IV. Outstanding Employee of the Year Award (OEYA)
Recipient - Milcah Gitau:
In recognition of Milcah's dedication to *icipe* and the support of the Centre's scientific activities through the supply of high quality insects that underpin a diverse range of research projects. The professionalism she shows in managing the *icipe* insect rearing facilities, including managing unpredictable demands, is appreciated by all those who rely on her services.

V. Outstanding Team of the Year Award (OTYA)
This year the panel felt that the contributions of two teams to the Center was worthy of recognition.
Recipients - Plant Health research team and Facilities and Assets team

Plant Health Team: In recognition of the Plant Health team's exceptional efforts and achievements in scientific publication, achieving stakeholder impact through the application of *icipe* developed technologies, including public-private partnerships to commercialize a range of products and in raising funds to carry on a diverse range of research.
Facilities and Assets Team: In recognition of the team's efforts and achievements in revitalizing the Centre's infrastructure including the oversight of the construction of new facilities such as the bee health lab, student accommodation at Mbita and the water harvesting facilities at both Mbita and Duduville. The team's achievements also include carrying out rejuvenation projects in house, including the renovations of the Centre's Nguraman research field station. The team's work has been of the highest quality whilst saving *icipe* considerable financial resources compared to outsourcing the projects.

VI. Outstanding Partner-of-the-Year Award (OPYA)
Recipient - German Academic Exchange Service (DAAD)
The German Academic Exchange Service (DAAD) has been a consistent, major donor to *icipe's* capacity building programme for the past 32 years, by providing PhD fellowships to students entering ARPPIS, *icipe*'s flagship capacity building programme.
The partnership between DAAD and *icipe has* provided young doctoral candidates, scientists and academics, with the opportunity to carry out research and continue their education.

In November 2015, the following scholars were awarded the 2015 *icipe* Governing Council Award in various categories for publications and posters:

In the publications category the awardees were:
Winner: Xavier Cheseto for his paper on " Potential of the desert locust *Schistocerca gregaria* (Orthoptera: Acrididae) as an unconventional source of dietary and therapeutic sterols" published in the journal *PLOS ONE*
First Runner Up: Edith Chepkorir for her paper " Vector competence of *Aedes aegypti* populations from Kilifi and Nairobi for dengue 2 virus and the influence of temperature" published in *Parasites & Vectors*
Second Runner Up: Purity N. Kipanga for her paper " High-resolution melting analysis reveals low Plasmodium parasitaemia infections among microscopically negative febrile patients in western Kenya" published in *Malaria Journal*

In the poster category the following were awarded:
Winner: Beatrice T. Nganso for her poster: "Aspects of the mechanisms of tolerance in *Apis mellifera scutellata* colonies to *Varroa destructor* mite in Kenya"

First Runner Up: Nelly Ndungu for her poster: "*Hypotrigona* bees (Hymenoptera: Meliponini): Morphology, behaviour, chemistry and genomics"

b.) External recognition of the Centre and its staff

Science Fair Certificate of Participation awarded to *icipe*: The certificate was awarded in recognition of the Centre's participation in the Science Fair during the Meetings of the Conference of the Parties to the Basel, Rotterdam and Stockholm Conventions held in Geneva, Switzerland, 4 to 15 May 2015.

Certificate of Recognition awarded to *icipe*: On 16th September 2015, *icipe* was awarded a Certificate of Recognition for its contribution towards the implementation of the Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) on the occasion of PATTEC's 15th Anniversary.

***icipe* Stockholm Convention Regional Centre** has formally been endorsed to continue operations for a further 4 years (2016 to 2019) by the more than 160 countries that are members of Stockholm Convention, following evaluation of the performance of the regional centers.

Micky Mwamuye, an MSc scholar, was awarded the "Emerging Research Talent Award" during the UNESCO Merck Africa Research Summit 'MARS 2015' in Geneva (19-20 October).

Dr Benard Kulohoma, a Postdoctoral Fellow in the EID Lab, was selected as the "2015 H3Africa-Harvard Fellow", which recognised him as an exceptional researcher and trainer. H3ABioNet funds this fellowship, and the H3ABioNet Harvard node supports it. The appointment as a Visiting Researcher is for the period 25 January 2016 to 25 May 2016. He will be based at Harvard Faculty of Public Health (Harvard H3ABioNet Node). He is also the winner of the 2015 award for "Young Researcher" conferred during the UNESCO Merck Africa Research Summit 'MARS 2015' in Geneva (19-20 October). This award comes with a 6-months fellowship to gain professional experience in one of the Merck R&D hubs around the world.

Dr Daniel Masiga, Head of the Molecular Biology and Bioinformatics Unit (MBBU), has been invited to participate in the Wellcome Trust Public Health and Tropical Medicine Interview Committee (PHATIC).

Dr Charles Midega, a Senior Scientist in the Push-Pull Programme, Plant Health Theme, is the Cornell University, Ithaca, Distinguished Africanist Scholar. In September 2015, Dr Midega, in his capacity as "Distinguished Africanist Scholar' (awarded in September 2014), delivered various classroom and public lectures meant to stimulate discussion on agricultural research and development in Africa, challenges, opportunities and future policy directions.

Dr David Tchouassi, a Postdoctoral Fellow in the Chemical Ecology Unit, was been selected as a TWAS Young Affiliate. The prestigious affiliateship is for a period of five years, and was awarded by the World Academy of Sciences Regional Office for Sub-Saharan Africa (TWAS-ROSSA). Dr Tchouassi will be invited to participate in TWAS general meetings and conferences.

Dr Tchouassi received a Book Award entitled "*One Health: The Human-Animal-Environment Interfaces in Infectious Diseases*" edited by John S Mackenzie, Martyn Jeggo, Peter Daszak, and Juergen A. Richt, as a Runner Up Winner for his poster at the 3rd International One Health Congress, on 15-18 March 2015, in Amsterdam, The Netherlands. His winning poster was entitled: "*Association of genetics of two key mosquito vectors of Rift Valley fever and changing outbreak patterns of the disease in Kenya"*.

Prof. Zeyaur Khan, Principal scientist, Push-Pull Programme, Plant Health Theme, was awarded the Royal Entomological Society, UK, Honorary Fellowship in June 2015, which is awarded to those who have given "eminent and distinguished service to Entomological Science and /or the Society".

In addition, Prof. Khan's presentation entitled "*Exploiting plant behavior and chemical ecology for developing new crop protection strategies for Africa*" was selected as one of the 20 Premier Presentations that was made at the Entomological Society of America's 2015 meeting in Minneapolis, Minnesota from 15–18 November 2015.

In April 2015, Prof. Khan was appointed an Adjunct Professor of Entomology at Cornell-Ithaca, with Dr Katja Poveda and Dr Andre Kessler as hosts.

Prof. Khan received the Louis Malassis International Scientific Prize for Outstanding Career in Agriculture in March 2015.

Dr Paul-Andre Calatayud, Visiting scientist to 15th August 2015, Plant Health Theme, won the Prix Réaumur from the French Entomological Society, for his book *Interactions insects-plantes* (Insect-Plant Interactions), edited by MM. Nicolas Sauvion, Paul-André Calatayud, Denis Thiéry and Frédéric Marion-Poll. Established in 1960, this prize is awarded to a book about biology written in French, with biology taken in its broadest sense. The award was presented at an official ceremony at the National Museum in Paris in March 2015.

Dr Baldwyn Torto, Head, Behavioural and Chemical Ecology Unit, was selected as a plenary speaker at the 2016 XXV International Congress of Entomology.

Dr Torto has also been selected to serve as a member of the African Academy of Sciences (AAS) Commission on Sciences Education, one of four commissions that the AAS has established to build capacity and set the agenda for science in Africa. The others focus on women in science, Africa's science heritage, and Pan-African Science Olympiads.

The AAS has also selected him to serve on the jury for the award of the Africa Union (AU) Prizes.

Ms. Prisca Oria, a student working in the SolarMal project, won a poster award at the Third Global Symposium on Health Systems Research in Cape Town, South Africa. Her poster was entitled '*Weaving together the technical, social and ecological perspectives in an innovative malaria control project'*.

Dr Segenet Kelemu, Director General, *icipe*, was invited to serve on the National Science and Technology Council of the Republic of Rwanda.

The DG was celebrated in a commemorative calendar celebrating the 25th anniversary of the Organization for Women in Science for the Developing World (OWSD). The calendar recognises some of the senior members of OWSD from eastern and southern Africa who have made an immense contribution to gender, science and technology.

She is also being featured in an upcoming book on science and technology for Africa's development in a chapter devoted to highlighting the research, teaching, and leadership accomplishments of selected individuals who have contributed much to Africa.

The DG was invited to serve on international science award juries such as the L'Oreal-UNESCO Sub-Saharan women in science award held in South Africa; the Malassis and Olam Prizes held in France as well as Rolex Enterprise Awards, Geneva, Switzerland among others.

She was invited to speak on high profile science, food security and related gatherings, or to contribute to publications on important issues, at the Advancing Pest and Disease Modelling conference held at the University of Florida, Gainesville, USA; Valagro Global Conference held in Italy; UNESCO's Science for Africa's Economic, Social and Technological Insurgence consultation held in Zimbabwe; the 2nd International Global Food Security Conference 2015 held at Cornell University, Ithaca, USA as International Scientific Committee member; and to contribute to a UNESCO special issue on "Women and Biotechnology; Outlooks in Pesticide Management", among others.

In addition, the DG was invited to Expo Milano 2015 Women's forum to speak at the plenary session on women and food security. She was the only participant from Africa invited as a member of a high level panel on Science Week in Italy that TWAS and the Italian Government organised, where she presented and participated in a roundtable discussion at the Trieste Next 2015 Science week. The topic for the roundtable discussion was "Ask Africa—Can Agribiotech Make the Difference?" An Italian journalist with international experience moderated the session, which involved two other speakers, Prof. Michele Morgante (University of Udine), and Prof. Alessandaro Vitale (National Research Council of Italy). The DG made a presentation on *icipe* titled "Out of Africa: Bioscience Innovations in Agriculture and Health" prior to the roundtable discussion. The event was given wide exposure in over thirty-one (31) print and electronic media platforms during the month of September. (See print coverage included as Annex 7ii). Considering that most of *icipe*'s current funding comes from Europe, this positive media coverage and fascination with *icipe* is valuable for the Centre. The strong partnership with TWAS is also critical on many fronts.

The DG (and *icipe*) is invited to be featured in an international science TV series called The Mind of the Universe, see http://themindoftheuniverse.nl/. The Mind is an ideological cross media project. It will be the first open source TV series ever, providing the whole series for free to all countries in the world in order to 'spread knowledge'. UNESCO is ambassador of The Mind of the Universe. Open University UK will create an international online learning experience to make all information available for everyone.

Dr Lucy K. Murungi, a Postdoctoral Fellow in the Chemical Ecology Unit received a book award from African Women in Agricultural Research and Development (AWARD), for the best laboratory progress (February 2013-March 2015).

She also received a grant from RUFORUM for research on soil-borne pathogens in smallholder greenhouse tomato production.

Ms. Fiona Nelima Mumoki, a Research Assistant in the Molecular Biology and Bioinformatics Unit (MBBU), was named an AWARD Postgraduate Fellow for 2015, which is a prestigious fellowship for young African Women in Agricultural Research and Development awarded by the Organisation for Women in Science for the Developing World (OWSD). She commenced her PhD studies at the University of Pretoria, South Africa in March 2015.

Dr. Sunday Ekesi, Head of the *icipe* Plant Health Theme, was elected a Fellow of the African Academy of Sciences in 2015. He is scheduled to attend the next General Assembly Meeting (21-24 June 2016) where he will receive his Certificate of Fellowship.

Prof. Clifford Mutero: Prof. Mutero and his colleagues won the Best Overall Publication: Qualitative/ Education/ Health Systems Research from the University of Pretoria Faculty of Health Sciences for their manuscript entitled: Mutero CM, Kramer RA, Paul C, Lesser A, Miranda ML, Mboera LEG, Kiptui R, Kabatereine N, Ameneshewa B. *Factors influencing malaria control policy - making in Kenya, Uganda and Tanzania*.

Ms. Edith Chepkorir: Ms Chepkorir, an ARPPIS PhD scholar supervised by Dr. Rosemary Sang, received the L'Oréal-UNESCO for Women in Science Sub-Saharan Africa 2015 Award on 3rd December 2015 in South Africa worth EUR 5000, to support her PhD work.

Ms. Matilda Gikonyo: Ms Gikonyo's presentation at the 2nd Africa International Biotechnology and Biomedical Conference, held at Nairobi, Kenya, Sep. 17th – 19th, 2015 was awarded the second runner –up award. Further Ms. Matilda also succeeded in gaining a PhD fellowship in the renowned Max Planck Institute for Chemical Ecology, Jena.

1.1.8. Communication Highlights

icipe communications team continues to make solid contributions to the Centre

Improved operations for enhanced publicity: A system is now in place to ensure that media opportunities are utilised for the greatest possible impact. This includes regular consultations between the Centre's management, scientists, and the Communications Unit, to better identify and prioritise publicity activities, and ensure proper messaging, content packaging, and quality control of all media items. This system also guarantees a quick and efficient response to media queries.

Media relations: icipe has also enhanced its relations with the media, across the spectrum, in Kenya, East Africa, and internationally. The Centre has also amassed a growing pool of trusted and dedicated journalists, who report on the Centre's activities. In 2015, *icipe* has been featured in all key Kenyan media outlets, including newspapers, TV and radio. In addition, the Centre has obtained coverage in a range of emerging blogs and online platforms that Kenyan journalists are administering. *icipe*'s solid relationship with the Nation Media Group (East Africa's largest media house), has helped raise its visibility in the region; for instance, through coverage in *The EastAfrican*, a weekly newspaper that is circulated in the Great Lakes Region of Africa, including Tanzania, Uganda and Rwanda.

icipe continues to strengthen its media relationships, evidenced by continued coverage by CNN International, the *New Scientist*, National Geographic, *The Guardian*, *SciDev.Net*, *The Scientist*, *The Washington Post*, *CBS News*, Al Jazeera, the BBC and *Fox News*. The Director General's participation in Trieste Next 2015, and strong support from TWAS-The World Academy of Sciences led to extensive coverage in the Italian and other European media.

Social media: We have continued to enhance our presence with the social media, with an increasing number of engagements from development partners, end-users, and journalists.

News and features: Between November 2014 and October 2015, the Communications Unit produced a number of news and features items, covering various research themes and projects. The *icipe* quarterly e-bulletin was issued twice—in March (issue 1), and in September 2015 (issues 2 and 3). It has been a great source of information to our stakeholders given the feedback we receive.

The African Reference Laboratory for Bee Health launch coverage: The Bee Health Lab launch in November 2014 was a major achievement for the Communications Unit, and *icipe,* which led to more than 50 stories in the local and international press being featured even in early 2015. As well, 28 *icipe* projects were featured in local and international media, with a total of 210 stories appearing in both print and electronically, which has enhanced the visibility, and helped to disseminate information about *icipe* projects.

New website re-design and development: This project entailed a consultative process that involved representatives across the Centre, to ensure that the new website provides a synergised, interactive, multimedia tool between the Centre and its various audiences.

1.1.9 Other accomplishments

Cambridge-Africa Day: Dr. Daniel Masiga was invited to the Cambridge-Africa Day in Cambridge on November 21, where he presented a paper entitled: "Excellence in engaging with Africa: the example of THRiVE and the PhD progam at *icipe*". SciDev.net interviewed him, and the interview was published in January 2016: http://www.scidev.net/global/communication/multimedia/culture-multitasking-threatens-african-research.html. The interview was titled: "Culture of multitasking threatens African research". Dr. Masiga also featured in the 2015 Annual Report of the International Foundation for Science (IFS) as a reviewer in the Animal Health Section.

Soil health and soil arthropods: A new area under development at *icipe* is soil health, and soil arthropods and nematodes. Soil health plays an important role in overall agricultural productivity, and insects and arthropods contribute through a number of mechanisms (including the breakdown of organic matter). *icipe* has now established a Nematology Lab and has a number of projects running as well as scholars attached to it.

Post-harvest science: A lot of agricultural produce is lost between harvest and consumption, with some figures citing losses totalling 40%, depending on the system and country. To meet the growing demand for food worldwide, we can produce more food and reduce the amount of food that is produced but never consumed. A reduction in waste has the added advantage that the increased demand can at least be met with minimal inputs and impacts on the environment. Insects play a significant role in post-harvest losses; and therefore, we believe *icipe* has a role in developing strategies to mitigate this. Reducing insect infestation during grain storage not only has direct benefits, but also has follow-on benefits in reducing losses resulting from microbial spoilage and production of aflatoxins. The appointment of Dr Tadele Tefera as the new Head of our Ethiopia office, a seasoned post-harvest scientist, will strengthen our work in this area.

1.2. Research and Development Thematic Highlights

In 2015, *icipe* continued to implement the Insects for Food and Feed Strategy, while looking for opportunities to further expand our work and define a niche for *icipe.* In this research area, an important concern will be the food source used to raise the insects on. The team acknowledges that this is a critical issue that needs to be resolved for the technology to reach its full potential. This energy source should represent a waste product from an existing industry, to further capitalise on the 'green' aspects of the project, and minimise production costs.

Soil health related to nematodes and soil arthropods; and post-harvest science are areas that *icipe* is exploring, and we hope to develop position papers on the opportunities for *icipe* in these areas. The impact of the push-pull technology on soil health is a point of engagement of *icipe*, and was one of the topics for discussion with the Director of Rothamsted Research (UK) during his visit to *icipe* in June 2015. *icipe's* Director of Research and Partnership also travelled to the UK and made a presentation at an international conference that Rothamsted hosted, and also took the opportunity to explore areas for collaboration between the two Centres.

Insects play a significant role in post-harvest losses of agricultural products; and therefore, we believe *icipe* has a role in developing mitigation strategies. In 2015, we appointed the Head of *icipe*-Ethiopia office, with expertise in post-harvest, and grain storage and losses caused by insects. Reducing grain-infesting insect during storage not only has direct benefits, but also has indirect benefits, such as reducing losses resulting from microbial spoilage and aflatoxins.

1.2.1. Plant Health Theme

The Plant Health Theme contributes to reducing quantitative and qualitative pre- and post-harvest yield losses due to insect pests, mites, weeds, and mycotoxin-producing fungi to increase horticultural and staple food production, through developing economically viable and ecologically sound production systems with low pesticide input. The Theme contains the following focal areas:

Push-Pull: A climate-smart version of *icipe's* push-pull technology is enabling farmers living in drier regions affected by pests and parasitic weeds to harness the benefits of the technology.

Plant signalling and communication: Plants have an inherent ability to modify their defences in a variety of ways. The oviposition-induced release of parasitoid attractants was discovered in maize landraces, the so-called 'smart maize'. However, this trait was absent in commercial hybrid maize varieties, suggesting that indirect plant defence traits may have become lost during crop breeding, and could be valuable in new resistance breeding for sustainable agriculture in Africa and beyond. These findings have significant consequences in designing integrated control programmes.

The push-pull technology helps to increase the productivity of smallholder maize producers; but our work with farmers is also revealing a role in maize quality. Mycotoxins are toxins produced by fungi that are associated with grains, and if ingested, have health impacts across Africa (they cause cancer, stunting, and death). A study of farmer perceptions indicated that push-pull technology plays a role in reducing mycotoxin contamination of maize, as it reduces incidence and severity of ear rot, as well as mycotoxin attack on maize grain. We are elucidating the mechanisms by which the technology delivers these benefits, to develop frameworks for exploitation of services rendered via cropping systems as components for management of ear rot of maize. Once confirmed, the role of push-pull in combating mycotoxins (such as aflatoxin) may be a major breakthrough.

International recognition of push-pull: In August 2015, a thriving push-pull field in front of the Paul Klee art museum in Berne, Switzerland, was part of an exhibition called "Culture and Agriculture".

Further in August 2015, the Report of the UN Secretary-General (Agricultural technology for development) to the 70th Session of the General Assembly, push pull was included as an Integrated pest and weed management technology that can particularly benefit marginalized populations and women (http://www.un.org/ga/search/view_doc.asp?symbol=A/70/298

In its 2016 publication "A Guide to Sustainable Cereal Production" The Food and Agricultural Organisation (FAO) of the United Nations (UN) included a chapter on push pull as an example on how *sustainable crop production intensification 's like'? Push pull describes "Save and Grow" farming systems in practice.* The FAO noted that In East Africa, two of the region's most serious maize pests have been overcome by growing two local plants in maize fields. The 'push-pull' system produces other benefits, including high quality cattle feed. (http://www.fao.org/3/a-i4009e.pdf

Scaling out push-pull technology: A number of new opportunities to extend the reach and impact of push-pull have arisen during the reporting period. The Ethiopian government, through the country's food security initiative and poverty alleviation programme, made a commitment to reach 20,000 Ethiopian farmers with push-pull technology in 2015 alone.

The availability of a regular and reliable cheap source of *Desmodium and Brachiaria* seed has been one of the major constraints of adopting the push-pull technology. During 2015 -16, *icipe* worked with a number of seed producers to develop a commercial sector to produce push-pull seeds. *icipe* has signed agreements with two private sector African seed companies, SeedCo in Zimbabwe, and East African Seed Company in Kenya to develop *Desmodium* and *Brachiaria* seed production and marketing systems. In addition, *icipe* also signed contract with Ethiopian Institute of Agricultural Research (EIAR) Seed Unit to produce seeds for Ethiopian farmers.

Mycotoxins are a major challenge across Africa resulting in significant human health issues. In maize, mycotoxins are often associated with ear rots and the cropping system is a factor in maize ear rot and mycotoxin incidence. *icipe* scientists sought to establish the impacts of the push-pull cropping system on maize ear rot incidences and severity. Incidence of *Gibberella*, *Fusarium*, *Diplodia* and *Aspergillus* ear rots were significantly lower in push-pull than in maize monocrop plots. Similarly, mean severity ratings were significantly lower in push-pull plots for all ear rots. This observation requires further evaluation to determine the mechanism of action and how it may be exploited to reduce the risks associated with mycotoxin contamination in the region.

icipe's fruit fly activities involve the development and deployment of a range of technologies into an integrated pest management (IPM) package for use by farmers. The *icipe* fruit fly team is evaluating the effectiveness of the strategies developed in the field using socio-economic studies. Growers using *icipe*'s mango IPM aproach had approximately 54.5% reduction in mango rejection; spent 46.3% less on insecticide per acre and received approximately 22.4-48% more net income. Cumulatively, 72.0% of the sampled mango farmers adopted at least one component of the fruit fly IPM package in Kenya. Post-harvest treatment of mangoes to inactivate fruit flies serves to both reduce post-harvest losses and open doors to high value export markets. Parameters for post-harvest treatment of mangoes based on hot water treatment for exotic fruit fly species have been examined. On three mango cultivars (Apple, Tommy and Kent), the third instar larva was found to be the most heat tolerant requiring 54.4 min at 46.1°C to achieve probit 99.9968. This observation was confirmed by immersing 1000 mangoes for 55 min at 46.1°C that left no survivors and met the Probit 9 quarantine security (survival rate of ≤22 per million) enabling the treated fruit to be exported to Europe. The immersion of Apple mangoes in hot water at 46.1°C for 55 min did not damage the fruit quality.

On-farm community-based participatory dissemination of fruit fly IPM technologies: The dissemination of fruit fly IPM technologies based on the use of food bait, male annihilation, biopesticide, and field sanitation expanded beyond Kenya, Tanzania, Benin, and Cameroon, to 4 SADC countries—Botswana, Namibia, Zambia and Zimbabwe—during the 2014/2015 mango season. *icipe, NARS, private sector partners, NGOs, farmer groups, and farmers facilitated the uptake of the fruit fly IPM technologies, and more than 2,100 growers are participating. In excess of 26,000 growers are now adopting at least 2 to 3 components of the fruit fly IPM technologies across various African countries. We also unravelled the mechanisms underpinning the dominance of the invasive fruit fly Bactrocera dorsalis over the native Ceratitis species.*

Fruit fly endosymbionts: Facultative endosymbionts in various insect taxa can protect them from natural enemies (including predators, parasitoids, fungal pathogens, and viruses). Now that *icipe* has identified biopesticides and parasitoids for the management of tephritid fruit flies in horticulture, any potential resistance in these insects induced by endosymbionts, to the management products, may affect the use of the fruit fly IPM technology for management of fruit flies. We are assessing the diversity, host population dynamics, and interactions of tephritid fruit fly endosymbionts with their associated parasitoids and entomopathogens. Preliminary observations have revealed the occurrence of *Spiroplasma* and *Wolbachia* endosymbionts in exotic and native African fruit fly species; but we cannot rule out the existence of other endosymbionts (such as *Arsenophonus, Sodalis, Cardinium,* and *Rickettsia*), and hope to unravel this within the fruit fly component of the EU-IBCARP programme.

Discovery of bean flower thrips aggregation pheromone: The bean flower thrips (BFT), *Megalurothrips sjostedti*, is a key African pest of grain legumes and French beans that is inflicting yield losses ranging from 20– 80%. Semiochemicals (such as aggregation pheromones) that are produced by the sternal glands of male thrips, have been developed for monitoring and managing thrips such as western flower thrips, *Frankliniella occidentalis.* BFT males are reported to lack sternal glands, and thrips biologists never considered the prospect of a BFT aggregation pheromone. However, the thrips IPM programme scientists made preliminary and pioneering field observations of BFT male aggregation. *icipe,* in partnership with Plant Research International (Netherlands), Keele University (UK), and Martin Luther University (Germany), investigated BFTs aggregation ecology, characterised the headspace volatiles of males and females, and undertook ultrastructural investigations of the male sternum to confirm this male aggregation, and unravel the factors associated with it. Results confirmed the male aggregation in BFT, which occurred at a specific time of the day, on the upper surface of leaves, and differed with agroecologies. The BFT males produced two distinct molecules that were absent from the females, but were attractive to them. The identified molecules share the same characteristic as the reported thrips' aggregation pheromones, but are distinct. The ultrastructural studies also revealed the presence of sternal glands that are only visible through a 0.4μm pore plate opening. *icipe,* in collaboration with partners, is working towards patenting this finding, and to commercialising it, which could improve monitoring and management of BFT.

Developing IPM for African indigenous vegetables (AIV-IPM): The entomopathogenic fungi isolate ICIPE 62 of *Metarhizium anisolpiae* was selected as the best bio-pesticide against the cowpea aphid *Aphis craccivora* under laboratory, green house and field conditions. Field studies revealed that amaranth Lepidopteran defoliators are seasonal, with sporadic outbreaks. Very low field parasitism rates are recorded and based on successful parasitoid colonies rearing techniques developed at *icipe*, conservative and augmentative biological control can be included in IPM packages against these pests. *Apanteles hemara* and *Cotesia* new species were found to be efficient under laboratory condition against leaf webbers and leaf worms respectively.

Insects for food and feed: Surveys carried out in Kenya and Uganda covered 153 farmers (86 females and 67 males), and 18 research and extension officers. Results confirmed that feed remained the most important limiting factor in poultry and fish farming, and majority of small-scale farmers mix their own feed at household level, or purchase it from small-scale feed producers. While female respondents preferred insect-fed chicken because of its enhanced taste, male respondents were indifferent about feeding chicken with insects, or with conventional feed. Various similarities and differences were recorded between men and women regarding the rearing process. A total of 1194 small-scale farming households (452 female and 742 male), 221feed traders and processors (99 female and 122 male), were interviewed for their perception, knowledge, attitudes, and practices towards the use of insects as feed. In addition, 184 households (114 female and 70 male) were interviewed for their postharvest practices regarding insects.

Seven insect species are maintained in Kenya and Uganda with monthly production levels of up to 10,000 and 35,000 adult insects/week for crickets and black soldier flies, respectively. Preliminary nutritive profiling of insects confirmed the high protein content in 9 different insect instars.

The media and general public have shown particular interest, making repeated phone calls, sending emails, requesting for interviews with staff, and for training opportunities, as well as hosting of a TV programme, (https://www.youtube.com/watch?v=C_6_8XFEk-A) which gave visibility to the project.

In a paper published in *PLOS ONE* on 13 May 2015, and covered globally, *icipe* researchers, together with those from Jomo Kenyatta University of Agriculture and Technology in Kenya, and the United States Department of Agriculture/Agricultural Research Service (USDA/ARS), showed that the desert locust, *Schistocerca gregaria,* contains rich compounds known as sterols that have cholesterol-lowering properties, thereby reducing the risk of heart disease. Aside from cardiovascular protective effects, the researchers found that the desert locust has a wealth of other nutrients, including proteins, fatty acids, and minerals, which are beneficial for anti-inflammatory, anti-cancer and immune regulatory effects; thus, the desert locust is an excellent source of dietary components for both humans and animals. The *icipe* findings are redeeming for the desert locust, which is reputed for its alarming threat to food security; for instance, through causing outbreaks in the Sahel region of Africa, which have destroyed land and crops, leaving hunger and poverty in their wake. Further, a recent study by *icipe* scientist published in the *PLos One journal* found that the edible stink bug, which is known scientifically as *Encosternum delegorguei* Spinola, and in some parts of southern Africa as thongolifha, contains vital nutritional components. The bug was found to be a rich source of fatty acids, including seven that are considered essential for human nutrition and health. The insect also contains some flavonoids, a nutrient group most famous for its antioxidant and anti-inflammatory health benefits.

Citrus pests: In March 2015, the German Ministry of Economic Development and Cooperation (BMZ) provided funding for *icipe* and partners to launch a major project to uplift citrus farming in Kenya and Tanzania. The initiative will address the major constraints to citrus production—insect pests and the diseases they transmit—including two of the most serious pests, the African citrus triozid (ACT), and the false codling moth (FCM). In addition to other damage, ACT transmits a devastating bacterium known as *Candidatus Liberibacter africanus* (CLaf) that is responsible for the citrus greening or huanglongbing (HLB) disease. The larvae of FCM bore into citrus fruits, causing them to drop prematurely. The poor quality fruits that remain on the trees are inedible and are prone to bacterial and fungal infections. In addition, FCM is a quarantine pest, and the detection of a single larva in fruit destined for export markets can result in the rejection of an entire consignment. HLB is most significant in the highlands where it has caused yield losses of between 25-100%, and is implicated in the collapse of the citrus industry in these regions of Kenya.

Biopesticides: icipe's work on biopesticides continues to expand and to have impact in Africa and beyond. During the year, we discovered a novel and potent formulation of *M. anisopliae* (isolate ICIPE 7) for the control of ticks. In field trials, the formulation achieved a reduction of 76 and 85% of on-host cattle ticks 3 and 7 days after treatment, respectively, over the control, compared to 70 and 71%, respectively, with the commercial acaricide Amitraz, against which many tick species have developed resistance. A patent for this formulation is in progress.

Metarhizium anisopliae isolate ICIPE 69, commercialised under the trade name Met 69, continues to gain commercial success, and during the year, the product was registered in Tanzania for the control fruit flies. Isolates of *M. anisopliae* failed to endophytically colonise different parts (root, stem and leaves) of the bean plant, but reduced feeding, oviposition, pupation, and emergence of the bean stem maggot, *Ophiomyia* spp. They can, therefore, be considered for the control of this pest in East Africa. The underlying mechanism is being investigated.

1.2.2 Human and Animal Health Themes

The consolidated Human and Animal Health Themes contributes to reducing vector-borne diseases through tools and strategies aimed at controlling insect vectors; and, therefore breaking the transmission cycle of this diverse group of pathogens. The new Theme leadership has been focusing on reviewing the current portfolio of malaria work, and the development of a new malaria research strategy for *icipe*.

Malaria: An invasive weed known as *Parthenium hysterophorus* (and within the region as famine weed) could increase malaria incidents in East Africa. This is because Parthenium has the ability to sustain the malaria-transmitting mosquito, *Anopheles gambiae,* extending its lifespan in the absence of a blood meal. The *icipe* study opens new dimensions in the analysis and control strategies of invasive plants, concerning the unexplored area of their effects on human health through interactions with disease-transmitting vectors. Such knowledge will be useful in creating risk-analysis models of invasive plants, in relation to vector-borne diseases and associated public health issues.

icipe and the University of Canterbury, New Zealand undertook an extensive review of the only two spider species known to target mosquitoes, *Evarcha culicivora* and *Paracyrba wanlessi,* as published in the *Journal of Arachnology*. The research shows that the manner in which *E. culicivora* and *P. wanlessi* specialise on mosquitoes is different. *Evarcha culicivora* is drawn to the malaria-transmitting female *Anopheles* mosquitoes whose guts are filled with blood. Like an eight-legged vampire, it seeks them out and destroys, or terminates, them. *Paracyrba wanlessi* prefers to feed on mosquito larvae lurking in pools of water inside bamboo. In their own ways, both are specialised mosquito assassins, as they ignore any other insect that gets in the way as they pursue their target victims – mosquitoes. This unique research highlights ways in which these mosquito terminators can help us understand what 'predatory specialisation' means. It also poses the question as to whether we can exploit mosquito terminators for the biological control of malaria vectors, in view of the predominant fear and loathing of spiders.

The SolarMal project: The SolarMal project, a collaborative project with the Laboratory of Entomology, Wageningen University (WU), completed installing 4000 solar-powered mosquito traps on Rusinga Island in May 2015. The results of the 4-year study are still being analysed to understand the impact of the intervention though early results indicate that the project has reduced the prevalence of the malaria parasite by 30% on the island.

Integrated vector management (IVM) for malaria control: Larvicides play an important role in *icipe's* IVM for malaria control. A total of four effective plant-derived larvicides for control of mosquito larvae have been developed by the *icipe*. The larvicides were found to be potentially more cost-effective and suitable alternatives to *Bti,* which is the current industry best practice though it has to be imported into the region and is not always readily available. Plants from which the larvicides were derived grow abundantly in both Kenya and Ethiopia. Thus, they are suitable for cultivation for income generation purposes by the local communities. Registration of one of the larvicidal products (*icipe*-Med-Plant-11) is in progress in Kenya.

Oviposition attractant for gravid malaria vectors: New strategies are needed to manage malaria vector populations that are resistant to insecticides and that bite people while outdoors. *icipe* scientists and partners have identified and evaluated an oviposition attractant for *Anopheles gambiae s.l.*, by developing 'attract-and-kill' strategies targeting gravid female mosquitoes. In a world first, the team found that a naturally occurring chemical, cedrol, attracts pregnant malaria-transmitting mosquitoes. The chemical is found in mosquito breeding sites near Africa's Lake Victoria, and could be used in traps that would 'attract-and-kill' the female mosquito, preventing the pregnant mosquitoes from laying hundreds of eggs. This is the first chemical confirmed to attract female mosquitoes after they have fed, while they search for a place to lay their eggs, and offers a new way to control them. The OviART research group, a multinational team bringing together researchers from *icipe*, the London School of Hygiene & Tropical Medicine, the Swedish Royal Institute of Technology, and the UK's Durham University, published this study in *Malaria Journal*.

Endosymbionts for controlling the malaria parasite (*Plasmodium falciparum*): Transmission-blocking strategies for control of vector insects have shown promise for arboviral diseases (e.g. dengue). There is interest in using endosymbionts to control vector-borne parasites (e.g. *Plasmodium*); however, more research is needed to identify and study those that confer hosts with parasite-specific protection. One widespread endosymbiotic bacterium, *Spiroplasma*, confers insect hosts with protection against a variety of parasitic and fungal infections. The Spirovector Project has isolated two strains of *Spiroplasma* from *Anopheles arabiensis* mosquitoes: One is present in both Mwea and Mbita, whereas the other is present in Mbita samples only. The overall prevalence of *Spiroplasma* is higher in Mwea (an area of low malaria endemicity) than in Mbita (an area of high endemicity). By sequencing the mitochondrial DNA of infected mosquitoes, we have demonstrated that certain mitochondrial haplotypes harbour *Spiroplasma*. This pattern is similar to other insect endosymbiotic *Spiroplasmas,* and suggests a combination of vertical and horizontal transmission routes. This discovery is important in the long-term vision to develop endosymbiotic microbes (e.g. *Spiroplasma*), as a strategy to prevent *Anopheles* mosquitoes from transmitting the malaria parasite. This research has established a *Spiroplasma* screening and characterising pipeline that is being applied to other economically important insects (such as crop pests and beneficial insects).

Risk factors associated with leishmaniasis: icipe scientists, working with the Kenya Medical Research Institute (KEMRI), are examining the risk factors associated with leishmaniasis. The team investigated a reported outbreak of kala-azar (visceral leishmaniasis) in Marsabit County that occurred between May and August 2014, with 112 cases being admitted at the Marsabit County Hospital, and a reported fatality of 10 patients. They collected 3000 sandflies from both indoor and outdoor settings. The trapping was done at various habitats (such as termite mounds, swampy areas, human dwellings, toilets, and animal sheds). Results show that the presence of post-kala-azar dermal leishmaniasis patients and termite hills could contribute to the continuous disease transmission in the area; and are, therefore, considered significant risk factors for disease spread.

Biting flies and surra: icipe shall transfer its tsetse repellent collars technology for use on cattle, to camel health research, to control surra, which is transmitted by biting flies. Funded by the EU and *icipe* core donors, the study will investigate how biting flies interact with each other, their environment, hosts, and non-hosts; and use this knowledge to develop improved control strategies for these vectors of camel diseases. *icipe* will seek to identify the olfactory cues the principal vector species transmitting surra use to find their hosts (camel), and their resting and ovipositing sites. We will also develop novel repellents from natural sources, and use their templates for the discovery of synthetic mimics. Unpreferred hosts will serve as sources for development of these natural repellents, as well as the optimised tsetse repellents. Development of collars for camels will also benefit from the public–private partnerships being forged for large-scale manufacture of the tsetse repellent collars.

Important pathogens associated with camel milk production: Through the Somaliland Camel Milk Value Chain project, the team is conducting surveys of the most important pathogens associated with this industry, including surra, with the aim of developing control strategies to support the industry. The objective is to develop an attractive and effective management system to reduce fly populations, penside diagnostic kits for field diagnosis of the disease, accurate and quick fly molecular diagnosis, and better camel husbandry practices, thus providing a holistic camel health package that pastoralists can use.

Prototype tsetse repellent collars development: Work on improving the tsetse collars for commercialisation in partnership with the private sector continues. The two companies *icipe* selected have produced five different prototypes that are being evaluated under field conditions for their robustness, and efficiency in releasing the repellent at a predetermined and constant rate. We have identified a local entrepreneur who can produce the existing dispensers at a cheaper cost to farmers, pending availability of the improved dispensers. Farmers in Shimba Hills have registered their own community-based organisation for selling the repellent dispensers and compounds (including servicing and maintenance of the dispensers). They have also collected over $2000 for purchase of the repellent compounds, which is a positive sign and step towards adoption and upscaling of the repellent technology; furthermore, this amount continues to increase every month. So far 352 homesteads have been registered with 2033 cattle, of which 958 have repellent collars. We have recruited a chemical ecology scientist and a postdoctoral fellow to work on the camel and tsetse components of IBCARP. Two PhD students will work on determining the semiochemical basis of the repellency of zebra to tsetse flies, and on the efficacy of a repellent mixture isolated from waterbuck to protect cattle and enclosures from a vector of human sleeping sickness, *Glossina fuscipes fuscipes*.

Understanding Tsetse flies: In a paper published in *PLoS Neglected Tropical Diseases journal*, *icipe* researchers reported that different species of tsetse flies responsible for transmitting sleeping sickness and nagana, use the same set of genes to find their hosts (humans or animals from which to feed). This is a surprising finding, considering that tsetse fly species differ in their responses to animal odors. The research found that tsetse flies have fewer chemosensory genes as compared to other insects. Tsetse flies only feed on blood, which means that they do not need the same number of chemosensory genes as other insects that feed on other hosts. However tsetse flies have more genes that can sense carbon dioxide than other insects. These genes are the key players for the tsetse fly being able to find their food. Overall, there are no major differences in the numbers or types of genes for sensing chemicals that are present in different species of tsetse fly, despite the fact that they respond differently to chemicals in the environment.

Development of assay for differentiating arboviruses in samples: We developed an assay for differentiating various arboviruses in samples, which will have applications for use in surveillance programmes. The technology has the potential for use in differentiating species of *Plasmodium,* identifying mosquito blood meal vertebrate hosts, and in differentiating mosquito species and bovine MHC. The work was published in *PLOS ONE* journal.

Rift Valley fever research: Rift Valley fever (RVF), a mosquito-borne zoonotic disease, poses substantial public health and economic threat to vulnerable pastoral communities in East Africa. We have improved our understanding of inter-epidemic ecology of the disease. This information had remained obscure for a long time; yet, it is critical to improving early warning systems, preparedness, and control. There is evidence for the existence of an active inter-epidemic circulation of the virus among livestock, because of increase in numbers of the mosquito vectors during the short and long rains seasons in Garissa, Kenya. In addition, we have mapped the distribution of the vectors along the major nomadic livestock movement routes in Garissa, and identified key vegetation types that the primary vectors use as resting/refuge sites (from environmental pressure), as this is important in developing approaches for their control. Our research has identified knowledge gaps on the manner that RVF is transmitted, as well as preventive measures taken among communities living along the nomadic routes; thus, focus should be put on these aspects to reduce the likelihood of infection and death.

Ticks and tick-borne diseases: Ticks are obligate haematophagous ectoparasites that transmit a wide range of pathogens to humans and animals. Apart from incidences of outbreaks of arboviruses in Baringo and Homa Bay counties of Kenya, other tick-borne pathogens (TBPs) remain understudied in both areas. We analysed 553 tick pools consisting of 4299 ticks collected in both study areas, and sampled more ticks (12 species) in Baringo (86%), and eight species in Homa Bay (14%). These findings reveal significant presence of agents of ehrlichiosis, anaplasmosis, rickettsiosis, babesiosis, theileriosis, and hepatozoonosis among ticks feeding on, and possibly transmitting to, domestic animals with undetermined impact on humans. The information is important to public health in mitigating TBPs, and possible disease outbreaks in these areas.

1.2.3. Environmental Health Theme

The Environmental Health Theme deals with basic and applied research on *environmental health*-related diseases and pests of beneficial insects, including the impact of climate change on the food web. The Theme has three major programme areas: *Biodiversity and Conservation,* Commercial Insects and Applied Bioprospecting.

Remote sensing: icipe and collaborators have developed a new remote sensing-based methodology to map flowering plants in Africa. Using this methodology, which combines two hyperspectral mapping formulas, the researchers have produced the world's first floral map. Knowledge on floral cycles can be used to draw up flowering calendars, which categorise flowers, their value to bees, abundance, season, and duration of bloom. Floral calendars help us to understand bee diversity, and they also strengthen landscape conservation efforts that focus on the value of flowering plants for beekeeping. In the long term, a better understanding of floral diversity will enable decision makers and beekeepers to discern the interaction between bee colonies and the floral environment, and enable them to optimise beekeeping. Because flowering patterns are an important indicator of a range of factors (such as climate change and soil moisture), remote sensing of floral diversity will contribute towards the ultimate goal of enhancing food security in Africa.

Insect diversity: icipe taxonomists, in collaboration with colleagues from the Tropical Entomology Research Institute and the University of Tuscia, both in Italy, discovered 14 wasps species in Kenya and Burundi. In naming the new species, the researchers immortalised various sites and individuals from the two countries, and from across the world. The findings, published in the journal *Acta Entomologica Musei Nationalis Pragae* on 1st June 2015, contribute indispensable knowledge to the global taxonomy network. Wasps are beneficial to humankind, because of their ability to control agricultural pests, as the majority are parasitic, and lay their eggs in or on the eggs or larvae of other insect species, which, as the wasp larva develops, leads to the death of the host insect. For almost every pest insect, there is at least one wasp species that parasitises it. Parasitic wasps are increasingly being used in the biological control of crop pests. *icipe* has in the past recorded significant success in using wasps to control pests of cabbage and maize in Africa.

The Coastal Forests of Eastern Africa comprise one of only eight African Biodiversity Hotspots that Conservation International recognises. This hotspot is a collection of small, isolated, forest relicts extending from Mozambique to Kenya. Muhaka Forest is part of this forest chain and *icipe*'s Muhaka Field Station provides access to the forest, and logistical support to carry out entomological survey-and-inventory studies. *icipe* scientists working in Muhaka discovered a strange, undescribed parasitic wasp, structurally different enough to warrant the establishment of a new genus. Collaborating with hymenopterists at the Smithsonian Institution, the wasp has now been described (Buffington M.L. and *Copeland R.S.* (2015) *Muhaka icipe*, an enigmatic new genus and species of Kleidotomini (Hymenoptera: Figitidae: Eucoilinae) from an East African coastal forest. *Journal of Natural History*, doi: 10.1080/00222933.00222015.01042411). In recognition of *icipe*'s role in furthering knowledge of Africa's amazing insect biodiversity, the new species has been named *Muhaka icipe.* The tiny (ca. 2 mm) wasp joins four other recently described insect species known only from Muhaka Forest.

Stingless bees: icipe's work on stingless bees continues to have an impact on the livelihoods of African honey producers. Traditional methods of harvesting honey from the hives of stingless bees involved invasive methods that resulted in the destruction of the hive. *icipe* scientists have designed new hives that not only stimulate stingless bees to colonise hives, but also enable the honey to be harvested without damaging the hive; which has significant food security implications. *icipe* scientists have developed a technique to mass produce stingless bee colonies using *in vivo* and *in vitro* queen rearing methods. The effectiveness of stingless bees to improve fruit and seed quality of green peppers under enclosure, compared to self-pollinated plants and plants pollinated by feral pollinators in the open field, has also been studied.

Development of a plant-derived product for control of bee pests and diseases: Apicure, a shelf-stable plant-based product was developed for control of bee pests in beehives. In field experiments, it was effective in controlling varroa mites in bee colonies where it acted as a fumigant biopesticide by killing varroa mites. It was also a repellent to other bee pests such as hive beetles. A patent application on the composition of the Apicure active ingredient and methods of its use for bee pest control was filed at the Kenya Industrial Properties Institute (KIPI) for intellectual property protection.

1.2.4. Capacity Building and Institutional Development

A key focus of *icipe's* capacity building is the training of young, talented researchers from across Africa in insect and related sciences at MSc, PhD and postdoctoral levels. This is conducted through the African Regional Postgraduate Programme in Insect Science (ARPPIS), the Dissertation Research Internship Programme (DRIP), and the Postdoctoral Fellowship Programme. These programmes not only build the capacity of individual scientists, but they also add new research capacity to icipe, which has led to important research outputs and scientific discoveries, thus contributing to knowledge creation and sustainable development, and enhancing the status of icipe as a world-class centre for insect science research and development. During the reporting period *icipe* had 88 PhD fellows and 87 DRIP MSc fellows at various stages of their research training. Three new postdoctoral scientists were recruited in 2015, and we also hosted two visiting scientists for up to 1 year during 2015.

icipe is committed to advancing excellence in science through gender equity: 43% of all post-graduate, postdoctoral fellows and visiting scientists are women, and 47% of fellows in the PhD programmes are women. The postgraduate and postdoctoral programmes have a continent-wide impact: our alumni and current research fellows represent 37 countries in Africa. In 2015, 18 African nationalities were represented by postgraduate students at icipe; and 30% of PhD students were from Southern, Central and West Africa. In July 2015, the German Academic Exchange Service (DAAD) confirmed its approval of an increased support to the *icipe* ARPPIS PhD fellowship programme. As a result, 10 new ARPPIS PhD fellows started in Oct 2015 with scholarships from DAAD. With nine African nationalities represented (Benin, Cameroon, Ethiopia, Ghana, Ivory Coast, Kenya, Nigeria, Sudan, Tanzania, and Uganda) this new student cohort represents a doubling of the number of nationalities entering the ARPPIS programme.

Postgraduate and postdoctoral fellows make a significant contribution to the research output of *icipe*. Of the 151 peer-reviewed papers published by *icipe* between April 2015 and March 2016, 74 (49%) were attributed to postgraduate and postdoctoral fellows, who were lead authors on 58 (38%) of these papers. Research findings by postgraduate students have been highlighted by the international media, and a number of *icipe* fellows are recipients of prestigious international awards and other recognitions. Postgraduate students also participate in a large number of national, regional and international scientific conferences to gain experience in communicating research findings, to learn about the most recent advances in their fields, and to establish contacts with other scientists. In 2015, 35 postgraduate students participated in 30 scientific meetings and conferences.

By strengthening the research capacity of universities and research institutions in sub-Saharan Africa, icipe alumni are playing an important role in the multiplier effect of capacity building and development outcomes in Africa. Overall, approximately 80% of all *icipe* postgraduate and postdoctoral alumni remain in research, development and academia in Africa, where they conduct research, impart knowledge to the next generation of researchers, and contribute to development. For example, of the 23 PhD students who completed training in 2014-2015, 16 (70%) are currently in research, development and higher education in Africa; and of the 18 MSc students who completed training in 2014-2015, 15 (83%) are following careers in R&D or pursuing a PhD. Of eight postdoctoral fellows who completed their tenure in 2015, all are currently in research, development or higher education: seven are in Africa; four are following a research career as scientists with *icipe*, three are scientists/lecturers in national systems, and one is a research scientist in the UK.

Capacity building at *icipe* spans the whole continuum of its research and development activities, from fundamental strategic research, to applied research, technology development and validation. As such, capacity building also supports training and capacity building for those who implement the adaptation and adoption of new technologies in the field. For example, *icipe,* in 2015 through its various research programmes, carried out 37 training courses for 10,844 trainees including researchers, community workers, and farmers.

1.3 Research and Development Partnerships

*Rothamsted Research***:** During 2015, *icipe* entered into a cooperation agreement with Rothamsted Research (RRes), UK. Rothamsted Research is a longstanding strategic partner in *icipe's* flagship Push-Pull Programme. Through this partnership, RRes aims to establish a strategic collaboration programme with *icipe*, which also includes using it as a regional hub to work in other partner countries in Africa. To advance the scientific partnership, a joint workshop focusing on new opportunities for Insect Pest Management was held at Duduville campus from in November 2015. The primary purpose of the workshop was to brainstorm and generate concept notes for 2 to 3 large joint research projects in the areas of:

- Next generation chemical ecology solutions for integrated pest management (IPM);
- Comparative vector biology with applications for plant, animal and human health; and
- Bee health (all aspects of it, including pollination services).

Agroscope, Switzerland: Agroscope and *icipe* signed an MoU in March 2015. The CEOs of both institutes endorsed the convening of a joint proposal workshop scheduled for 25 – 27 January 2016. The workshop would allow *icipe* and Agroscope to present research in the areas of biological and integrated control of arthropod pests with the aim of identifying possible areas of collaborative research. Biological control would include classical, augmentative and conservational approaches. Discussions would not be limited to a particular production system but would include horticulture (fruits and vegetables), staple crops (cereals and pulses) as well as postharvest systems (cereals and pulses). In addition, the environmental risk assessment for novel pest control methods would be addressed. This includes the potential for unacceptable effects on useful non-target organisms.

Alexander von Humboldt (AvH) Foundation, Germany: The Centre has signed an MoU with the Alexander von Humboldt (AvH) Foundation, Germany. The MoU signed in December 2014, sets out collaborative arrangements that will see us work together to promote research excellence, and capacity building to boost Africa's development, promote academic cooperation between scientists from Africa and Germany, and strengthen the AvH network in Africa. One of the first activities under the MoU was *icipe* hosting the AvH Head of Africa and Middle East Division, in March-April 2015. Further towards the end of 2015, Dr. Obiero who was a DAAD supported ARPPIS scholar in *icipe* and lecturing at The Technical University of Kenya was awarded the Georg Forster Research Fellowship becoming the first *icipe*-supported recipient of a fellowship from the Alexander von Humboldt Foundation. This will be tenable for 2 years at Max Planck Institute of Chemical Ecology, Jena, Germany.

Cirad/IRD, France: icipe has long-standing collaborative arrangements with research organisations such as Cirad and IRD who have staff that are either hosted on our campuses, or spend significant amounts of time each year working within our facilities. Effective 1st September 2015, and for a 2-year period, we welcomed Dr Emilie Deletre, a Cirad researcher who will contribute to the development of innovative pest management strategies to reduce chemical pesticide use on vegetables. While these scientists add to the *icipe* research community, bringing additional scientific skills to our research activities, and are also among the most prolific authors of scientific papers, they are not always well integrated into our research programmes. As we renew these agreements we are looking to broadening the relationship to access synergistic, as well as complementary skills (beyond entomology), and to integrate these scientists into our existing activities or into priority areas for development. The DG visited Cirad in February 2015 to explore further opportunities for collaboration between the two organisations, and a reciprocal trip was made during March 2015 to finalise the renewal of the MoU between the two organisations.

Cornell University, USA: In July 2015, the DG participated in a symposium on bacterial pathogenesis *"Pseudomonas-Plant Interactions: A System Facing the Future".* The mission entailed discussions with current *icipe* partners at Cornell, on areas of collaboration that could be of benefit to the organisations, staff and student exchanges, and joint fund-raising possibilities. Cornell partners suggested that *icipe* consider writing a book on the push-pull system that can serve as a textbook, and act as a teaching resource. Further, we are hosting Prof. Laurie Drinkwater, a soil scientist from Cornell University in the USA, who is undertaking a sabbatical at *icipe* that begun mid-2015. She joined our push-pull team and her work explores the impact of push-pull on overall soil health.

The *icipe* Environmental Theme has entered into a partnership with the *Commonwealth Scientific and Industrial Research Organisation (CSIRO)***,** Australia. CSIRO is currently leading a global research effort based on a new technology and scientific cooperation in bee micro-sensing, using micro chips as back-packs to measure bee foraging behavior and environmental traits. The partnership was initiated with the Micro-sensing technology and systems unit (Prof. Paulo de Souza) of CSIRO.

A new partnership was established with thrips semiochemical experts from *Keele University*, which has already resulted in the identification of the exact molecules in Bean Flower thrips Aggregation pheromone responsible for the biological activity. Discussions on patenting of the results are on-going.

The push-pull program entered into a series of partnerships that we hope will expand the area and regions utilizing the push-pull production system. New partnerships have been established with the One Acre Fund in Kenya and Uganda, and the CABI Plantwise project, World Vision and Project Concern International in Kenya and Tanzania. Through these partners target-specific and cost-effective dissemination pathways have been established to extend the technology, cumulatively with the other partners leading to adoption of the technology by about 26,000 smallholder farmers in eastern Africa in 2015.
Our partnership with the German private sector under *icipe's* tsetse repellent work has resulted in the identification of a new material suitable for the manufacturing of a new generation of dispensers that eliminates all metallic parts, making them much cheaper to produce. This material has been used to mold new dispensers with promising results. Two prototypes of the new dispensers are currently being tested under field conditions. Until this new generation of dispensers is available, a private company has been identified to produce the current model of dispensers locally.

1.4. Engagement with the Private Sector

Partnerships play a key role in *icipe*'s strategy, as they enable us to link with complementary research organisations across the globe, thus increasing both the breadth and depth of the skills we can draw upon to deliver scientific solutions to the challenges facing Africans. Commercial partnerships enable us to take our technologies from the lab to the field, and to communities where they are needed most.

In October 2015, *icipe* signed a partnership agreement with Kenya Biologics Limited, paving the way for the establishment of a commercial pilot processing plant to produce food bait for the management of fruit flies in Kenya. We anticipate that the processing plant will be constructed, equipped and operational by mid-2016. Elephant Vert, through Kenya Biologics, is funding the construction of the processing plant. Elephant Vert (EV) is a Swiss company that operates on an international scale with a specific focus on the development and commercialisation of biopesticides. BMZ/GIZ is equipping the facility through a grant to *icipe*.

icipe and Real IPM, a Kenyan-based private sector company, have a strategic partnership, and Real IPM has taken on the commercialisation of a number of *icipe* biopesticides (ICIPE 69, ICIPE 78, ICIPE 7 and ICIPE 62). Real IPM's footprint on the African continent is increasing, leading to availability and impact of *icipe* products. Real IPM has plans to market *icipe*-based products to the world with current negotiations/ registrations underway that would see *icipe* technologies commercialised in Europe, North America, and Asia. The Centre also signed an MOU with Elephant Vert S.A., a Company that has physical presence in Morocco and west Africa and is a major shareholder in Real IPM UK that will underpin the development and evaluation of new biopesticides and support the commercialization of existing *icipe* products on the international stage.

1.5. Patents

In September 2015, *icipe* filed a patent to cover work on a plant-derived product for control of bee pests and diseases. A patent for the innovation has been filed through the Kenya Industrial Property Institute (KIPI), and is in the process of being filed in other countries (Patent No: KE/UM/2015/00554). Validation of the product has been initiated in other African countries including Madagascar, which has a serious bee pest and disease problem.

In November 2014, Wageningen University (WU), on behalf of the SolarMal partners, filed a PCT patent entitled "Insect repellent composition and methods of use". The patent application entered the examination phase in late 2015. In collaboration with WU, Vanderbilt University, and Yale University, we are preparing a provisional patent to cover our work on aggregation pheromone of bean flower thrips, which will have application as part of an integrated pest management programme. *icipe* has an additional two patents focused on insect attractants (blood feeding insects) and repellents (insects and arthropods), and one on antimicrobial agents that are in the examination and grant phase. Because the Centre has no commercial partners associated with these patents, we are working to review their commercial value with the objective of identifying a commercial partner before the applications lapse.

1.6. Publications record

The publication report for April 2015 – March 2016 is presented in Annex 1. During this period, *icipe* has published 151 peer-reviewed journal articles and 52 books and other publications.

From Lab to Land—Women in 'Push–Pull' Agriculture: Last year *icipe* unveiled its new publication *From Lab to Land—Women in 'Push–Pull' Agriculture*, which brings together the voices of women scientists, agricultural extensionists, and farmers from across eastern Africa. The stories they relate the origin and development of push–pull, and in doing so, offer a unique view of what it is like to be a woman in farming, in agricultural extension, or in science, in Africa today. Read more at: http://www.pushpull.net/women_in_push-pull.pdf

International recognition of push-pull: In August 2015, a thriving push-pull field in front of the Paul Klee art museum in Berne, Switzerland, was part of an exhibition called "Culture and Agriculture".

Further in August 2015, the Report of the UN Secretary-General (Agricultural technology for development) to the 70th Session of the General Assembly, push pull was included as an Integrated pest and weed management technology that can particularly benefit marginalized populations and women (http://www.un.org/ga/search/view_doc.asp?symbol=A/70/298

In its 2016 publication "A Guide to Sustainable Cereal Production" The Food and Agricultural Organisation (FAO) of the United Nations (UN) included a chapter on push pull as an example on *how sustainable crop production intensification 'look like'.* Push pull describes *"Save and Grow"* farming systems in practice. The FAO noted that in East Africa, two of the region's most serious maize pests have been overcome by growing two local plants in maize fields. The 'push-pull' system produces other benefits, including high quality cattle feed. (http://www.fao.org/3/a-i4009e.pdf)

icipe has produced, with the climate change and ecosystem services project, a 421 page book "***A Natural History of the Wild Fruits of the Taita Hills, Kenya***", filled with detailed images of fruit and the guild of insects that exploit them. Quentin Luke, the world authority on Kenyan plants was a co-author.

1.7. Reduction of *icipe*'s Environmental Footprint

icipe has established an environment management committee that has made considerable advances in setting targets and measuring the Centre's efforts in reduction of carbon emissions as well as monitoring our progress towards achieving them. The committee that regularly reports to senior management on environmental matters oversees *icipe's* Environment Management System (EMS) Strategy. The Centre has to date implemented a range of water saving activities that include the installation of water tanks that have a total capacity of 250,000 litres, that will soon be doubled to 500,000 litres. Highly inefficient water taps are being replaced with water efficient systems across the Centre including sensor systems for toilets. Last year we identified the distillation plants that cool our insectory as being a major user of water and an opportunity to make significant reductions in the Centre's overall water use. This year we have modified the water cooling system so that the water is recycled saving 50,000 litres of water per month. *icipe* has two additional water distillation plants associated with our research laboratories which are scheduled for refurbishment. When the refurbishments are complete and the distillation plants are upgraded our total water savings will be approximately 1.5 million litres per year or 10% of our Dududville campuses total water use. This year our efforts in monitoring the Centre's water use was rewarded with the early detection of broken water pipes that allowed repairs to be made in a timely manner saving many litres of water.

icipe's flagship carbon reduction programme is the installation of solar photovoltaic and solar thermal systems at our Duduville and Mbita campuses. On 11th March 2016, the Centre signed an EPC (engineer, procure and construct) agreement for the installation of Solar panels for the generation of renewable energy with Solar Century East Africa. Work started almost immediately and is due for completion during 2016. This is a US$ 2.5 million renewable energy initiative, funded by the Swiss Agency for Development and Cooperation (SDC); it is one of the largest of its kind in Africa. Through this project, *icipe*'s goal is to create a sustainable energy supply and to reduce diesel fuel dependency by constructing solar photovoltaic (PV) power plants at its Duduville Campus headquarters in Kasarani, Nairobi, and at the *icipe* Thomas Odhiambo Campus on the shores of Lake Victoria. This is expected to reduce consumption of grid supplied power by approximately 50% and significantly reduce dependency on diesel powered generators. The energy saving measures and Solar PV production has an environmental impact equal to reducing carbon emission by 1,500 tons of CO2 annually in Duduville and 280 tons of CO_2 annually in Mbita. A total of 4130 PV modules will be installed on rooftops on both *icipe* campuses, creating the largest rooftop solar PV plant in Kenya. Photovoltaic modules placed on roofs have various advantages, for instance, better use of available space and natural cooling of the spaces underneath. Another 228 PV modules fixed on various facades, such as carports. Excess energy generated during peak periods of sun light will be directed into the Kenya power grid leading to a further off set in the Centre's carbon emissions.

The Centre is also reducing its use of power through a programme of replacing highly inefficient fluorescent lighting with energy efficient EID systems, to date we have completed the switch over in our main office building at Dududville and we are currently continuing our programme across our sites; more than 50% of the Centre's fluorescent tubes have been replaced to date. This has reduced the overall energy consumption by approximately 3% during second half of 2015.

- 4,663 Fluorescent tubes switched off. This has a saving of approximately 272,300 kWh.
- 550 Fluorescent tubes replaced with LED light tubes. The LED light tubes use half the energy consumed by similar fluorescence tubes. This has a saving of 4,000 kWh

The Centre is currently undergoing an external energy audit by E-Enovators to identify future opportunities for energy reduction. Our works programme to reduce the Centre's carbon footprint is complimented with a staff awareness programme on the need and opportunities to reduce our footprint as well recycling programmes (water, glass and electronic equipment) to reduce our waste and the introduction of Centre policies directed towards travel and transport. The Centre also continues a programme of tree and vegetation planting on our campuses and field stations to offset our carbon emissions. In 2016 *icipe* will undertake an independent external audit of our environmental systems as part of our Kenyan National Environmental Management Authority (NEMA) requirements.

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SECTION 2: Programmatic Results Based Management Reporting for 2015

Plant Health Results Based Management Report

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 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 observed 1.1: Development and implementation of a sustainable IPM and surveillance programme for the invasive tomato leafminer, Tuta absoluta (Meyrick), in North and sub-Saharan Africa.				
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 2014. ▪ 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.	▪ The abundance, distribution, pest status and inventory of the host plants of *T. absoluta* established in target countries by end of 2014. ▪ Modelling and distribution maps of the pest at country and regional levels made available by end of 2015. ▪ Specific markers developed, and origin and invasion pathways established by 2016. ▪ Vibrant colony of *T. absoluta* and at least one indigenous natural enemy species established in target countries by end of 2014.	▪ The abundance, distribution and pest status has been established in Tunisia and Sudan (Manuscripts are in preparation). Host range has been established in Sudan and data was published in EPPO Bulletin (Mohamed *et al*., 2015). ▪ The pest distributional range and risk maps have been modeled and data has been published in *Plos One Journal* (Tonnang *et al*., 2015). ▪ Best markers for *T. absoluta* identification and barcoding have been established and a manuscript is under review (Kinyanjui et al.). Invasion history is underway samples have been collected and are being genotyped. ▪ Colonies of *T. absoluta* and two indigenous parasitoid species have been established at *icipe*, Kenya and ARC, Sudan.	Modeling results revealed that temperature and moisture are key factors determining *T. absoluta* population growth and that the pest represents an important threat to Africa, Asia, Australia, Northern Europe (Belarus, Lithuania, Estonia, and Denmark), New Zealand, Russian Federation and the United States of America (USA). Thus, the pest is at high risk of spread and establishment in most of the high risk countries. Therefore, an area wide IPM approach should be implemented to suppress this pest. Moreover, the pest also attacks other important indigenous African vegetables such as night shade, *Solanum nigrum* and this has to be taken into consideration when designing IPM strategies for this pest.
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.	▪ At least one co-evolved parasitoid identified, tested and if feasible introduced to Africa by mid 2015. ▪ Vibrant colony of at least two species of the most promising natural enemies established by end of 2014. ▪ At least one parasitoid introduced to Africa by end of 2015.	▪ An efficient co-evolved parasitoid species, *Dolichogenidea gelechiidivoris* has been identified in Peru. ▪ A colony of this parasitoid has been established in Lima, Peru for introduction into Africa. ▪ Based on performance studies of this parasitoid on *T. absoluta* conducted in CIP, Peru, a dossier has been submitted to KEPHIS to seek permission for importation of this parasitoid into *icipe* Animal Rearing and Quarantine Unit.	*Dolichogenidea gelechiidivoris* is an efficient larval parasitoid of *T. absoluta with parasitism* of up to 57%. This will make a good candidate for *T. absoluta* suppression in Africa.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 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.	▪ At least one new technology for *T. absoluta* management identified, and together with the already existing technologies, implemented in at least one location of the target countries by end of 2015. ▪ At least one attract-and-kill strategy developed and tested in Peru by end of 2014. ▪ One companion crop suitable for management of *T. absoluta* identified and tested widely by end of 2015. ▪ At least one virulent isolate/strain of an entomopathogen (fungi or virus) identified, and when possible, field-tested by end of 2015. ▪ Discussion initiated with at least one private company for commercialisation of the natural product by end of 2015.	▪ Mass trapping technique was evaluated as a component in *T. absoluta* IPM strategy. TUA- Optima® pheromone lure has been proven to be most effective for mass trapping of *T. absoluta* male. This is being promoted to growers for suppression of the pest in their gardens. ▪ An attract-and-kill product based on a pheromone concentration of 0.05% and a pesticide Beta-Baytroide at a concentration of 0.5% has been tested for efficacy and stability under natural environmental conditions. The product is ready and awaiting field validation. ▪ Trials to establish a companion crop for *T. absoluta* suppression is underway using fenugreek and coriander. ▪ Among the *M. anisopliae* isolates screened, ICIPE 18 and 20 were the most pathogenic incurring percent mortality of 94 and 92, respectively. Also two baculovirus strains *Tuab*GV and the *Phop*GV showed high biological activity against *T. absoluta* have been isolated for potential use as biopesticides.	Due to the pest's aggressive nature, one bullet approach for its management is not sustainable hence a need to develop a comprehensive IPM package for it management.
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.	▪ Status of *T. absoluta* in high-risk countries of Kenya, Republic of South Sudan and Uganda established by end of 2014.	▪ Through surveillance activity of the project, the pest was detected for the first time in Kenya in 2013 (S. Mohamed unpubl.data), in Republic of South Sudan (2014) (M. Garang et al., unpubl. data) and in Uganda (2015) (Tumuhaise et al., 2016). ▪ We have also detected the pest in Tanzania.	▪ This surveillance activity showed a clear trend of downward movement of the pest and spread across sub-Saharan Africa and signified the dire need for intervention to suppress the pest and its impact on the horticultural sector in Africa.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 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.	▪ At least one training-of-trainers (ToTs) workshop and one farmer field day conducted in each of the target countries by end of 2014. ▪ At least 10 NARS in each of the target countries trained on, and 100 growers exposed to, *T. absoluta* IPM by mid 2015. ▪ At least 1500 training materials on *T. absoluta* monitoring and management developed, and distributed in the target countries by 2015. ▪ At least 3 PhD and 3 MSc students trained on *T. absoluta* IPM by 2015.	▪ First ToT workshop was conducted at *icipe* for 21 staff of the Ministry of Agriculture from Kiambu County, Kenya on monitoring, management, taxonomy and rearing of *T. absoluta* on 25th and 26th of August 2014. ▪ Another ToT workshop was held in Sudan for 37 extension and quarantine personnel on *T. absoluta* monitoring, management and taxonomy which took place on 2nd and 3rd of February 2016. ▪ Following the ToT workshop, a farmer field day was conducted in Sudan for field demonstration on monitoring and management of *T. absoluta*. 170 tomato growers attended the field demonstration. ▪ A factsheet on *T. absoluta* was developed and distributed to the beneficiaries in the target countries. ▪ Also a Tuta IPM project website was developed and embedded into the *icipe* website, and is accessible through this link: tutaabsolutaipm.icipe.org ▪ A total of 4 PhD and 3 MSc students are at various level of their training in the project.	
Specific Objective 1.2: Develop and implement integrated pre- and postharvest pest management approaches for thrips and tospoviruses infesting vegetables and grain legume crops in East Africa in collaboration with international and national partners by 2015.				

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Biopesticide for thrips IPM developed and commercialised. Thrips IPM strategies based on intercropping, use of biopesticides, semiochemicals and botanical pesticides developed.	Thrips and tospovirus management strategies for French bean, onions, tomato and grain legumes encompassing at least two IPM components formulated by 2014.	▪ At least one tospovirus-resistant cultivar of onion and tomato identified by 2015. ▪ Large-scale implementation of IPM strategies for thrips and tospoviruses encompassing at least two IPM components undertaken in at least two key production areas by 2015. ▪ Reduction in use of synthetic pesticides by at least 20% by 2015. ▪ No. of peer reviewed publications. ▪ Number of theses.	▪ Two thrips resistant onion accessions (VI038512 and VI038552) identified and the basis of resistance elucidated ▪ Large-scale field demonstration/ implementation of thrips IPM technologies encompassing IPM strategies such as seed treatment, use of colour sticky traps with kairomones and bionets were undertaken in key vegetable productions regions of Kenya such as, Embu, Mwea, Loitokitok and Nyeri. ▪ Significant reduction in pesticide sprays were observed in IPM treatment plots as compared to current farmer practices. ▪ 7 peer reviewed publications (Gikonyo et al.., 2016, Int. J. Trop. Insect Sci., Accepted; Niassy et al., 2016, Ent. Exp. et App.158, 17 – 24; Mfuti et al., 2016, Pest manage. Sci. 72, 131-139; Krueger et al., 2015 Arthro. Str. Dev. 44, 455 – 467; Abtew et al., 2015 Insects 6, 608 – 625; Nyasani et al., 2015 6, 279 – 296; Muvea et al, 2015, Journal of Pest Science, 88, 555 – 562). ▪ PhD thesis – 3 (Muvea, 2015; Abtew, 2015; Mfuti, 2016) ▪ MSc thesis (Gikonyo, 2016; Krueger, 2015; Mujuka, 2016; Siguna, 2016)	▪ Adoption of thrips and tospovirus IPM strategies resulted in significant reduction in pesticide use ▪ Benefit cost ratio of IPM strategies in French beans were comparable or even better than pesticide use

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Training of trainers programme for agricultural extension officers/ plant quarantine inspectors in East Africa. Training materials and curricula developed Field demonstration of thrips IPM strategies based on intercropping, use of biopesticides, semiochemicals and botanical pesticides undertaken. IPM technology adapted and validated with French bean, tomato, onion and grain legume farmers. *Ex-ante* and *ex-post* assessment of the introduced management strategies.	▪ Awareness on thrips, tospovirus monitoring and management strategies created among agricultural extension officers/plant quarantine inspectors. ▪ French bean, tomato, onion and grain legume farming enhanced by 2015.	▪ Awareness among at least 200 agricultural extension officers/plant quarantine inspectors enhanced on thrips and tospovirus monitoring/ management by 2015. ▪ Awareness among at least 1000 French bean, tomato, onion and grain legume farmers enhanced for adoption of the thrips and tospovirus management strategies by 2015. ▪ French bean, onion, tomato and grain legume yields increased by at least 15%. ▪ Rejection of French beans reduced by at least 10% in local, urban and export markets by 2015 ▪ No. of training reports. ▪ Popular articles, mass media reports. ▪ No. of peer reviewed publications. ▪ Number of theses.	▪ Awareness among 229 agricultural extension officers/plant quarantine inspectors from Kenya, Uganda and Tanzania enhanced on Thrips and tospovirus management strategies ▪ More than 425 lead farmers were directly trained by the farmers on thrips and tospovirus IPM strategies for French bean, tomato, onion and grain legumes ▪ Through the private sector partner, RealIPM, biopesticide based IPM technology for vegetables has reached over 20,000 smallholder growers in East Africa ▪ A report on training activities undertaken in the thrips IPM program developed ▪ A report on the stakeholder workshop undertaken at the end of the thrips project completed. ▪ One popular articles on Iris yellow spot virus incidence and management on onions communicated in the Organic farmer newsletter which reaches over 250000 growers in East Africa ▪ One MSc study on *ex-ante* impact assessment conducted ▪ One MSc study on standardization of post harvest treatment parameter for quarantine security against thrips completed	▪ Field demonstration and field days were effective for dissemination of Thrips IPM technologies to both lead farmers and Extension officers ▪ Extension mechanisms of private sectors could be effective for promotion of IPM technologies ▪ *ex ante* impact assessment over a period of 8 years revealed an IRR of 31% and a BCR of 3.94 for investment on research ▪ Simple postharvest techniques such as warm water treatment could be effective to ensure quarantine security against thrips.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Specific objective 1.3:	**Development of sustainable management strategies for insect vectors of maize lethal necrosis disease (MLND) in East Africa by 2018**			
To identify and understand ecology of potential vectors responsible for transmission and spread of viruses causing MLN in East Africa. To develop novel, effective and sustainable seed treatment strategies for the management of MLN. To develop innovative and effective crop diversification strategies that influence both vector ecology and virus epidemiology.	▪ Integrated pest management strategies for key vectors of viruses causing MLN developed, through seed treatment, use of biopesticides and crop diversification techniques by December 2015. ▪ At least one key vector of *Maize chlorotic mottle virus* (MCMV) /*Sugarcane mosaic virus* (SCMV) identified by September 2014. ▪ Distribution maps of key vectors established by December 2014. ▪ Seasonality and alternate hosts of key vector in MLN hotspot areas studied by June 2015. ▪ Competence of key vectors to transmit viruses causing MLN published by November 2015. ▪ At least two sustainable seed treatment strategies against MLN identified by December 2014. ▪ Levels of systemic insecticide residues in corn, tassels and silk estimated and safety to honeybees assessed by December 2015. ▪ At least two intercrops that reduce the incidence of key vectors and thereby MLN identified by December 2014. Impact of crop rotations on vector population and thereby the MLN identified by December 2015.	▪ Roving surveys for insect vectors and their natural enemies have been conducted in 39 counties and 286 maize fields. ▪ Five (5) potential vectors of MCMV have been identified. ▪ One (1) potential vectors of SCMV has been identified. ▪ Competency of 3 potential vectors for transmission of MCMV has been determined. ▪ Protocols for rearing 3 potential vectors of MCMV have been developed and optimized ▪ Occurrence maps of three potential vectors of MCMV have been developed ▪ Protocol for studying the pattern of dispersion of potential vectors such as thrips has been developed. ▪ Seasonality of corn thrips, common blossom thrips, cereal leaf aphid, and sap beetles in MLN hot spots in Bomet and Nyamira counties been determined. ▪ Six host plants of either MCMV or SCMV causing MLN have been identified. ▪ Spatio-temporal distribution of annual and perennial hosts (e.g. couch grass, kikuyu grass, napier grass, finger millet, maize, onion, kale, and cabbage) of potential vectors of either MCMV or SCMV has been determined ▪ 2 Peer reviewed publications (Mahuku et al., 2015, Phytopathology 105 956 – 965; Kusia et al., 2015, Plant disease) ▪ 2 MSc study on-going	▪ Diversity of Maize lethal necrosis vectors is more in East Africa than other regions ▪ The MLN vectors are widely distributed in the region ▪ Density and occurrence of alternate hosts influences the epidemiology of MLN ▪ Plant endophytes can induce systemic resistance to both MLN vectors and viruses	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Specific Objective 1.4: Develop and implement integrated pest management approaches for invasive agromizid leafminer flies infesting vegetables and flower crops in East Africa in collaboration with international and national partners by 2014.				
Leafminer flies' (LMF) Biopesticides identified LMF natural enemies introduced and released LMF IPM strategies based on use of intercropping, botanicals, biopesticides, trapping and biorationals developed.	Agromizid leafminer IPM strategies that encompasses at least three IPM components formulated by 2014	No. Peer reviewed publication	A total of 5 peer reviewed papers were published: Foba *et al*., 2015, African Entomology 23: 120 – 131; Guantai *et al*., 2015; Journal of Economic Entomology 108: 662 – 671; Foba *et al*., 2015; Environmental Entomology 44: 223 – 232; Akutse *et al*., 2015; Biological Control 80: 8 – 13; Foba *et al*., 2015; Environmental Entomology Doi: 10.1093/ee/nvu065;	
Specific Objective 1.5: Develop and implement integrated pest management strategies for production of important indigenous vegetables in Kenya and Tanzania by 2016 (AIV-IPM & GlobE-Hortinlea)				
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 source of resistance against key pests	African Indigenous Vegetables (AIV) IPM strategies that encompasses at least three IPM components formulated by 2016	The key insect and nematode pests of at least 1 indigenous vegetable produced in Kenya and Tanzania identified by 2015	Population dynamic studies were established in 2015 under various agroecological conditions. First farming season studied was from September to December 2015. In amaranth, *Spoladea recurvalis* was the most important pest but only towards end of December. In nightshade main pests recorded in the same season were red spider mites *Tetranychus evansi* & aphids *Aphis gossypii*.	
		The pheromone biosynthesis activating neuropeptide (PBAN) and its correlation to variability in sex pheromone analyzed in at least 1 AIV insect pest by 2016	Partial gene sequences of PBAN and PBPs have been identified and primers have been developed for amplification.	
		The role of indigenous natural enemies against at least 1 AIV insect pest determined by 2015	The performance of Apanteles hemara was carried out on S. recurvalis and found efficient against the pest. A news *Cotesia* pecies to science was found against Spodoptera spp. Five other parasitoids are being tested.	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
		Diversity, distribution and molecular characterization of at least 1 species of nematode pest assessed on nightshade in Kenya by 2015	A survey conducted in Kenya between June - August 2015 revealed that African nightshades and amaranth are attacked by a large community of plant parasitic nematodes (PPNs). Both on Amaranth and nightshade, these PPNs were dominated by Root knot nematodes (RKNs, *Meloidogyne* spp.), virus vectoring nematodes (*Trichodorus* spp., *Xiphinema* spp.) and other PPN nematodes (*Helicotylenchus* spp., *Rotylenchus* spp., *Tylenchus* spp., *Pratylenchus* spp., *Tylenchorhynchus* spp., *Globodera* spp.).	
		Attract and kill strategy developed and tested against at least 1 AIV major insect pest by 2016	Phenylacethaldehyde, amd initial pheromone tested caught few *S. recurvalis* in traps.	
		The role of seed dressing assessed against at least 1 insect pest of AIV by 2016	Research proposal was developed by PhD student expected to carry out the tests in 2016.	
		Amaranth germplasm and commercial lines assessed against at least 1 major amaranth insect pest by 2015	In addition to the 777 accessions from 15 species where six were found resistant, in 2015, A total of 282 amaranth accessions were screened. These accessions belong to nine different species of amaranth. Among the 282 accessions screened, no accession was rated as highly resistant, whereas only one accession (VI036227) was rated as resistant.	
Socio economic constraints and opportunities for value addition of amaranth, leafy cowpea and nightshades production and protection assessed Capacity building and technology transfer initiated with national agricultural research partners and growers. Awareness on AIV IPM strategies created among agricultural extension officers, plant quarantine inspectors and farmers by 2016		Baseline information on current growers' knowledge, attitude and practices (KAP) with regard to IPM and other AIVs production measures collected by 2014	Famer's KAP was evaluated in June and July 2015 using a household survey of 600 randomly selected respondents in three counties in Kenya (Busia, Nyamira and Machakos). While most of the farmers seem to be well acquitted with the nutritive (98% of total respondents) and economic (99%) benefits of AIVs, there exist knowledge gap concerning adaption of AIV to unfavorable climatic conditions and disease infestation and control whose knowledge rate was 85% out of total respondents.	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
		The effect of growers training on growers KAP evaluated by 2016	The MSc student finalized his data collection and analysis and submitted thesis for internal review. He is expected to graduate in 2016. Papers being drafted for publication	
		Constraints and opportunities for AIVs' production and marketing evaluated by 2016	MSc thesis submitted for external review. Papers being written for publication.	
Specific-objective 1.6: ***Dissemination and Promotion of Mango Fruit Fly Integrated Pest Management (IPM) technologies.***				
Proven fruit fly IPM technologies disseminated and promoted among smallholder mango growers. ▪ Establish partnerships with NARS, NGOs, private sectors, farmers and farmer groups relevant for the implementation of the 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.	▪ At least 5 partnerships established with national institutions and research partners relevant for implementation of fruit fly activities. ▪ 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%.	▪ Partnership agreements with ADS Eastern in Kenya and Hawassa University in Ethiopia concluded. Similar agreement with KALRO and Technoserve in Kenya near completion. Engagement with other private sector partners e.g. Real IPM Ltd, Kenya Biologic Ltd and Elephant Vert is on-going. ▪ Assessment of fruit fly composition, abundance and damage is ongoing at 4 sites (Machakos, Kitui and Makueni) and Mbeere (Embu) and the most important fruit fly pests on mango in this region are *Bactrocera dorsalis* and *Ceratitis cosyra*. *Bactrocera dorsalis* is the most abundant comprising more than 80% of flies captured. ▪ Six food-based attractants namely Dudulure, Nulure, Torula yeast, Hymlure, Biolure and GF-120 were tested for their efficacy in fruit flies catches.	*icipe* continues to actively engage with other private sector partners e.g. Real IPM Ltd, Kenya Biologic Ltd and Elephant Vert who are important partners in technology dissemination. The damage due to fruit flies to mango fruits is estimated at 40-44% at Machakos, Kitui and Makueni and 87.9% at Embu, warranting IPM dissemination in these regions. Among the food based attractant tested, Torula yeast and the locally developed food attractant (Dudulure) were the most effective attractants capturing between 2.4-2.6 times more females and 3.4-4.0 times more males, respectively. Also all the attractants tested were female selective with percentage female catches ranging from 55-71%.	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
		▪ The combination of protein food bait (PFB) with male annihilation technique (MAT), biopesticide or sanitation provide 92%, 84% and 72% reduction in fruit fly infestation. Corresponding mango fruit infestations were 12% in food bait+MAT, 24% in PFB+biopesticide and 30% in PFB+sanitation. ▪ Mapping of the growers who will benefit from the IPM technology have also been initiated and 123 growers at Kitui, 881 at Makueni, 177 at Wote, 166 at Kangundo and 977 at Machakos have been mapped.		
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.	▪ *icipe* has initiated procedures for securing import permits for parasitoid introduction in to Ethiopia. ▪ Inventory of native species present in the project benchmark sites include *Psyttalia cosyrae*, *Psytallia species*, and *Fopius* spp. ▪ Colonies of two introduced fruit fly parasitoids (*Fopius arisanus* and *D. longicaudata*) are being boosted at the insect rearing facility at *icipe* for mass releases in both Kenya and Ethiopia for fruit flies suppression. ▪ Two awareness campaigns, a pre-requisite to parasitoid releases, have been undertaken in Machakos and Meru.	The Overall parasitism of the native parasitoid species does not exceed 5% warranting the need to introduce efficient exotic natural enemies.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
		▪ At least one study on establishment and dispersal of one parasitoid species conducted in each project action site; At least one impact study of one parasitoid species conducted on one cultivated and one wild fruit type in at least two project action sites.		
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.	▪ Formulation of blends from host fruit compounds from mango, tropical almond and marula (e.g. isobutyl acetate, alpha-pinene myrcene etc) shows high promise with 20-32% attractant to *B. dorsalis* . ▪ Feacal matter of native fruit fly species (*Ceratitis capitata*, *C. fasciventris C. rosa* and *C. cosyra*) was shown to deter conspecific or heterospecific oviposition. ▪ Faecal matter of each species contained three unknown fly-produced methanol-soluble compounds, which could be the flies' host-marking pheromones. ▪ Screening for potent food attractants from various yeast substrates has revealed high level of attraction of waste brewer's yeast to both exotic (*B. dorsalis* > 80%, *Zeugodacus cucurbitae* >70%) and native fruit fly species (*C. cosyra* >61%, *Dacus punctatifrons* >52%). ▪ For the first time novel primers were designed to identify endosymbionts in African fruit flies. Of particular interest was the discovery of Spiroplasma species that are entirely new to science in *B. dorsalis*, *C. capitata*, *C. rosa* (highland) and *C. cosyra*. In addition, various Wolbachia were also recovered from the genetic profiling.	Faecal matter of *C. cosyra* had a broader spectrum of efficacy, deterring heterospecifics *C. capitata* and *C. fasciventris*. Therefore, this could be processed further to identify the host marking pheromones for mass trapping and suppression.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
		▪ Preliminary results showed that mortality of third instar *B. dorsalis* subjected to hot water treatment in Kent mango at 46.1^{0}C causes 100% mortality which meets the Probit-9 requirement of 99.9968% mortality.		
Socio-economic impact of the introduced fruit fly IPM and classical biological control technologies assessed.	▪ Develop baseline of knowledge, attitudes and practices (KAP) related to mango production and IPM technologies using complementary methods including focus group discussions and household surveys with data disaggregated by sex and age. ▪ Undertake an *ex-ante* impact assessment to assess economic impact of IPM implementation. ▪ Conduct a follow-up *ex-post* impact assessment of IPM up scaling on smallholder farms with data disaggregated by sex and age.	▪ Baseline on KAP related to mango production and IPM technologies developed in at least two project action sites. ▪ At least one *ex-ante* study undertaken in at least two project action sites; Income of growers increased by at least 20% in at least two project action sites; Mango rejection reduced by at least 25% in at least two project action sites; Reduction of insecticide use by at least 30% in at least two project action sites. ▪ At least on *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.	▪ Baseline data for mango fruits damage at Machakos showed that 44% of fruits is lost as a result of fruit fly infestation. ▪ *Ex-ante* analysis revealed that gross revenue from mango in the region was Ksh.14,814/= /acre for growers currently not using fruit fly IPM technologies. The growers also spent Ksh. 2,643/= in pesticides to control fruit flies. ▪ Survey questionnaire has been designed for data collection at other action sites in Kenya and Ethiopia. Thirty enumerators have been recruited and trained for carrying out the activities in the various locations. The data will be collected from 13 locations at Kitui and 18 locations at Makueni.	The *ex-ante* study showed that farmers resolve the fruit flies menace by indiscriminate use of pesticides. This is hazardous to both human health and the environmental. Hence the need to disseminate the *icipe* developed fruit flies IPM technologies for suppression of these pests.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
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 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.	▪ Six ADSE personnel participated and acquired knowledge and skills related to fruit fly taxonomy, monitoring, surveillance and management through a training-of-trainers (ToT) workshop organized by *icipe*. ▪ The 6 ADSE staff that acquired the fruit fly management knowledge from *icipe*, trained 60 Community Extension Service Providers (CESPs) and model farmers that cut across three counties [Machakos (20), Kitui (19), and Makueni (21)] on fruit fly taxonomy, monitoring and management. ▪ Three field days were organized at Makueni where 195 mango growers (87 males and 108 women) were exposed to the technologies to *icipe* fruit fly IPM technologies. ▪ 40 fruit fly IPM technology learning sites have been identified at Machakos, Kitui and Makueni. At Makueni 9 sites are now fully operational and in Machakos and Kitui, 12 and 13 respective sites have been earmarked to become functional in the fruiting season of 2016/2017. ▪ A total of 3908 traps, 7816 ME and 50 augmentoria have been distributed to growers in preparation for implementation of suppression measures in the various localities in Kenya.	Incorporating the Community Extension Service Providers in the training is vital for project implementation. The CESPs provide the much needed support in farmers' mobilization, technology dissemination and technical backstopping of the fruit flies IPM strategies.	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
		▪ 1000 copies of the Fruit Fly Manual were reproduced for distribution to partner NARS, NGOs and private sector. During the ToT and CESPs trainings, 66 copies of the fruit fly manual were distributed to agricultural officers and CESPs from Machakos, Kitui and Makueni. Over 400 copies of leaflets were also made available to the participants. These fruit fly management brochures are also available for free download and reproduction at the *icipe* website (www.icipe.org). ▪ One PhD student (Mr. Joseph Gichuhi – Kenyan) was recruited to undertake research on fruit fly endosymbiont interactions. One, Msc student has also been identified to conduct KAP and ex-ante studies.		
Specific-objective 1.7: ***Implement, in collaboration with international and national partners in sub-Saharan Africa, effective approaches to reduce pre- and post-harvest mango losses due to insect infestations leading to improved quality and quantity of production to meet the demands of local, urban and export markets by 2015.***				
Community-based participatory dissemination of fruit fly and mango seed weevil (MSW) IPM technologies based on baiting and male annihilation technique, application of entomopathogens, 'soft' pesticides and orchard sanitation implemented.	▪ At least 50% of the mango growers in the benchmark sites get acquainted with the fruit fly and MSW IPM technologies by 2013.	▪ At least 20% of growers in project localities adopt at least two components of IPM package for fruit flies and MSW by 2015. ▪ Fruit fly and MSW infestation reduced by at least 70%. ▪ Mango yield increased by at least 20% by 2015. ▪ Use of synthetic pesticides for fruit flies management in the benchmark sites reduced by at least 40% by 2015. ▪ Rejections of mango reduced by at least 10% in local, urban and export markets by 2015.	▪ In the project benchmark sites, at least 58.5% of the sampled growers adopted at least one of the fruit fly IPM components (Korir *et al*. 2015). ▪ 697 growers were enrolled in a demonstration activity and fruits samples taken from a subset of 21 farms at harvest after the intervention with the various IPM components revealed fruit infestation varied from 7-11% in apple mango, 5-8% in Tommy Atkins, 9-12% in Van Dyke and 8-12% in Kent clearly demonstrating the impact of the management methods on fruit flies in the location.	For management of fruit flies, growers should at least adopt two components of the IPM package. For successful management of fruit flies in Africa, an area wide/regional approach is recommended hence *icipe* is up-scaling the technology dissemination to other African countries.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ Also at the end of the mango growing season, average mango fruit infestation by MSW was 22.8% in the 4 frequency of biopesticide applications while infestation in the control was 75.8%. ▪ Mango fruit production increased by 23% in the project bench mark sites (Muriithi *et al*., 2016) ▪ Expenditure on synthetic insecticides for growers at the project benchmark sites reduced by at least 45% (Kibira *et al*., 2015; Muriithi *et al.,* 2016). ▪ The mango IPM intervention reduced mango rejections by 54.5% (Kibira *et al*., 2015). Also mango fruit sales increased by 30% (Muriithi *et al*., 2016).	
Field releases, post release evaluation and impact of *Fopius arisanus* and *Diachasmimorpha longicaudata* for the suppression of *Bactrocera invadens* and native *Ceratitis* species conducted.	▪ Establishment of the two parasitoid species in at least two of the target countries leading to at least 30% reduction of fruit flies populations by 2015.	▪ *F. arisanus* and *D. longicaudata* released in at least 15 major mango production localities by 2015. ▪ Impact of released parasitoids and their establishment quantified by 2015. ▪ At least 50% of growers are aware of parasitoid releases and impact, and reduce cover spray of pesticides by 20% by 2015. ▪ Parasitoid species recovery.	▪ Follow up assessment of the impact of *Fopius arisanus* on *Bactrocera (invadens) dorsalis* infesting mango in the greater Meru region showed an increase in parasitism of up to 28.8%. ▪ *Fopius arisanus* have also been recovered 5-7 km from the release sites with percent parasitism at the sites at which parasitoid had dispersed ranging from 5.3-11.7%. At the old projects action sites in Kenya, parasitism rates by *F. arisanus* and *D. longicadata* ranged from 12.24-30.1% and 16.8-26.7%, respectively. ▪ In Tanzania, parasitism of *B. dorsalis* has increased from 8.1-20.2% in the 2013-2014 mango season to 10.1-27.2% in the 2014/2015 season.	The two parasitoid species have establish in the project bench mark sites and beyond.

Outputs Produced (Activities run)	**Expected Outcomes as per RBM framework plan**	**Performance Indicator of Outcome**	**2015 Progress Observed in Obtaining Outcomes**	**2015 Lessons Learned**
Parameters for post-harvest treatment based on hot water treatment of mango against *B. invadens* developed and disseminated.	▪ Heat treatment parameters required to achieving Probit of 99.9968% for *B. invadens* on at least one mango cultivar developed by 2015.	▪ Parameters established. ▪ Opportunity for access to export markets by the mango growers.	▪ Hot water treatment of mango at 46.1^{0}C for 70 min successfully killed all larvae in the treated mango thus meeting the Probit 9 quarantine security. Likewise, at this temperature and exposure time, the mangoes did not display any shriveling, different color, scald or different flavour and unusual aroma.	The hot water treatment parameters was successfully developed for one mango cultivar hence the need to develop for all export mango cultivars in Kenya.
Socio-economic impact of introduced control technologies determined.	▪ Number of adopters of the disseminated fruit flies and MSW IPM technologies established by 2015.	▪ At least two *ex-ante* studies completed by 2015. ▪ At least one *ex post* impact assessment of the management package on mango production and livelihood completed by 2015.	▪ Results from adoption studies showed that 58.5% of the sampled mango growers adopted at least one of the fruit fly IPM components. ▪ The most popular IPM component among the sampled mango farmers was burying of fallen fruits, which was adopted by 46.9% of the respondents followed by the use of male annihilation technique (MAT) which was adopted by 18.8% of the respondents. ▪ Also 23.0% of farmers who participated in fruit fly IPM training, awareness campaigns and demonstration activities adopted the use of male annihilation technique (MAT) compared to 13.4% in the non-participants group.	Cumulatively, 72% of the sampled mango growers adopted at least one component of the fruit fly IPM package.
Capacity of NARS and other partners in the transfer of IPM technologies strengthened.	▪ Knowledge on fruit flies and MSW IPM technologies enhanced at all levels.	▪ At least 50 NARS personnel trained on fruit fly and MSW management by 2015. ▪ At least 6 IPM technology learning sites/FFS established for grower training by 2015. ▪ At least 1000 leaflets, manuals and posters on management printed and distributed by 2015. ▪ At least 3 PhD and 5 MSc students trained on fruit fly and MSW management and post-harvest treatments by 2015.	▪ As activities expanded to Embu West, a ToT workshop was conducted for participants from Ithaara, Kithimu and Muthethe. In this locality, an additional 15 NARS personnel were trained to help in facilitating technological uptake among growers. ▪ Following this ToT workshop, 697 growers were enrolled spreading across Ithaara (345 growers -197 males +148 females), Kithimu (239 growers – 176 males + 239 females) and Muthethe (113 growers – 53 males + 60 females).	For successful implementation of an IPM strategy which is inclusive of classical biological control, NARS personnel are vital partners in this venture. Once trained, the NARS personnel become a knowledge hub to the growers. Also, growers and community sensitization is of paramount importance for successful implementation of IPM strategies.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ A field day was then organized to train the growers on basic knowledge of mango seed weevil and fruit fly management. ▪ A total of 1214 IPM starter packs (ME, food baits, Augmentorium and traps) were distributed to the growers for implementation of fruit fly management measures on mango. ▪ A total of 987 fruit fly manual, leaflets, posters and brochures were distributed to partners during the period under review. ▪ Some of these materials continue to be available for free download on the project website (www.icipe.org/africanfruitfly). ▪ Two PhD students (Shepard Ndlela – Zimbabwe and Valentina Migani – Italy) are writing up their thesis in readiness for defense.	
Specific Objective 1.8: ***Promote adoption of push-pull technology for effective management of striga and stemborers infesting maize, sorghum, millet and rice, and also for effective management of Napier stunt disease, through collaboration with international and national partners by 2016.***				
Push-pull technology implemented by over 90,000 farm households, and indirectly benefit over 1 million people East Africa Food sufficiency and household incomes of 90,000 push-pull farmers increased by at least 50% by 2016 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 utilizing fodder from push-pull in their dairy production ▪ Number of dissemination channels optimized and employed ▪ Cereal and fodder yields and milk production levels among target farmers ▪ Number of partnerships formed ▪ Number of stakeholders trained	▪ Target surpassed. A total of 26,115 more farmers adopted the Push-pull technology in 2015, bringing the cumulative number of direct beneficiaries to 122,650 in eastern Africa. This translates to over 858,550 indirect beneficiaries having improved food sufficiency, nutrition and incomes. ▪ Among the additional adopters, 21,472 farmers (13,527 females and 7,945 males) adopted the climate-smart push-pull technology in 2015 in parts of Kenya, Tanzania, and Ethiopia translating to about 150,304 indirect beneficiaries.	▪ Use of farmer based communication channels is sustainable in the long term as it is base on local networks and social capital, and can be used as an innovation platform. ▪ Integration of cereal and livestock production improves the demand of Push-pull as a multi-functional technology. Farmers in Africa traditionally practice mixed agriculture ▪ 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 livelihoods	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ The technology beneficiaries experienced more than double increase in cereal crop yields, fodder, milk, soil fertility, and incomes. ▪ Over 175 training events delivered through at least five dissemination channels (farmer field days, farmer teachers, farmer research networks and agricultural shows) increased farmer knowledge in agronomic best practices, utilization of quality fodder from Push-pull and integration with livestock production and other on-farm enterprises. ▪ A total of 98 new community farmer groups were also recruited and introduced to Push Pull technology. These includes 2 groups of people living with disabilities, 5 youth groups and 1 dairy cooperative .Through these groups 5,477 (1,549 males, 3,928females) farmers were trained on the establishment, management and utilization of products from push-pull plots. ▪ Further technology scaling up options were introduced through and expanded partnership with Send- a-cow, One Acre Fund in Kenya and Uganda, and CABI Plantwise project, World Vision and Project Concern International in Kenya and Tanzania, using their existing operational structures. ▪ The use of mobile telephones in disseminating push-pull was also tested among 400 smallholder farmers in Uganda. New farmers identified during field days were enrolled to receive short text messages from time to time on management of push-pull plots for improved production.	▪ Working closely with grassroots institutional collaborators such as local chiefs, churches, private sector and Community Based Organisations (CBOs) increases the level of ownership of Push-pull technology. ▪ More female farmers are adopting Push-pull technology because it is gender-friendly and reduces drudgery, and time spent on looking for animal fodder.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ The use of new media, including cartoon books was also piloted through 203 primary school pupils (107 Males and 96 females). This will be used to train more pupils, and in conducting research on the pathways' effectiveness. ▪ At least 15% of early adopters increased cereal acreage under push-pull, in the targeted countries	
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 stakeholders trained on integrated disease management ▪ Number of peer-reviewed publications	▪ 122 Napier grass cultivars were screened for susceptibility to phytoplasma infection. So far only two (Ouma2, South Africa) have remained negative by nPCR and LAMP with no disease symptom expression after the second screening. ▪ The resistant cultivars (Ouma2 and South Africa) were re-screened and resistance status confirmed; they have been multiplied and distributed to over 200 pioneer farmers in western Kenya for seed multiplication after field-testing. As a result over 6000 farmers have clean Napier grass material, each gaining on average 3 more litres of milk per day. ▪ Community-based resistant Napier multiplication and distribution systems have been established through 6 principal stakeholders (KALRO, NARO, Heifer, Send-a-Cow and Ministries of livestock in Kenya and Uganda) and now over 50 farmer groups. ▪ One peer-reviewed paper was published in plant Pathology, and two manuscripts submitted for publication in Plant Disease and Crop protection.	▪ Many strains of stunt phytoplasma exist in western Kenya, with a wide host range in the graminae family, causing similar symptoms as Napier stunt disease, and threatening production of economically-important crops like millet, rice and sugar cane. ▪ Two Napier stunt resistant cultivars have been confirmed and represent an opportunity for smallholder farmers to address the stunt disease problem if they are used in combination with other disease management approaches ▪ Fodder grasses like brachiaria cv Mulato are available in western Kenya as possible alternatives to Napier grass. As most fodder grasses are still susceptible to the stunt phytoplasma further carefully evaluation is necessary before being released to farmers. ▪ Phytoplasma infection increases rates of emission of the following compounds Benzaldehyde; α-Pinene; 6-Methyl-5-hepten-2-one; 7-Ethyl-1, 3,5-cycloheptatriene; Eugenol; Phytol Dihydroactinidiolide; Hexahydrofarnesylacetone

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Specific objective 1.9: Scaling-up technologies and successful experiences in biological control of diamondback moth (DBM) in cruciferous crops in Eastern Africa to other African countries				
Surveys of DBM and its indigenous natural enemies in Mozambique, Malawi, Zambia and Rwanda conducted by June 2015 and June 2015, respectively.	▪ Presence or absence of DBM and its natural enemies established by December 2015.	▪ Two researchers from each country trained in baseline survey methodology before end of 2015. ▪ Baseline surveys conducted by trained national researchers in Mozambique and Malawi by June 2015. ▪ Baseline surveys conducted jointly by *icipe* and national researchers in Zambia and Rwanda by June 2015.	▪ In Malawi two baseline surveys conducted in Njolomole and Dwale Agricultural Extension Planning Areas (EPAs). The surveys were conducted from June to October in 2015. ▪ In Mozambique, a 3rd survey was carried out in 2015 in 9 districts from 21st July to 15th August. A total of 427 farms were surveyed. ▪ A baseline survey conducted in Rwanda revealed that DBM was not a problem but aphids. ▪ Prelease baseline surveys wee conducted in Chipapa, Chilanga and Kafue, in Zambia	▪ DBM, aphids and *Cotesia vestalis* phids were observed in the project countries but parasitism of *C. vestalis* on DBM was low. ▪ Farmers were mostly using synthetic pesticides to control the pests, with many of them applying many spray frequencies per season.
Effective and functional rearing facilities and systems for biological control agents of DBM established in Mozambique and Malawi before end of 2015.	▪ Functional DBM biocontrol structures established in target countries before end of 2015.	▪ Members of staff from Mozambique and Malawi (2 each) trained in mass rearing of DBM parasitoids. ▪ Trained staff members set up mass rearing facilities and production of parasitoids in Mozambique and Malawi by June 2015. ▪ Field releases of DBM parasitoids piloted in selected areas in Mozambique and Malawi before end of 2015.	▪ Malawi: One Research Scientist and two Research Technicians trained at *icipe* in C. vestalis rearing, field release and surveying. Two Research Attendants trained in-country on the same subject by officers trained at *icipe* ▪ A functional facility for mass-rearing of *C. vestalis* established at Bvumbwe Agricultural Research Station, being run by the trained officers. ▪ In Mozambique, functional DBM/ parasitoid rearing facility in Maputo was establish at UEM and is running. Two more rearing facilities were established: ISPM (Manica) and DSV (Maputo). Both are running and functional. ▪ In Zambia, a functional facility for mass-rearing of *C. vestalis* was established at Mt. Makulu Research Station.	▪ A sustainable system for mass-rearing of *C. vestalis* for field releases in the project country is now available. ▪ The population *Cotesia vestalis* has been enhanced by augmentative releases of the natural enemy.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Extension agents and farmers trained in locally adapted biocontrol IPM approaches for crucifer pests.	▪ Locally adapted biocontrol IPM technologies promoted in Malawi and Mozambique by 2015.	▪ Country-specific report of key crucifer pests and current farmer practices. ▪ At least 15 master trainers trained in vegetable IPM each in Mozambique and Malawi by June 2015. ▪ At least 2000 farmers trained through at least 80 FFSs by June 2015. ▪ At least 10 field sessions/FFSs conducted during each growing season. ▪ Country-specific end user friendly IPM information packages produced and distributed by June 2015.	▪ Locally adapted biocontrol-compatible IPM technologies compiled. These included interplanting crucifers with DBM-repellent crops such as onion and pepper, practicing crop rotation, removing stumps of crucifer vegetables immediately after harvesting so that they do not ratoon and act as breeding grounds for DBM and other pests, use neem extract, spot-spraying, water-jet spraying and nurturing of ladybird beetles as means of controlling aphids instead of using chemicals indiscriminately. ▪ In Malawi, 13 FFS have been established in Dwale and Njolomole EPAs. The total number of farmers in all the 13 FFS is 340. Dwale FFSs have a total of 259 farmers; where 78 are adult males, 181 are adult females, with no young men or women. Njolomole FFSs have a total of 81 farmers; where 55 are adult males, 23 are adult females, 3 are young men, with no young women. ▪ In Mozambique, 5 extension staff (3 from Boane and 2 from Kamavota) were trained (1 day) at the university lab on DBM biological control. ▪ 26 farmer's groups established 3 in Kamavota (Associação Massacre de Mbuzine); 3 in Manica district, 3 in Boane district, 5 in Infulene; 3 in Moamba district, 3 in Chokwe, 3 in Nhamatanda and 3 in Angónia district.	▪ Knowledge on biocontrol-compatible IPM technologies being effectively disseminated to farmers for better nurturing of the released *C. vestalis* in the project countries.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Policy makers and general public sensitised on vegetable IPM methodologies.	▪ National stakeholders workshop with policy makers held in Zambia, Malawi and Mozambique by December 2015.	▪ Biological control and locally adapted IPM methodologies that reduce insecticide use and improve food safety promoted by July 2015.	▪ In Malawi, one stakeholders' meeting was held on 20th March 2015 in Lilongwe at the headquarters of the Ministry of Agriculture. It involved Agrochemical companies and officials from the Ministry of Agriculture. ▪ In Mozambique, presentations of the project activities were made at Ministerial level and Council of Ministers and national directors (DNEA and DNAS) participated in DBM project regional meetings. ▪ Pesticide dealers were present in all project launches, trainings, farmers meetings and specific meetings held in Manica and Maputo. Bacillus thuringiensis (*Bt*) formulation and other alternative environment friendly pesticides available in local stockists for farmers to buy. ▪ Visit to the FFS/field days by policy makers facilitated during the 3 project launches in the districts. In Boane, the Deputy National director for Agricultural Services was present during the field launch and parasitoid releases in Boane; the directors of agriculture services in Maputo Municipality, from districts of Kamubucuana and Moamba were present. In 2014, policy makers at district and provincial levels attended launch meetings in the added 5 districts.	▪ Significance of the DBM problem highlighted to stakeholders ▪ Abuse of pesticides by farmers to control DBM highlighted to stakeholders ▪ Need for biocontrol-compatible pesticides highlighted to stakeholders ▪ A strategy to avail biocontrol-compatible pesticides in the country developed.
Impact of *Cotesia plutellae* in semi-arid Eastern province of Kenya assessed and disseminated to other countries.	▪ Knowledge enhancement for further scaling up of DBM biological control in new areas of project countries compiled by 2015.	▪ Impact assessment data collected and analysed by end of 2015. ▪ Information shared in stakeholder and annual planning meetings. ▪ Awareness material produced and distributed.	▪ *Plutella vestalis* was confirmed as established in Makueni, Kitui, Machakos counties with parasitism rates of about 8%.	▪ Predictive models can determine potential areas of establishment of *Cotesia vestalis* in Africa. Hence the positive benefits of the natural enemy can be disseminated to other countries.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Knowledge products developed from field experience in Mozambique and Malawi by end of 2014.	▪ Brochures, posters, leaflet and/or video developed and distributed in Malawi, Zambia and Mozambique by March 2016.	▪ Updated FFS curriculum. ▪ Leaflets/brochures ▪ Documented lessons learned from field surveys.	▪ Malawi: 250 local language brochures, 250 English brochures and 250 English posters produced and distributed to farmers and Agricultural Extension Officers in the two project sites. ▪ In Mozambique, Posters and leaflets printed and distributed to farmers, extension personnel, provincial directorates and pesticide dealers. Brassica IPM Manual received from ICIPE, translated into Portuguese and printed. Poster and leaflet prepared and printed. ▪ 34 Posters and 880 leaflets printed and distributed to policy makers, extension personnel and farmers. 3 Survey reports produced Country TOT's crucifer manual prepared. ▪ Leaflet on alternative environment friendly pesticides prepared and distributed 8 BSc Hon. and 1 MSc student's thesis completed. ▪ DBM Video produced.	▪ The publications are some of the most important teaching and learning materials in the established farmer field schools.
Preparatory planning for scaling up of the activities in Mozambique, Malawi, Zambia and Rwanda with the IFAD projects and respective Ministries based on lessons learned.	▪ Linkages with ongoing developmental projects established by December 2015.	▪ Final regional stakeholders' workshop with policy makers and IFAD country officers for sharing of lessons learned and planning of scaling up held in Mozambique, Malawi, and Zambia by December 2015.	▪ In Mozambique, a Project proposal for scaling up prepared, finalized, presented to DNEA and IFAD and approved. Follow up project will start to be implemented in 2016 with funds from Ministry of Agriculture and Food Security, DNEA/PSP/IFAD. ▪ In Zambia, the project has been able to establish linkages with community based multi-purpose cooperatives and other donor funded projects engaged in the vegetable subsector such as USAID funded Commercial Agribusiness for Sustainable Horticulture (CASH) being implemented by ASNAPP-Zambia operating in Eastern and Central Provinces.	▪ Linkages of the DBM activities with ongoing developmental projects will ensure sustainability of the project outcomes.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Specific-objective observed: 1.10: *Strengthening citrus production systems through the introduction of IPM measures for pests and diseases in Kenya and Tanzania.*				
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. ▪ Vibrant colonies of ACP and FCM established by end of 2015.	▪ A country wide survey to establish the pest distribution and abundance in Kenya was undertaken using yellow sticky traps and Chempac® **yellow delta traps charged with Lorelei® pheromone dispenser** that were deployed in citrus groves. Preliminary results indicate that the number of adult ACT and FCM captured on traps varied widely among elevation and sites within elevation. In Tanzania, samples from trap catches and citrus plants for both ACT and FCM are being processed. ▪ A vibrant colony of ACT has been established at *icipe* Duduville campus on *Murraya koeinigii* seedlings. FCM colony is being established from field collected fallen citrus fruits.	Most of the ACT trap catches are from mid to high elevations but no catches were made at low altitude (0-500 masl.). This zone can be used to establish insect-proof nurseries for HLB-free stocks.
The incidence, severity and distribution of Huanglongbing (HLB)/citrus greening determined; and pathogen–vector interaction assessed.	▪ Countrywide survey conducted and the incidence, severity and spatio-temporal patterns of distribution of HLB assessed using molecular tools by end of 2017. ▪ The role of HLB infection on ACP vector competence, fitness parameters and dispersal capability assessed by quantitative real-time PCR assays by end of 2017. ▪ Stochastic models developed to assess the patterns of spread of HLB disease by end of 2015. ▪ HLB disease distribution and potential implications on citrus industry on a regional scale assessed using Earth Observation tools by end of 2017.	▪ Incidence, severity and spatio-temporal patterns of HLB established and geo-referenced maps of their distribution in the two countries made available by end of 2017. ▪ Role of HLB infection on ACP vector competence, fitness parameters (e.g. fecundity) and dispersal capability established using qRT-PCR by end of 2017. ▪ Stochastic model to assess the patterns of disease spread developed by end of 2015. ▪ Hyperspectral pattern of disease spread and regional distribution established using remote sensing tools by end of 2017.	▪ Alongside the psyllid surveys in Kenya and Tanzania, leaf samples have been collected from all suspected symptomatic trees and are currently being processed for molecular identification of the bacterial causative agent of the HLB disease in both countries. ▪ Colony of ACT has been established in *icipe* and biological studies are underway to establish basic developmental parameters and measure fecundity of the pest in readiness for vector competence studies.	The best host plant for ACT rearing is *Murraya koenigii* and a nursery is being put in place for the same to sustain the ACT colony.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Ecologically sustainable management methods for ACP and associated HLB disease, and FCM developed, tested and implemented.	▪ Behavioural evidence for kairomonal and female-produced sex attractants and repellents in ACP studied and tools for monitoring and suppression developed by end of 2017. ▪ Potent fungal and viral-based biopesticides and natural products identified, tested and implemented for management of ACP and FCM by end of 2017. ▪ An efficient attract-and-kill product that can be used in combination with biopesticides for management of both pests identified by end of 2017. ▪ Citrus plant materials/root stock for HLB resistance 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 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. ▪ 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.	▪ A PhD student has already been recruited for the chemical ecology study. ▪ A commercial isolate of entomopathogenic fungus, *Metarhizium anisopliae* ICIPE 69 (Met 69®) was tested for pathogenicity against egg, 1st instar, 5th instar and adult ACT. On egg, Met 69 showed significant promise causing 87.2% reduction in egg hatch. On the 1st, 5th instar and adult, moderate to high mortality was observed ranging from 72.6% in the 5th instar to 92% in adult stage. ▪ Plans are underway to introduce and test the virus biopesticide (Cryptogran®) registered by River BioScience (Pty) Ltd, Republic of South Africa) for FCM control. ▪ Twelve improved cultivars of citrus (including mandarins (Dancy, Clementine, Pixie), tangelo (Orlando, Osceola, Kara, Page and Calvahais), sweet orange (Valencia-VL 106, VL139, VL135, Washington navel-WN204 and WN216) that were introduced into Kenya in early 80's have been propagated as scions on lemon rootstocks in preparation for screening for resistance against HLB.	Observations from this initial screening clearly demonstrate the potential of fungal-based biopesticide as part of the management components for the two pests.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
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 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.	▪ Two MSc students (Ms. Dorothy Gitahi and Ms. Charity Wangithi) have been recruited to carry out the socio-economic impact assessment. ▪ Survey design and data collection instrument have been developed and field survey in the four identified sites in Kenya (Machakos, Kitui, Makueni, Meru) is expected to commence soon.	
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.	▪ The first training of trainer workshop was organized on April 21, 2015 for 11 project NARS participants. The participants were exposed to training on taxonomy and identification of ACT, the greening disease (symptoms and damage), use and application of monitoring tools and protocols for bioecological studies to guide management of the pest. ▪ Two sites (Kangundo, Kenya and Morogoro, Tanzania) have been identified for establishment of potential citrus IPM learning sites. ▪ Five PhD students (Abdullah Mohamed Mkiga, male, Tanzania; Brenda Rasowo, female, Kenya; Owusu Fordjour Aidoo, male, Ghana; Richard Kyalo, male, Kenya; Akua Konadu Antwi Agyakwa, female, Ghana) and 2 MSc students (Dorothy Gitahi, female, Kenya; Charity Wangithi, female, Kenya) have been recruited into the project and making satisfactory progress with regard to their work.	Knowledge on the taxonomy and identification of ACT, the greening disease (symptoms and damage), use and application of monitoring tools and protocols for bioecological studies to guide management of ACT and FCM is very scanty for the NARS and other stakeholders, therefore there is need to organise more workshops to build capacity in this area.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Objective 2: Minimise the vulnerabilities of horticulture and staple crops to climate change-induced pest problems by at least 10% by 2020				
Specific Objective 2.1: To eliminate gaps in knowledge of climate change impacts on ecosystem services and food security in Eastern Afromontane Biodiversity Hotspots by 2015.				
Baseline information on ecosystem services (pollination and pest management, biodiversity and habitats) established.	Study outcomes utilised by scientists, policy makers, extension workers and other stakeholders by 2015.	▪ Effects of climate change on biodiversity and habitats explored through modelling by 2015. ▪ Species distribution maps for pest insects for maize, crucifers, avocado and coffee created by 2015.	4 digitized historical datasets on pollinators, insect pests and natural enemies of target crops available for the project partners.	Understanding past environmental conditions and land use/land cover patterns will help in understanding the larger picture of environmental and climate change/climate sustainability in the research areas.
Use of remote sensing and geographic information systems (GIS) for land cover and land use change monitoring.	Geospatial datasets developed for the three target areas (Taita Hills in Kenya, Kilimanjaro in Tanzania and Jimma in Ethiopia) are widely utilised by stakeholders by 2016.	▪ GIS platform established for sharing geospatial datasets among at least 25 East African stakeholder organisations by 2015. ▪ No. of participants at trainings that showcase the utility of geospatial products. ▪ No. of new local and regional products derived. ▪ Geospatial datasets developed for target areas by 2015. ▪ MSc and PhD training on GIS organised for at least 25 staff members of the stakeholder organisations.	▪ Mapping of current LU/LC in Kilimanjaro "Savanna Zone" is completed and results presented and shared. ▪ Methodology for LU/LC (agroforestry) mapping in Taita Hills using data fusion developed. Preliminary mapping completed and results published. Next step: Validation of results and extension of the mapping to cover the full research area. ▪ Taita Hills baseline LU/LC map using medium-resolution satellite imagery is completed and results are shared in CHIESA GeoNetwork. ▪ A crop suitability map showing areas suitable for agriculture production in Taita Hills was created through spatial analysis and environmental modelling. ▪ Historical vegetation cover of Ethiopia before agricultural expansion was mapped and ecosystems most affected by land changes were identified. ▪ New important geospatial datasets added to GeoNetwork, for example CHIRPS precipitation and GLC-SHARE land cover datasets. ▪ GeoNetwork platform was completely rebuilt with new software version, user interface, improved search and reporting functions. The database was also cleaned and re-arranged.	Sharing of CHIESA results (i.e. spatial datasets and maps) did not increase as expected by the end of CHIESA. Some scholars remained hesitant to release their datasets until results have been published in scientific articles. Data sets now include reflectance observation obtained from MODIS satellite source for better description of the transect and more accurate characterization of the coffee plot sample. Land cover mapping is a tedious and slow process. To get a product that is accurate and usable for modeling requires good ground truth data, careful pre-processing of remote sensing data, designing a classification scheme, testing different classification algorithms, and finally a lot of manual work to correct the errors of automatic classification and fill data gaps.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Modelling and economic valuation of the benefits of ecosystem services.	Beneficiaries and benefits of ecosystem services identified, characterised and quantified, and future scenarios developed for target areas in EABH by 2015.	▪ Integrated valuation of ecosystem services and trade-offs models used in the economic assessment. ▪ Gender disaggregated stakeholder analysis and reports completed by 2015. ▪ Stock values of ecosystem goods and services defined by 2015.	▪ Gender-disaggregated Questionnaire/ WTP & WTA survey in Kilimanjaro and Taita Hills accomplished. ▪ PSAM campaigns incl. gender-disaggregated Willingness to Pay/ Willingness to Accept surveys organized and reported. ▪ 2 databases of socio-economic indicators of vulnerability available. ▪ Field surveys on SPK CC/ES in Kilimanjaro and Taita Hills; data compilation and analysis fully completed and key results published in journal papers and MSc thesis. ▪ Prevision models and maps for main coffee pests available for scientific community and stakeholders of the coffee industry in eastern Africa.	Users of ecosystems are sufficiently knowledgeable of the impact of CC on ES as well as the values of the ecosystems to human and the need to conserve these ecosystems to sustain the benefits and flow of ecosystem goods and services. However, there are marked spatial and demographic differences in their perception of ecosystems, which can potentially alter the value they attached to different ecosystem services and the spatial significance of climate change.
Effects of climate change and land cover change on biodiversity and habitats explored.	Reliable models and maps for each target area available for stakeholders by 2015.	▪ Species envelopes completed for three target areas. ▪ Regionally tailored climate change projections by 2015. ▪ Maps and models available for all known species of major biodiversity trigger taxa; 4 crops (maize, coffee, avocado and crucifers); carbon storage and sequestration rates; main pollinators and pests by 2015.	▪ Biodiversity assessments completed. High-resolution downscaled regional climate ensemble projections completed across 16 GCM-RCM combinations for Africa– in response to new output from CORDEX. Datasets available for every country in Africa, as well as for each Biodiversity Hotspot and Endemic Bird Area are freely available online through KITE website at University of York. ▪ Maps defining the variations in 3 biophysical characters such as soil Silica, Nitrogen and total carbon established. ▪ Coffee shade trees identified for the Jimma transect. C quantified for these trees, and compared against total AGC across LULC types (journal article submitted). ▪ Diversity of wild crucifers and seasonality established in Kilimanjaro and Taita Hills.	Climate change warming effect will increase CLR impact on the Jimma transect and will reduce CBD impact. In the same time, it is probable that coffee cultivation will be reduced in the lower part of the transect due to unsuitable conditions (too high temperature, longer dry season). Scientific data sets and calculated trends do not often match with the experiences/perceptions of the communities on the climate variability and extreme climatic events. Improved and high resolution regional climate models can be used by decision-makers in the development of adaptation strategies. Predictions can be utilized by other scientists for assessing the impacts on hydrology, pollination, biological control and food security. In both transect the higher stem borer pest infestation is recorded between 1200-1500 m. a.s.l. with a mix of the stem borer pest species.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ Coffee farming systems in the Kilimanjaro and Jimma transects characterized according to the shading and cropping characteristics. ▪ Microclimate characterized and related to the macroclimatic conditions. ▪ Temperature data layer established with datasets collected from individual data loggers and utilized for developing models for current scenario.	Natural enemies were recorded from all altitudes in both transects; instead of lower densities of borer pests in Kilimanjaro transect we recorded a higher parasitism rate compared to Taita transect. Diversity of wild crucifers could influence the population density of DBM.
Baseline data and monitoring protocols for functional ecosystem pest management and pollination established along altitudinal gradients in three research areas.	▪ Historical data on pollinators, pests and natural enemies of target crops compiled by 2015. ▪ Species distribution maps available for stakeholders by 2015. ▪ Species composition and abundance on target crops available by 2015. ▪ Predictive models generated by 2015. ▪ 3 MSc and 5 PhD level staff trained, especially females by 2015.	▪ Identification of study transects across the altitudinal gradient in the Taita Hills, Kilimanjaro and Jimma Highlands undertaken. ▪ Field sites for monitoring pest and natural enemy dynamics identified. ▪ 5 PhD students and 3 MSc students to undertake research on climate change impacts on pest management and pollination selected. ▪ Upgrade of laboratory to undertake research on climate change with incubators undertaken. ▪ 11 automatic weather stations installed and maintained by national meteorological agencies in the Taita Hills and Mt. Kilimanjaro, and in Jimma Highlands.	▪ 1 MSc study on Avocado pollinators completed. ▪ Protocols for monitoring coffee pests designed and implemented in Kilimanjaro transect. The monitoring of coffee pests ended in June 2015. ▪ Protocols for biological studies on coffee pests (rearing, life history traits and life table analysis) designed and implemented. ▪ Selected coffee plots characterized for agroecological factors (shade, coffee phenology, coffee tree development). Preliminary models available. ▪ Voucher specimens of 7 CWSB parasitoid species available at the BSU department, icipe. A nymphal parasitoid has been identified as the ichneumonid *Gabunia ruficeps.* ▪ Other species, presumably parasitoids of eggs or barking stage nymphs own to 5 different hymenoptera families (identification in progress). ▪ A two-year dataset for monthly ▪ monitoring of CBB populations and parasitoids is available. ▪ A two-year dataset for the monthly monitoring of CWSB damage and parasitoids available. ▪ A dataset of four observations of AB populations in different climatic seasons available.	Honeybees were the key pollinators of Avocado across the altitudinal gradient. CBB populations were very low during the survey and limited to lowest elevations. CBB is not an important pest of coffee on the Kilimanjaro transects but its distribution is supposed to expand to higher elevations due to climate warming. By contrast, AB is more present in the highest part of the transect with optimal temperature for development lower than for CBB. AB may not be favoured by an increase in temperature. Very high levels of damage by CWSB whatever elevation have been observed on the transect and CWSB is the main pest of coffee in the area. Knowledge of CWSB parasitoids is poor. The identified ichneumonid *Gabunia ruficeps* has never been reported on coffee with this name. Research on this species should be done in order to assess its potential use as biocontrol agent.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ species available at the BSU department, icipe. A nymphal parasitoid has been identified as the ichneumonid *Gabunia ruficeps*. ▪ Other species, presumably parasitoids of eggs or barking stage nymphs own to 5 different hymenoptera families (identification in progress). ▪ 13C/15N Isotope data analyzed. ▪ Data for SOC/TN/GHG trends is generated and currently available. ▪ Manuscripts on spatial temporal trends for soil carbon dioxide respiration submitted for publication. ▪ One publication has been submitted for review in PlosOne. ▪ Datasets for laboratory observations on coffee pests available. ▪ Protocols and datasets for life table analysis at different temperatures ▪ One manuscript based on Phenology model for DBM submitted. ▪ Effects of climate change on coffee disease epidemics explored through modelling by 2015. ▪ Development of predicting models combining different parameters evaluated by 2015. ▪ One Ethiopian student (PhD) is trained on plant pathology, in epidemiology. ▪ Data sets on life table studies of both *B. dorsalis* and *F. arisanus* have been made available. ▪ Manuscripts on the life table study of *B. dorsalis* have been prepared and currently internal review ▪ Manuscripts on the life table study of *F. arisanus* are currently under preparation. ▪ Life table studies for stem borer pests and their main natural enemies completed and complete life cycle models established.	CBB populations were very low during the survey and limited to lowest elevations. Very high levels of damage by CWSB whatever elevation have been observed on the transect and CWSB is the main pest of coffee in the area. By contrast, AB is more present in the highest altitude. With climate change, the suitability for DBM infestation is likely to increase in the high altitudes, however with a decreased number of generations. With climate change the incidence of B. dorsalis is likely to increase in the higher altitudes. Mid altitude zones between 1,000-1,400 masl are the most vulnerable to stem borer attacks. Soil Silicon and its assimilation plays a key role in defining the dynamics of stemborers at it is influenced by the climatic factors. Results based on temperature only indicated a worsening of stem borer impact on maize production along the two East African mountain gradients studied attributed to three main changes occurring simultaneously: (1) range expansion of the lowland species C. partellus in areas above 1,200 m.a.s.l.; (2) increase of the number of pest generations across all altitudes, thus by 2055 damage by both pests thus damage will increase in the most productive maize zones of both transects;

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ Assessment of population community composition and dynamics of stem borer pests and their parasitoids completed on Taita hills and Kilimanjaro transects; Assessment of temperature on silicon assimilation by maize and hence on the distribution of lepidopteran stem borers. Data collections related to soil and plant characteristics have been completed. Data collection to capture the different cereal farming systems and farmers' perception of climate change and adaptation has been completed.	(3) disruption of the geo- graphical distribution of pests and their larval parasitoids will cause an improvement of biological control at altitude below 1,200 m.a.s.l. and a deterioration above 1,200 m.a.s.l. The predicted increase in pest activity will significantly increase maize yield losses in all agroecological zones across both transects but to a much greater extent in lower areas.
Adaptation strategies to changes in ecosystem services elaborated and adaptive management framework (AMF) tools developed.	▪ A set of AMF tools available by 2015. ▪ Tools for vulnerability assessment prioritised, susceptibility index and vulnerability maps completed by 2015. ▪ Community-based adaptation action plans and reporting mechanisms completed by 2015.	▪ 6 MSc students to carry out research on household vulnerability and adaptation strategies to climate change in Taita Taveta, Mt Kilimanjaro and Jimma Highlands. ▪ Project website to share information among partners and other stakeholders developed. ▪ Community sensitisation on climate change effects and need for research undertaken.	▪ Adaptation Action Plan documents disseminated in Policy-makers seminars organized at national and local levels in all the target areas during October-December 2015. ▪ Climate change adaptation options on Integrated Pest Management (e.g. release of selected parasitoids), and 2 rain water harvesting sites set up in institutions in Taita Hills and Mt. Kilimanjaro. ▪ AMF structure identified, and compilation of contents began (downscaled climate scenarios, risks, impacts, adaptation options and tools). ▪ Downscaled AFRICLIM Climate change projections for the East Africa region and IPCC assessment of climate change risks, impacts and adaptation options integrated in the Adaptation Action Plans, providing a baseline for the AMF tools in the 3 target areas.	Growing demand and competing uses of natural resources create the biggest challenges for the action plans and AMF. Supporting policies and regulations exist but enforcement and political will seem to be lacking. There is need to downscale the AMF such that the designed tools are targeted to specific users in the target areas. Capacity building and filling knowledge gaps among all stakeholders especially communities will be critical for successful adaptation as it will improve the ability of people to make informed decisions to respond to climatic and other changes at individual, household and institutional levels. Integrated adaptation approaches are most effective (e.g. combining drip irrigation and IPM technologies to ensure sustained crop yields). For example in Taita Hills, farmers who had drip irrigation kits installed needed follow-up support to combat pests attacking their vegetables.

Outputs Produced (Activities run)	**Expected Outcomes as per RBM framework plan**	**Performance Indicator of Outcome**	**2015 Progress Observed in Obtaining Outcomes**	**2015 Lessons Learned**
Specific objective 2.2: Integrated Biological Control Applied Research Programme (IBCARP) – Push-Pull Research Component				
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 21,472 farmers (13,527 females and 7,945 males) adopted the climate-smart push-pull technology in 2015 in drier parts of Kenya, Tanzania, and Ethiopia (translates to about 150,304 indirect beneficiaries). The technology beneficiaries' experienced more than double increase in cereal crop yields, fodder, milk, soil fertility, and income.	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. 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 dairy cattle, in the target areas.
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 Desmodium spp. continued to be evaluated including *D. intortum* and three spp. of African origin and incorporated as potential repellent plants in the climate-smart Push-pull technology. The repellent plants were *D. repandum*; D. *incanum* and D. *ramossisimum*, while Brachiaria cv Mulato was screened and adopted as the attractant plant. ▪ Although Brachiaria cv MulatoII and Greenleaf desmodium were identified and incorporated into the push-pull technology, these companion plants face pest challenges, principally blister beetles on desmodium flowers, and mites and shoot-flies on Brachiaria MulatoII that impede seed production in desmodium and interfere with the growth of Brachiaria respectively, in addition to limited ability to withstand extended dry weather conditions that have been observed in parts of Kenya, Tanzania and Ethiopia. We are therefore screening additional Brachiaria and African desmodium species for incorporation into the climate-smart push-pull.	▪ Substantial amounts of the stemborer repellent compound (E)-4,8-dimethyl-1,3,7-nonatriene (DMNT) were produced by unstressed Brachiaria cv Mulato plants as well as D. *intortum* volatiles, that is, 3-methyl-1-butanol acetate and (Z)-3-hexenyl acetate. ▪ Drought stressed plants produced less DMNT and methyl salicylate, chemicals which are known to attract parasitic wasps that attack stemborers hence the proof that the border crop is attracting beneficial insects. This conclusion, boosted by the observed reduction of stemborer populations in the field has encouraged continued assessment of the possibility that the border crop may also be repelling the herbivore from the area and enhancing the 'push' effect of the companion crop.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ 12 peer-reviewed papers were published, deepening and expanding scientific knowledge and capacity development.	▪ Whereas well watered *D. intortum* did not produce large amounts of repellent volatiles, drought stressed *D. intortum* did produce significant levels of (*E*)-ocimene, DMNT, (*E*)-caryophyllene and TMTT; compounds which are documented to repel stemborers and attract their natural enemies. This data thus suggests that the insect repellent properties of *D. intortum* are enhanced by drought stress. ▪ All the highly drought tolerant desmodium species were found to possess the same biochemical potential for striga control previously reported in other desmodium species, albeit through different allelochemic modes of action.
Specific objective 2.3: Determine the contribution of organic agriculture to sustainable development in the tropics by 2018				
▪ Effect of organic and conventional farming systems on pests and diseases incidence, severity and damage determined and documented ▪ Effect of organic and conventional farming systems on Soil biodiversity assessed and documented ▪ Effect of organic and conventional farming systems on Soil fertility and safety evaluated and documented ▪ Yields and incomes generated through organic and conventional farming systems compared ▪ Participatory on-farm research (POR) conducted for wider result dissemination and adoption	▪ Long term organic and conventional farming systems compared and their effects on soil fertility, soil biodiversity, pests and diseases, yield and health determined and widely disseminated by 2018.	▪ At least 1 major pest and 1 major disease of maize assessed under the 2 different farming systems by 2016 ▪ At least 1 major pest and 1 major disease of vegetables assessed under the 2 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 1 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 location by 2015	▪ Data was collected on organic and conventional maize during first farming season in 2015 ▪ Data on pests and diseases collected on organic and conventional vegetables in 2nd farming season of 2015 ▪ Nitrogen update data collected and PhD thesis being reviewed internally. ▪ Soil physical characteristics were assessed in 2015 under maize and vegetable production ▪ An MSc student was engaged towards end of 2015 to carry out pesticide leaching studies ▪ A paper submitted to document profitability difference between organic and conventional farming systems ▪ Farmer field experiments are ongoing.	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Objective 3: Assess the effect of hermetic storage on mold and aflatoxin contamination of stored maize and the qualitative changes in grain legumes during hermetic storage				
Specific objective 3.1: *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 under field conditions	▪ 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 2015.	▪ Participatory field trials for hermetically stored maize conducted in Eastern Kenya ▪ 703 households in 9 rural villages reached and trained. ▪ One scientific article published; one under peer review ▪ One international scientific conference presentation made ▪ Two online videos and one web blog made available	▪ Achieved 100% activity completion	▪ Mobilisation of target groups was a challenge and adequate sensitization mechanisms were found to be especially important to achieve outcomes.
Specific objective 3.2: *Evaluate qualitative changes in grain legumes during hermetic storage.*				
Qualitative changes in common beans during hermetic storage evaluated under laboratory conditions	▪ Qualitative changes in at least two (2) grain legumes during hermetic storage known by early 2015.	▪ Laboratory trials conducted using three common bean varieties ▪ One scientific draft manuscript prepared.	▪ Achieved 70% activity completion; laboratory trials completed; publication of results in progress.	▪ Irregular student participation slowed down progress towards desired outputs
Objective 4: Undertake acoustic fingerprinting of postharvest insect pests' sound spectra for long-term monitoring of storage pests of grains in bulk storage warehouses in Kenya				
Specific objective 4.1: To carry out acoustic profiling of sounds produced by 5 postharvest pests of adult and immature stages of Prostephanus truncatus, Sitophilus zeamais, Sitophilus oryzae, Acanthoscelides obtectus, Tribolium castaneum				
Acoustic profiles of adult and larval stages of *Prostephanus truncatus, Sitophilus zeamais, Acanthoscelides obtectus,* developed under laboratory conditions	Acoustic profiles developed for at least five (5) storage pests by end 2015.	▪ Laboratory experiments for three (3) storage pests completed ▪ Acoustic profiles of three (3) storage pests developed ▪ Two scientific draft articles submitted for peer review ▪ Two international scientific conference presentations made	▪ Achieved 70% activity completion; laboratory trials completed; publication of results in progress	▪ Stronger collaboration with experts in the field of acoustics was key to resolving constraints around data acquisition and interpretation.
Specific objective 4.2: To undertake the selection of specific unique frequency identifiers for Prostephanus truncatus, Sitophilus zeamais, Sitophilus oryzae, Acanthoscelides obtectus, Tribolium castaneum using sound characteristics that were developed in Specific objective 4.1.				
Unique frequency identifiers for *Prostephanus truncatus, Sitophilus zeamais, Acanthoscelides obtectus,* selected.	At least five (5) unique frequency identifiers selected for at least five (5) storage pests by end 2015.	▪ Three (3) potential frequency identifiers for three storage insect pests selected from laboratory data	▪ Achieved 50% activity completion; field trials started and are in progress	▪ Laboratory data alone not sufficient to achieve outcome; data collected under field context needed for authentication of the frequency identifiers

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Specific objective 4.3: 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 2015.	▪ One (1) ex-ante study to estimate acceptability and willingness-to-pay for acoustic early warning system by store managers conducted. ▪ One (1) report/working made available	▪ Achieved100% activity completion.	▪ Useful data obtained but more valuable data need to be collected in an ex-post framework.
Objective 5: Promote the utilization 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 5.1: Develop and promote insect feed for poultry and fish production in Kenya and Uganda (INSFEED)				
▪ Socio-Economic surveys carried out on the use of insect for feed in poultry and fish farming ▪ Market demand analysis for insect as feed ingredient for poultry and fish conducted ▪ Economic performance of insect based feed assessed. ▪ 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 by end 2015 ▪ At least 500 small scale farmers surveyed per target country by end 2015 ▪ At least 100 livestock feed processors surveyed per country by end 2015 ▪ Comparative costs of at least 3 insect based feed assessed by end 2016 ▪ Market demand and cost benefit analysis conducted for at least 1 insect based feed by 2017 ▪ Cost efficiency studies of poultry and fish reared on insect based feed evaluated by 2017 ▪ Key market segments described by Dec 2015		▪ Three focus discussions held in each country in 2015 ▪ A total of 1, 308 farmers interviews ▪ 223 livestock feed processors and traders were interviewed. ▪ MSc student recruited ▪ Market demand analysis completed and documented. ▪ MSc student recruited ▪ Market demand analysis finalized and documented	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
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 of production and high profit margin by 2017	▪ Rearing techniques developed for at least 3 insect species by June 2015 ▪ Safe and cost effective substrate for rearing of at least 3 insect species documented by end 2016 ▪ Chemical and microbial toxicity of at least 3 insect species under different rearing techniques profiled by end 2016 ▪ Entomopathogens affecting at least 3 insect species colonies documented by 2016 ▪ Wild harvesting techniques developed or adapted for at least 3 species by Sept 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 utilization rate of at least 2 insect based feeds tested on fish and poultry by end 2016 ▪ Effect of at least 2 insect based feeds on fish and poultry growth assessed by end 2016 ▪ Storage techniques developed for at least 3 insect based feed by Sept 2016	▪ Colonies of Black soldier flies, crickets, cockroaches established and running successfully ▪ Brewery waste found to be the most efficient substrate. MSc student recruited to analyze cost ▪ Initial chemical toxicity test was negative while microbial contamination of fresh insect was mitigated by boiling for more than 5 minutes or toasting for more than 2 minutes. ▪ MSc student recruited ▪ Biting flies were assessed regarding best type of traps and nzi trap was found the most performing one ▪ MSc studies ongoing ▪ Nutritive profiles of at least 26 insect species done and will be used for feed formulation of most promising ones	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Results used to inform policy to support use of insects based feed in poultry and fish farming.	Enhance awareness among stakeholders and inform policy by 2017	▪ At least 2 stakeholder workshop held by 2016 ▪ At least 10 media coverage on the INSFEED project by Dec 2016 ▪ At least 2 policy briefs documented by Dec 2016 ▪ At least 2 desk studies and expert interviews conducted per country by 2016 ▪ At least 1 situation paper on the use of insect for feed produced by June 2016 ▪ Documentation of processed leading to national and international standards (Codex) developed by Dec 2016	One inception workshop held in 2014 and a legislation workshop process initiated in 2015 Media coverage by local and international media	

Animal Health Results Based Management Report

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Objective 1: To develop attractive and effective killing and repellent system for control of vectors of camel trypanosomosis (surra) and to reduce vector and disease levels by 50%.				
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.	▪ This project has just been initiated and staff recruited with effect from January 2016 to undertake project activities. Three monitoring sites in 3 counties Laikipia, Isiolo and Marsabit have been identified where field activities have been initiated and baseline entomological and parasitological data attained. ▪ Sentinel camel herds have been recruited in different agro-ecological zones of semi-arid North Kenya. These include: One Somali camel herd in Mukima in Laikipia; two Somali camel herds in Bankare and in Dhakadera in Isiolo; and three Rendille camel herds in Ngurunit, Lependera and Lmoti in Marsabit. ▪ Familiarization of camel herd owners and their camel herdsmen with the routine monitoring procedures of the project and selection of one contact herdsman per herd has been undertaken. ▪ Development, testing and fine-tuning of the field sampling and diagnostic protocols has been completed. ▪ Identification and geo-referencing of flies trapping sites and a first assessment of biting flies' species and their activity levels around herd night enclosures and on pasture have been undertaken. ▪ Numbering and recording of names, age, body weights and reproductive status of camels in the sentinel herds has been completed.	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ Basic screening of the hematological (PCV) and parasitological (buffy coat examination for trypanosomes) status of camels in the sentinel herds has been initiated. ▪ Evaluation of camel urine and body swabs from camels as potential attractants has been initiated. ▪ Evaluation of tsetse repellent compounds as potential repellents for biting flies has been initiated.	
Objective 2: To upscale and adapt tsetse repellent technology in partnership with the private sector and to reduce trypanosomosis risk by 50%.				
Repellents for control of vectors of human sleeping sickness evaluated.	▪ Synthetic and waterbuck repellent blend evaluated for *Glossina fuscipes fuscipes* in Kenya.	▪ At least two tsetse repellent blends evaluated for control of vectors of human sleeping sickness, *Glossina fuscipes fuscipes* ▪ At least 50% decrease in fly catches in presence of repellents. ▪ No. of trials undertaken. ▪ Publications produced.	PhD student from Zambia, Joshua Njelembo has been selected in November 2015 to initiate this Activity along the shores of Lake Victoria, Western Kenya..	▪ IPR issues should be addressed adequately during formulation and implementation of projects ▪ Identification of private sector partners is not easy and professional assistance is required to assist scientists ▪ Primary beneficiaries must be involved in the commercialization process
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 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.	Post Doctoral Fellow, Dr. Michael Okal has been recruited and has joined the project from October 2015 to initiate this Activity in pastoral areas in Nguruman.	
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.	▪ 1 p-p-p collaborative arrangement has been established with Celanese in Germany for R&D of the repellent collars for eventual manufacturing scale-up. A Non-Disclosure and Materials Transfer Agreement has been signed with Celanese. ▪ Three different engineered materials supplied by Celanese for absorption and chemical resistance testing have been evaluated. Of these, Fotron material was found to be suitable and has been selected as base material for further development of the dispensers.	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			New dispensers made from Fotron with flat tygon sheeting are being evaluated for their robustness, reaction with the raw material, constant release rates of the repellent compounds, stability and protection provided under field conditions in Kenya These new models are very promising and are being taken to the next stage for dispenser production. ▪ Four new models of the dispensers supplied by Sigma Scientific were also testing but these failed their robustness and release rates tests and the material reacted with the repellent compounds and hence have been dropped from further development. ▪ One local entrepreneur –has been identified for production of the current dispensers at a cheaper rate for use by farmers pending availability of new dispensers. They have already produced 1000 dispensers to be used as starter kits by the farmers. 500 dispensers have also been sent to Ethiopia for evaluation in Assosa region.	
Business plan for commercialisation, packaging, product registration, marketing and dissemination for rollout of the technology developed.	▪ Business plan developed for commercialisation, dissemination, registration and roll out.	▪ Business plan developed. ▪ At least one P-P-P partner using the business plan.	▪ A consultant has been hired to assist with the registration of the water buck repellent compounds (as natural repellents) and the dispensers in Kenya; and this exercise is expected to be completed by April 2016. After product registration and after new dispensers are available a business plan for commercialization, packaging, product registration, marketing and dissemination in partnership with the private sector and local manufacturers for up-scaling will be made ▪ PCT Patent Application - Repellent compositions for insects and other arthropods has been filed.	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ Farmers in Shimba Hills have registered their own community based organization (CBO) with >1200 farmers members already registered with the objective of selling the repellent dispensers and compounds including servicing and maintenance of the dispensers. They have also collected over $2000 for purchase of the repellent compounds which is a positive sign and step towards adoption and up-scaling of the repellent technology. So far 352 farmers have got their own repellent collars for 958 animals out of a total of 2033 cattle they possess. The CBO is also in discussion with the local county government for subsidizing the repellent collars	
Advocacy of the repellent technology enhanced.	▪ Advocacy of repellent technology enhanced in collaboration with stakeholders.	▪ At least 3 advocacy events undertaken.	▪ Advocacy meeting of farmers in Shimba Hills was held on 14th May 2015 in South Coast to sensitise them on the up-scaling of the tsetse repellent technology and the need for them to organise themselves for investing in the repellent technology. The 36 participants comprised of Chairman, Secretary and Treasurer of each of the 6 blocks where up-scaling is being undertaken	
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.	▪ Up scaling has been initiated in 5 different locations, Majimboni, Lukore, Mangawani, Mwaluvanga and Mwaluphamba of Kubo division and in these locations after introduction of the repellent collars >75% disease reduction has been attained. PCVs of cattle with collars are also much better than unprotected animals and drug use in protected animals has been reduced by >50% (these have been attained within 1- 6 months of introduction of the collars).	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Socio-economic impact of the repellent technology assessed.	▪ Awareness created and socio-economic impact of the tsetse repellent products documented.	▪ At least 3 stakeholder trainings held. ▪ At least 3 awareness creation workshops held for local government departments and other stakeholders. ▪ Socio-economic impact study conducted. ▪ *Ex-ante* and *ex-post* financial, socio- and economic impact assessments.	▪ Training of stakeholders *(27th November to 1st December 2015)* 429 farmers (287 men (66.9%) and 142 women (33.1%)) and 5 local Government Administrators from 5 different locations in Kubo South Division have been trained on: 1. tsetse biology and ecology 2. tsetse repellent technology (topics included): ▪ Servicing and maintenance of repellent dispensers ▪ Safety issues ▪ Compounds in the repellent ▪ How the repellents work 3. Nagana - transmission, diagnosis and treatment 4. Traps and targets: ▪ Maintenance of traps/targets ▪ Clearing the vegetation around the trap/target site ▪ Importance of the traps/targets in managing fly densities 5. Record keeping ▪ Milk production, acreage ploughed ▪ Drugs used for treatment, etc. 6. Ticks control techniques 7. Chemotherapy and chemoprophylaxis 8. Basic clinical signs and symptoms of nagana in cattle. These topics were selected as per the recommendations of the farmers. 9. 6 technical staff from Ethiopia have been trained at ICIPE/Shimba Hills from 15th to 25th March 2015 on the repellent technology for it to be introduced in Asosa area of Ethiopia.	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Objective 3 - A novel ticks management strategy that is based on the use of bioacaricide, semiochemicals and/or botanical, developed and implemented by 2016.				
Objective 3.1: To reduce ticks and tick-borne diseases by 50% in cattle by 2015.				
A joint committee (*icipe* and Real IPM) responsible for project implementation and monitoring of activities established. Novel ticks product (bioacaricide) market survey expanded to Tanzania and completed. A business plan to bring novel ticks control product into market developed.	▪ A novel ticks management strategy based on the use of bioacaricide, semiochemicals and/or botanical developed and implemented by 2015.	▪ At least 20 fungal isolates screened for virulence to at least two important tick species. ▪ At least 3 isolates identified and their compatibility with semiochemicals, botanicals and synthetic acaricides completed. ▪ A resistance management package for one synthetic acaricide developed. ▪ One large-scale field efficacy trial completed by 2015 for the combination of the most promising individual components.	▪ Production of microsclerotia of *M. anisopliae* ICIPE 7 and their formulation in granules was completed. The evaluation of their efficacy and persistence against questing ticks in plastic basins planted with grass to simulate pasture is in progress. ▪ A new formulation of *M. anisopliae* ICIPE 7 was developed and tested on large-scale trials in Nguruman and in Kilgoris. The new formulation increased the efficacy of the fungus by providing 90% cattle tick reduction (from 58% with emulsifiable formulation) ▪ In partnership with Real IPM and exosect, *M. anisopliae* ICIPE 7 conidia were formulated in Entostat powder and tested. ▪ With complementary funds from the European Union, the technologies was successfully tested and validated in Somaliland in 2015.	▪ The Kenyan regulatory body (Dept. of Veterinary Services, Kenya) informed; and jointly keen to see the bioacaricide optimised and eventually registered in the country since acaricide resistance is rampant. ▪ Farmers were very happy to see that ticks can be controlled by alternative means than chemicals and are eager to adopt the technology

Human Health Results Based Management Report

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Objective 1: Contribute towards malaria elimination through the development of effective vector control strategies and public health initiatives by 2020.				
IVM implemented in Kenya and Ethiopia through a project entitled: "Integrated Vector Management (IVM) for Sustainable Malaria Control in Eastern Africa"	▪ At least 30% increased awareness among communities on IVM strategies for vector-borne disease control. ▪ Adoption of IVM policy for malaria control by the Ministry of Health (Kenya) and Ethiopia by 2016. ▪ At least 50% decrease in malaria prevalence and mosquito densities in target areas.	▪ Number of community members trained. ▪ 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.	▪ Villages implementing a comprehensive IVM intervention approach comprising of long-lasting insecticide-treated nets (LLINs), larviciding with *Bti* and community education and mobilization (CEM) achieved the greatest reductions in larval and adult malaria vector populations as well as malaria prevalence in both Kenya and Ethiopia. ▪ Malaria prevalence among school children in Nyabondo, Kenya declined from 24% at baseline to 10% during the interventions while in Tolay (Ethiopia), children from villages with the comprehensive IVM approach had on average half the parasite prevalence of those in the experimental control situation where only LLINs were in use. Malaria prevalence in Tolay was nevertheless generally low, being about 2.4% in the control villages. The average malaria prevalence in Malindi (Kenya) was 7.5 % in 2014, reducing to 3.7% in 2015. ▪ Community education and mobilization promoted behaviour change in all the project sites with respect to proper use of LLINs and sanitation around houses, focused on draining unutilized stagnant water pools. In this regard, school children acted as effective agents of change in the community through their schools' health clubs. ▪ A total of four effective plant-derived larvicides for control of mosquito larvae were developed by the project. ▪ Multi-sectoral IVM working groups were established in Kenya and Ethiopia to help embed IVM principles in policies of health and non-health sectors.	▪ There is need to adapt IVM strategies and interventions to local vector ecology, epidemiology and resources, guided by operational research and subject to routine monitoring and evaluation; ▪ Community members need to be repeatedly engaged in discussions of malaria and mosquito control as they have other competing priorities that could overshadow implementation of IVM measures on an ongoing basis; ▪ Community education and mobilization is most practical and effective in reducing mosquitoes and malaria when there is also easy access to actual vector control technologies such as LLINs for self protection against adult mosquitoes or *Bti* and other bio-pesticides for larval control; ▪ Door to door education provides a good opportunity for achieving behavioural change; ▪ Involving communities in decision-making is vital for success of IVM at the local level; ▪ School pupils are generally knowledgeable about the causes of malaria and are enthusiastic about promoting malaria control activities including participating in events such as community mosquito days and world malaria day;

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ The IVM project contributed to greater recognition of icipe as a regional hub for capacity-building in IVM by WHO-AFRO and the Stockholm Convention on Persistent Organic Pollutants (POPs), among other partners. **Publications:** 1. Demissew A, Balkew M, Girma M (2016). Larvicidal activity of chinaberry, neem and *Bti* to an insecticide resistant population of Anopheles arabiensis from Tolay, South West Ethiopia. *Asian Pacific Journal of Tropical Biomedicine* (Accepted). 2. Diiro GM, Affognon HD, Muriithi BW, Wanja SK, Mbogo C, Mutero C (2016). The role of gender on malaria preventive behaviour among rural households in Kenya. *Malaria Journal* **15:** 14. DOI 10.1186/s12936-015-1039-y. Available online at: http://www.malariajournal.com/content/pdf/s12936-015-1039-y.pdf 3. Mutero C**,** Mbogo C, Mwangangi J, Imbahale S, Kibe L, Orindi B, Girma M, Njui A, Lwande W, Affognon H, Gichuki C, Mukabana WR (2015). An assessment of participatory integrated vector management for malaria control in Kenya. Environ Health Perspect; DOI:10.1289/ehp.1408748. Available online at: http://ehp.niehs.nih.gov/1408748/ 4. Imbahale S, Mukabana WR (2015). Efficacy of neem chippings for mosquito larval control under field conditions. *BMC Ecology* 25:8 http://bmcecol.biomedcentral.com/articles/10.1186/s12898-015-0041-0	▪ Print IEC materials such as MOCON bulletin in Nyabondo and simplified booklets on mosquito and malaria control in Malindi and Tolay are a highly effective means of communicating with the community. In the case of the MOCON Bulletin, the column 'Dear Farmer' written in the local language was most appreciated. Those farmers, schools and community members who had a chance to appear in MOCON Bulletin, were very proud about it.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			Community outreach for IVM awareness creation: ▪ Door to door visits conducted with community-based groups such as MOCON (Mosquito Control in Nyabondo) and PUMMA (Punguza Mbu Malindi). ▪ Exchange visit to Malindi project site by 5 community members from Nyabondo (3 community and 2 IVM team members) had a great impact and inspired both the visitors and their hosts. ▪ In all the project sites, meetings and field visits were held with individuals, families and different groups within the community to create awareness on IVM. ▪ In Nyabondo, 1,500 copies of a 4-page MOCON Bulletin were distributed in the community and greatly appreciated for its educational value related to malaria control as well as income-generating activities. ▪ Pupils in more than 30 schools in Kenya and 16 schools in Ethiopia were reached with IVM messages through school health clubs and cross-sectional malaria parasite surveys where those found positive were also treated by ministry of health personnel. ▪ In Tolay, about 6,000 seedlings of medicinal plants and others with known insecticidal properties were cultivated for income generation and local use. Overall, direct beneficiaries of the IVM project's awareness creation and capacity-building activities during 2015 were as follows: ▪ Nyabondo: 3,162 female and 2,749 male ▪ Malindi: 25,712 female and 21,426 male ▪ Tolay: 978 female and 2,447 male	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
IVM optimised in Kenya and Ethiopia through a project entitled: "Integrated vector management to improve health and livelihoods of communities in malaria-affected areas of Kenya and Ethiopia"	▪ At least 50% reduction in malaria prevalence within the project sites in Kenya and Ethiopia by 2018; ▪ 10% Increase in household income for community members applying IVM	▪ Reduction in malaria burden (parasite prevalence, morbidity and mortality); ▪ Increase in household income for community members applying IVM.	▪ Project idea discussed with donor Biovision Foundation; ▪ Concept note prepared by IVM project team, submitted to donor and approved for funding. ▪ Full three-year project proposal developed, submitted to donor and funded for the period 2016-2018.	▪ Donor recognition of successful implementation of a funded project phase is crucial for approval of follow-up support; ▪ Promotion of IVM is viewed as an important integral component towards achieving the goal of sustainable malaria control and elimination.
Potent plant-based lure(s) for malaria and other disease vectors targeting both sexes developed	▪ At least one phytochemical attractant identified	▪ Number of peer-reviewed publications. ▪ Laboratory and field data ▪ Thesis. ▪ Availability of lure	▪ A promising lure, linalool oxide (LO), identified and field evaluated ▪ 1 peer-reviewed publication on performance of LO on mosquito disease vectors of both sexes (Parasites & Vectors 8:581).	▪ Further assessment and chemical characterization required to improve LO as a promising lure for deployment in outdoor monitoring of vector populations with minimal requirement of carbon dioxide
Capacity of community health workers (CHWs), animal and public health workers and communities for improved early detection and response of Rift Valley fever developed. Potential opportunities to minimise risk and prevent RVF identified. Indigenous knowledge about RVF disease assessed	▪ Awareness about RVF community-based preventive measures ▪ Identifying opportunities for disease prevention and control to minimize impact of outbreaks. ▪ Capacity built on the use of mosquito-based sampling tools and analysing trends in key RVF vectors among CHWs and community	▪ Number of CHWs trained ▪ Meeting with community and stakeholders to discuss project ▪ Questionnaires ▪ Project reports ▪ Publications ▪ Mosquito data	▪ 3 training sessions organized for CHWs so far (2 at icipe, and 1 in each of the communities ▪ 1 focus group discussion held at icipe ▪ 233 CHWs trained so far in four communities in Ijara subcounty-Kotile, Korisa, Bulagolol and Mohamed Dahir. ▪ Knowledge has been enhanced among the CHWs and communities on RVF, how to recognize risk factors associated with RVF (e.g abortions in animals) with resultant behavioural changes among communities towards embracing preventive strategies to minimize exposure to humans enhanced ▪ Idirect impact to the community through dissemination of findings and project activities during community dialogue days ▪ 9 select CHWS able to conduct timely mosquito survey, identify primary Aedes vectors, analyze the trend and associate their levels with risk of transmission. ▪ 1 manuscript in preparation	▪ Successful implementation of the project and analyses of KAP findings highlighting the need for more training led to the renewal of the project for a phase 2 to upscale the activities to two more communities- Sangailu and Koranhidi

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Therapeutic importance of an edible insect pest assessed	▪ Enhanced knowledge regarding health benefit of the desert locust despite being a notorious pest of crops	▪ Chemical characterisation of sterols content in the desert locust profiled ▪ Laboratory data ▪ Student thesis ▪ Publication	▪ 1 publication in *PLoS One* 10(5):e0127171, 2015, highlighting the additional nutritive value in terms of health benefits of the desert locust which has been reputed for its alarming threat to food security	▪ Publication of the findings led to widespread media coverage both locally and internationally
Ecological drivers in the sustenance of malaria based on plant nutrition of the vectors identified	▪ Enhanced information on the connection between invasive plants and malaria transmission ▪ Global awareness on the threat posed by invasive weeds on public health	▪ Laboratory data ▪ Number of peer-reviewed publications.	▪ 1 peer-reviewed paper on how invasive plants can contribute to the transmission of malaria (*PLoS One* 10(9): e0137836)	▪ Publication of the findings attracted global interest and widespread international coverage by several media outlets including local dailies and news stations (NTV, K24, The Standard Newspaper etc) and science news agencies such as The New Scientist ▪ Also led to the first global conference on "Invasive Plants and Malaria" (December 4-6, 2015, Naivasha, Kenya) and brought together invasive plant specialists, ecologists, chemical ecologist, modellers and entomologists
Tick-borne bacterial and arboviral pathogen infections identified in wildlife and camels Surveillance of arbovirus diversity in mosquito vectors	Vector animal disease surveillance	Manuscript on tick and tick-borne bacterial diversity in ticks of Shimba Hills under review at *Ticks and Tick-borne Diseases*	Manuscript on tick-borne pathogens in Shimba Hills wildlife in draft Manuscript under review on pan-arbovirus surveillance and discovery in *Molecular Ecology Resources*	Close collaboration with Kenya Wildlife Services (KWS) has facilitated work progress significantly and should be exploited further. The camel work is expanding this collaboration with the FAO, Department of Veterinary Services (DVS) among others.
DNA barcode index generated of 63 mosquito species in Homa Bay and Baringo counties Arboviruses and blood meals identified in mosquitoes	Medical vectors of zoonotic importance	Publication accepted in 2016 in the Journal of Medical Entomology (Ajamma et al, 2016, *Journal of Medical Entomology*) Publication in *PLoS One* (Omondi et al. 2015)	PhD thesis for Ms. Yvonne Ajamma advanced.	The relationships between arboviruses their mosquito vector diversity and amplifying hosts are still poorly understood.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Vector Biology Course 2015 (April)	Capacity building within the existing study sites, expansion of activities in other regions and continuing education of African vector control specialists	26 students trained from Kenya, Uganda and Tanzania		Future workshops may include more international expertise of trainers. Collaboration with other institutions locally, such as KEMRI added good value to the conduct and outputs. *icipe*'s Thomas Odhiambo Campus (TOC) is a great venue for the VBC.
Bunyamwera and Sindbis viruses isolated in human febrile illness patient samples from Lake Victoria	Expand human health activities to include emerging and re-emerging infectious diseases	In 2016 published two papers on outbreaks in East Africa of Dengue (*Reviews in Medical Virology*) and RVF (*Emerging Microbes and Infections*)	Manuscript in draft on acute arbovirus infections in human febrile illness patients	A broad diversity of arboviruses is likely to contribute to undiagnosed febrile illness in Kenya. More work is needed to establish causation.
Characterization of endosymbionts in mosquitoes	Endosymbionts and insect vector competency	Significant discoveries of new endosymbionts in Anopheles mosquitoes. Dissemination of results to wider community.	Results presented at international meetings. Manuscript on Anopheles-endosymbionts in preparation.	Establishing endosymbiont-infected colonies will be critical for further characterization of *Anopheles* endosymbionts. Endosymbiont prevalence is highly variable across geographic locations.
Chemical parameters and bacterial communities associated with larval habitats of Anopheles, Culex and Aedes mosquitoes in western Kenya identified	Promoting One-Health	Accepted paper on chemical parameters of mosquito larval habitats (Onchuru et al. 2016, *International Journal of Insect Science*)		While a substantial amount of informative baseline data was produced, higher sample size investigations must be conducted for generalizing findings
Established collaborations with KWS and TAWIRI	Collaboration with government departments	Obtained funding for collaborative work on wildlife sample surveillance	Initiated collaborations with FAO and DVS in camel work	
Documentation of sandfly diversity, distribution and prevalence in leishmania endemic areas	Expand human health activities to include emerging and re-emerging infectious diseases	Incorporation of the data we generated in the 2015 - 2020 guidelines of leishmaniasis treatment and control	Manuscript draft on sandfly diversity in Marsabit	Visceral Leishmaniasis occurs in arid and semi-arid areas. Close collaboration with the community and the local health personnel is essential for progress.
Mapping of ecological factors as risk determinants of leishmaniasis occurrence in Kenya	Promoting One-Health		Manuscript in preparation on Mapping of risk factors to determine visceral Leishmaniasis Vulnerability in Marsabit County, Northern Kenya	
Established collaborations with: ▪ North Eastern University - USA ▪ MoH-NTD unit ▪ KEMRI ▪ University of Nairobi	Collaboration with government departments and private partnerships	Co-sponsored leishmaniasis activities in East Pokot	Discussions with these stakeholders have resulted in potential new collaborations, and new funding opportunities.	County health facility personnel can make very good project partners.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
	Capacity building	Laboratory based sandfly vector biology and leishmaniasis diagnostic training	Proper Visceral leishmaniasis diagnosis at the County health facilities and sandfly identification	
Objective 2: Preventing and controlling Rift Valley fever (RVF) in Kenya: An Eco-health approach.				
Pastoralists and stakeholders in NE, Garissa County engaged, to understand pastoral system dynamics.	Better understanding of the pastoral system dynamics and how it influences RVF disease dynamics	Publication; Muga GO *et al.* Sociocultural and economic dimensions of Rift Valley fever. Am J Trop Med Hyg. 2015 Apr;92(4):730-8. Feb 16. Review.	Completed	Human economic activity including pastoralism impacts disease transmission dynamism and must be considered in developing preventive measures
Circulation of RVF virus in animals, vectors and humans within the nomadic pastoral system (NPS) determined	Detection of virus activity and transmission among livestock, vectors, human population	i) Laboratory results, ii) Publication; Arum SO *et al*; Distribution and diversity of the vectors of Rift Valley fever along the Livestock movement routes in the north-eastern and coastal regions of Kenya. *Parasite Vectors.* 2015 May 28;8:294.	i) Evidence of virus activity detected among livestock sampled along nomadic route ii) Evidence of virus activity detected in human population along the nomadic route. iii) Primary vectors of RVF identified along the nomadic route. Completed work	RVF virus transmission occurs during inter-epidemic period with limited or no evidence of disease in animals and humans during rainy season. Nomadic pastoral movement serves to amplify and perpetuate and spread virus even to new areas
The impact of developmental change on RVF control determined	Use of infrastructural development to prevent/reduce RVF outbreaks.	i) Publication; Muga *et al*. ii) Community conference report.	Complete	Participatory mapping indicated scarcity of animal and public health infrastructural distribution as hindrance to RVF prevention
Potential opportunities for RVF control identified.	Awareness about RVF community based preventive measures assessed.	i) Publication; 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)	Complete - RVF knowledge gaps identified. - Risky practices identified and discussed with communities for prevention. - Information shared with the county government - Information shared with the Zoonotic diseases unit for action and enhancement of relevant public health education.	

Objective 3: Mass trapping of mosquitoes using solar powered mosquito trapping systems (SolarMal)				
At least one technology with potential to enhance mosquito control developed for malaria vectors.	▪ Odour-baited technology deployed on Rusinga Island, and efficacy tested. ▪ Health and demographic surveillance system (HDSS) established to underpin evaluation of intervention outcomes, and social studies.	▪ At least 90% of the households on Rusinga Island using technology. ▪ Favourable assessments by Rusinga Island community. ▪ Sustainability plan developed for handover to the community. ▪ Private partner identified. ▪ Publications produced ▪ Project reports.	▪ All target households on Rusinga Island received the odour-baited solar powered mosquito trapping systems in 2015. ▪ 4300 traps were deployed, representing all the households targeted at the project initiation in 2013. ▪ Savings groups established to enhance sustainability of technology after project closure. ▪ Community Advisory Board for project sustainability established, taking over from the community project advisory board.	▪ Continuous interaction with community representatives essential. ▪ Private partner identified to provide replacement parts. Establishment of a sustainable business model for a relatively small community not easy.

Environmental Health Results Based Management Report

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Objective 1: At least 6 new eco-friendly nature-based products for pest control adopted for improvement of livelihoods of rural and wider community members by the year 2020.				
At least 4 new potential insecticidal products identified from plants based on efficacy, safety and ease of application. Two insecticidal plant-derived products formulated and packaged. Community-based cultivation of selected insecticidal plants initiated. Community-based production and use of plant-derived insecticidal products initiated in at least one project site. One PhD and two MSc students trained. At least three papers prepared and submitted to international journals.	One plant-derived insecticidal product adopted for use in pest control by a local community by 2016. Three papers on potential insecticidal products published by 2016.	▪ Number of products produced and used ▪ Number of community members using the insecticidal products ▪ Number of reports and publications ▪ Number of students trained	▪ The registration dossier for the *Uzimax* mosquito larvicidal product that had been compiled and submitted to the Pest Control Products Board (PCPB) of Kenya was reviewed by PCPB. Following the review by PCPB and corrections and adjustments to and revisions of the dossier, it was approved by PCPB for the second phase of the registration process. For the second phase, 3 test permits were issued by PCPB for 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 before final review of the product by a review committee. ▪ 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 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. ▪ Patents: 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.	▪ There is a major potential for use of plants in vector control particularly with rural Community participation.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ Manuscripts: 1. 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). 2. 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.	
Two plants with bioactivity against honeybee pests/diseases identified. One plant-derived product formulated and evaluated for control of a honeybee pest/disease. The bee pest/disease control product submitted for registration with relevant bodies. Protocols for production of the bee pest/disease control product established.	One plant-derived product for honey bee pests/diseases control adopted for production and in use by 2016. Two publications /utility model/ patent on potential honeybee pest control products published by 2016.	▪ Number of products produced and used ▪ Number of reports and publications	▪ Laboratory studies confirmed the effectiveness of the *icipe*-BH-01 and *icipe*-BH-02 plant-derived products against varroa mites (*V. destructor*). Both products were also non-toxic to bees at relatively high doses. *icipe*-BH-01 plants were also shown to be highly attractive to bees. ▪ The safety of *icipe*-BH-01 to mammals was evaluated in laboratory oral toxicity studies in rats where it exhibited a median lethal dose (LD_{50}) of more than 2,500 mg per Kg body weight and classified under the category of low hazard according to Globally Harmonized System. Based on oral toxicity in rats, it is safer than the active ingredients in many of the commercial products that are currently used for control of bee pests and diseases.	▪ There is a major potential for use of plants in pest control particularly with rural Community participation.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
			▪ *icipe*-BH-01 was formulated into a shelf stable product named *Apicure.* In semi-field experiments, *Apicure* was effective in controlling varroa mites in bee colonies where it acted as a fumigant biopesticide by killing varroa mites. It was also a repellent to other bee pests such as hive beetles. ▪ A patent application on the composition and methods of use of the icipe-BH-01 plant product and its constituents for bee pest control was filed at the Kenya Industrial Properties Institute (KIPI) for intellectual property protection. Patents: 1. 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;	
Objective 2: Geographic information systems are fully integrated as a strategic research tool for *icipe* by 2020.				
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 collaborative publications within icipe that make use of GIS and remote sensing		▪ Six papers that utilize geo-spatial data variables were published/submitted jointly with four ARPPIS/Drips students in 2015 (Traore et al., 2015; Arum et at., 2015; Landmann et al., 2015; Abdel-Rahman et al., 2015; Njuguna et al., 2015; Mwalusepo et al., 2015). ▪ In 2015 two new projects (Citrus IPM and a NIH project on ecological factors affecting the spread of Yellow fever and dengue) were granted in which Geo-Information plays a pivotal role. ▪ The total number of projects that integrally utilize GIS or remote sensing rose from 8 to 10 over the reporting period	▪ Instead of several smaller project contributions an effort should be made towards contributing to larger and long term project endeavors ▪ There is little computer processing capabilities at icipe.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
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 EO that ecological variables for improved assessments of pests and diseases, i.e. RVF, Dengue, Malaria, etc	▪ A data portal that collates more than six ecological variables from remote sensing and other variables for mapping RVF in central and north-eastern Kenya (Lamu to Baringo County) was set-up. A paper was submitted (accepted March 2016) that shows the relevance of remote sensing variables for improved mapping of water-borne diseases in Kenya. The number of disease intervention projects using ecological from EO has increased by 1.	▪ Disease mapping needs more concerted attention since it is a much needed skill to support intervention strategies; however, the modeling capabilities at icipe are low.
Operational species diversity mapping framework developed	ICIPE can use operational SDM framework for enhanced decision making in IPM and as a marketing tool for funding	Number of ecological and remote sensing available and significance understood	▪ Innovative seasonality variables were derived from satellite time-series data and investigated within a SDM framework for their suitability to map the occurrence of key bee pests in Kenya. A total of 13 seasonality variables were derived and tested.	▪ Using ecological niche modelling to visualize current and future pest severity areas is very effective to support concerted interventions; this work should thus be extended beyond the EU Bee health project
Objective 3: Increasing honey and silk production by 20% in selected African farming communities by 2020.				
Potential and healthy silk and bee races identified for enterprise development in Africa by 2016. Healthy silk and bee races are distributed to 3000 trainers for the farmer groups. At least 15 PhD and 10 MSc. students trained. At least 50 peer reviewed papers and 5 books/proceedings published in international journals.	▪ 50% of the farmers use improved bee and silk races.	▪ Number of farmers using improved races. ▪ Number of bee and silk races identified. ▪ Number of students trained. ▪ Number of peer reviewed papers.	▪ 70% of the honey beekeepers/farmers in 12 African countries using improved bee keeping practises. ▪ 30% of the silk farmers in 5 countries in Africa using improved silkworm races. ▪ Over 7 stingless and 5 carpenter bee races identified in Kenya and Ethiopia. ▪ One castor silkworm species introduced for research at *icipe.* ▪ 15 peer reviewed papers published.	▪ New bee species identified have the potential to improve pollination and farmers' income.

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
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 manuals developed. ▪ Numbers of farmers trained. ▪ Numbers of farmers applying their new knowledge.	▪ Two manuals, one each for apiculture and sericulture, developed for use by farmers. ▪ 2000 and 150 farmers trained in beekeeping and sericulture respectively.	▪ Demonstration of improved beekeeping was found to be the most effective teaching method for farmers and should be scaled out and up in other project areas.
Business model developed using value chain approach.	▪ Business model and business responsibility adopted by at least 400 farmer groups.	▪ Number of enterprises registered.	▪ 50 farmer groups adopt new business models in apiculture and sericulture.	▪ Adoption of new business models is usually a slow process at the start.
16 to 20 marketplaces (honey and silk harvesting, processing and selling units) established.	▪ 25% increase in honey and silk quantity by 2016.	▪ Number of marketplaces established. ▪ Production records	▪ 11 Honey marketplaces established. ▪ 30% increase in honey production by beekeepers. ▪ 5% increase in silk production.	▪ The established marketplaces offer farmers the much needed central point to sell their hive and silk-based products.
Modern beehives supplied to farmers and rearing houses (silk moth) established.	▪ 500 beehives supplied to farmers by 2016.	▪ Number of Langstroth hives supplied. ▪ Number of rearing houses established.	▪ More than 6,000 Langstroth hives supplied to beekeepers in 11 African countries.	▪ Adoption of modern technology is usually slow at the beginning.
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 2016.	▪ Number of Marketplaces issued with Organic Certificates issued to Marketplaces. ▪ Number of farmers inspected for certification.	▪ 2 Honey marketplaces issues with organic certificates. ▪ 747 beekeepers inspected for certification in Ethiopia.	▪ Organic certification is a viable though costly form of honey value addition.
Objective 4: 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.				
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.	▪ In progress	
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 2016.	▪ Number of bee extensionists applying new knowledge. ▪ Peer-reviewed publication.	▪ In progress	
Innovative integrated honeybee pest control strategies developed.	▪ Use of honeybee integrated pest control strategies increased by 20% by 2016.	▪ Number of beekeepers trained. ▪ Number of beekeepers applying new knowledge. ▪ Peer-reviewed publication.	▪ Over 2000 farmers/beekeepers and NARS trained from 52 African countries in collaboration with AU-IBAR. ▪ 20% of the beekeepers applying new knowledge. ▪ One patent published.	

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
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 2016.	▪ Number of multi-stakeholder workshops held. ▪ Number of policies developed.	▪ 5 multi-stakeholder workshops held. ▪ Draft Policies developed in collaboration with AU-IBAR.	
Capacity of beekeeper/farmers' federations, Regional Economic Communities (RECs) and NARS on bee health management systems and policy options strengthened.	▪ At least 20 beekeepers associations supported/ strengthened by the end of 2016. ▪ 80% of the beekeepers' associations actively engaged in bee health policy processes at national level.	▪ Number of beekeepers associations supported.	▪ Over 20 beekeepers associations supported.	

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

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

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
Objective 1:	**Assess the spill over effects of Mango IPM fruit fly control technology on farm productivity and environment in Kenya**			
Objective 1.1: Collect data for the spillover effects assessment				
Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 Lessons Learned
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	▪ 2 focus group discussions conducted, ▪ One household survey comprising of 371 households successfully conducted. ▪ Data analysis completed and report produced.	
Objective 1.2: Evaluate the spill over effects of Mango IPM fruit fly control technology on farm productivity				
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	▪ Survey successfully completed in Meru County ▪ One MSc thesis and one manuscript produced, both under review	
Objective 1.3: Evaluate the environmental benefits of Mango IPM fruit fly control technology				
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 household survey comprising of 371 conduced in Meru County ▪ One report produced ▪ A thesis and journal article produced, now under review	

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

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 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 (Kenya), Malindi (Kenya) and Tolay (Ethiopia) and results of impact study disseminated to project's partners	▪ At least one (01) research report produced by end of 2015	▪ Data collection for impact assessment started in March 2016 in Ethiopia.	We did not have adequate financial resources to collect data as earlier planned
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 enrolled in the baseline study by 2014	▪ At least one (01)survey conducted in each study site by end of 2014	▪ Baseline database created comrpising households in Nyabondo, Malindi and in Tolay. ▪ One paper published in Malaria journal	
Objective 2: Assess the Economic Importance of Malaria in East Africa				
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	Preliminary results for Nyabondo (Kenya) generated; we shall utilize the IVM impact assessment survey data currently being collected for Tolay (Ethiopia) and Malindi (Kenya)	

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

Outputs Produced (Activities run)	Expected Outcomes as per RBM framework plan	Performance Indicator of Outcome	2015 Progress Observed in Obtaining Outcomes	2015 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 farmers knowledge and perceptions on the biological control*				
The spread of stem borers and its biological control agents known, and farmers 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	▪ Survey on pest density and parasitism rate completed for the growing year 2014-2015. ▪ A household survey of 600 households on farmer's knowledge and perception on biological control collected, analysis completed and report write-up ongoing.	
Objective 1.2: *Assessing the impact of the BC program on productivity, food security, poverty and environment at household level*				
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	▪ Two rounds of household survey of 600 participants in Costal, Eastern, Nyanza, Western and Rift Valley regions of Kenya conducted. Data entry for the second round in progress ▪ Two conference papers on (1) welfare impact of Biological Control of stemborers in Eastern and Southern Africa, (2) empirical analysis of productivity-effect of the biological control of stemborers in the Coastal Region of Kenya produced and presented at International Conferences ▪ Paper on welfare-effect of biological control in Eastern and Southern Africa submitted for peer review. ▪ Ex-post impact of Biological control on household's income, expenditures and poverty indicators: analysis completed and draft manuscript produced awaiting submission for peer review	

Capacity Building and Institutional Development Results Based Management Report

Outputs produced (activities run)	Expected outcomes as per RBM framework plan	Performance indicator of outcome	2015 progress observed in obtaining outcomes	2015 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				
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, 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.	▪ 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 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.	▪ During 2015, icipe had 88 PhD fellows and 87 DRIP MSc fellows at various stages of their research training. ▪ In 2014-2015 23 PhD students completed training. Currently 16 (70%) are in research, development and higher education in Africa; 4 (17%) are unemployed; records are not available for 3 (13%). ▪ 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 for the icipe capacity building database. ▪ Of the 18 MSc students who completed training in 2014 & 2015: 15 (83%) following careers in research, development and higher education [of these, 5 are pursuing PhD studies in Africa and 2 in Europe]; 1 (6%) is currently unemployed; we do not have records for 2 (11%). ▪ 43% of all postgraduate and postdoctoral fellows are women, and 47% of fellows in the PhD programme are women.	We lack some data on icipe MSc and PhD alumni, e.g. current positions, and number of projects initiated/led by alumni. More comprehensive data collection methods will be implemented in 2016. Although more than 40% of all fellows in our postgraduate and postdoctoral programme are women, approximately 29% of applicants to our programmes are women. To ensure we maintain our commitment to training women, we must find ways to attract more women applicants by (1) extending the reach of programme announcements; and (2) create stronger partnerships with capacity building organisations that focus on women scientists (e.g. AWARD, OWSD, UNESCO). Also, we should review the postgraduate programmes, and find ways to make them more attractive to women students, especially for those with young families. 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. Approximately 50% of all applications to the PhD programme are from Kenya and Ethiopia.

Outputs produced (activities run)	Expected outcomes as per RBM framework plan	Performance indicator of outcome	2015 progress observed in obtaining outcomes	2015 lessons learned
			▪ In 2015, 18 African countries were represented by postgraduate students at icipe; and 26/88 (30%) of PhD students were from Southern, Central and West Africa. *(Note: 10 new ARPPIS PhD fellows [Class of 2015] started in early October 2015, with scholarships from DAAD's renewed Postgraduate Scholarships Programme. With 9 African nationalities represented (Benin, Cameroon, Ethiopia, Ghana, Ivory Coast, Kenya, Nigeria, Sudan, Tanzania, and Uganda) the new cohort represents a significant increase in country diversity entering the ARPPIS programme).*	
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. ▪ Number of students participating in scientific meetings/conferences	▪ In 2015, of the 147 peer-reviewed papers published by *icipe*, 50 (34%) had at least one postgraduate student as an author – and of those, 43 (29 %) postgraduate students were lead authors. *Citations for these publications will be measured from the end of 2016.* ▪ 22 PhD and 9 MSc theses were completed in 2015. ▪ In 2015, 35 postgraduate students participated in 22 international/ regional scientific meetings & conferences and 8 local scientific meetings & conferences.	

Outputs produced (activities run)	Expected outcomes as per RBM framework plan	Performance indicator of outcome	2015 progress observed in obtaining outcomes	2015 lessons learned
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	▪ 599 mid-level practitioners and extension workers trained (32% women) ▪ 17 training courses ▪ 19 countries in Africa	We need to use more in-depth M&E to determine the number of trained middle-level practitioners applying their knowledge and expertise in NARS countries
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	▪ 89 interns were trained in insect and related sciences in 2015. 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 2016 to follow up on interns.
Research and training capacities in insect and related sciences strengthened at national and regional research and 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.		▪ Signed MoU's and collaborative agreements ▪ Exchange visits between icipe and national/regional institutions ▪ 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	▪ A side-meeting was held at the African Association for Insect Sciences (AAIS) Conference in Benin, Oct 2015 with icipe alumni and other insect scientists to reinvigorate a network of icipe alumni for institutional development in Africa. ▪ An online alumni networking platform that was previously developed is under technical review for improvement. ▪ Databases of all icipe postgraduate and postdoctoral alumni developed and continually updated with new information. ▪ MoUs signed with capacity building partners: Alexander von Humboldt Foundation (AvH), and International Foundation for Science (IFS). MoUs under development with University of Nairobi, University of Addis Ababa, OWSD and AWARD.	Funds must be raised to support institutional development, e.g. managing a network for capacity strengthening in Africa will require a full-time coordinator; completion and implementation of online platform will require part time developer; funds will be required for institutional development activities.

Outputs produced (activities run)	Expected outcomes as per RBM framework plan	Performance indicator of outcome	2015 progress observed in obtaining outcomes	2015 lessons learned
Five 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. ▪ At least 50% of fellows attract competitive research grants during their tenure at icipe or within 1 year of leaving icipe.	▪ Number of postdoctoral fellows and visiting scientists trained. ▪ Number of grants received by PDFs each year. ▪ Number of research publications in peer-reviewed journals.	▪ 19 postdoctoral fellows (PDF) were engaged in research at various stages of their tenure at icipe in 2015. ▪ Two new postdoctoral scientists were recruited in 2015. We also hosted two visiting scientists for up to 1 year during 2015. ▪ 33 peer-reviewed articles published by postdoctoral fellows in 2015 (17 as lead author). ▪ 9/22 (41%) of postdoc fellows have successfully applied for research grants during their tenure at icipe. ▪ 5 grants were successfully funded in 2015. ▪ Of 8 postdoctoral fellows who completed, all are currently in research, development or higher education (7 are in Africa; 4 as scientists with icipe and 3 as scientists/lecturers in national systems; and 1 is a research scientist in UK).	New funding is required to maintain 5 new career development opportunities (short-term visiting scientists and post-doctoral fellows) each year.

ANNEX: LIST OF REFEREED JOURNAL ARTICLES

Annex 1: April 2015 to March 2016 Publications List

2015 (REFEREED JOURNAL ARTICLES)

1. *Abdel-Rahman E.M.*, *Makori D.M.*, *Landmann T.*, Piiroinen R., Gasim S., Pellikka P. and *Raina S.K.* (2015) The utility of AISA Eagle hyperspectral data and random forest classifier for flower mapping. *Remote Sensing* 7, 13298–13318. doi:13210.13390/rs71013298.
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BASED ON
RESULTS BASED MANAGEMENT REPORTING

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