

Vision and Strategy 2013-2020

Addressing Africa's Challenges and Opportunities



icipe



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International Centre of Insect Physiology and Ecology (*icipe*)

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Cover photo: Participating African women farmers no longer need to remove the purple witchweed (*Striga*) attached to their maize or sorghum plants by hand, thanks to *icipe*'s novel habitat management approach known as Push-Pull. –*Photo: icipe.*

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Foreword

For more than 40 years, *icipe* has been the principal insect and arthropod research institute for Africa.

Within that period, *icipe* has delivered world-quality science, made crucial contributions to African food and health policy, delivered development outcomes to rural communities and has been at the forefront of building Africa's biological research capacity. It is a record to be proud of.

Our strategy for 2013–2020 builds on this outstanding record and the foundations laid down by previous strategies. This Vision and Strategy is not a new, “different” strategy, but one that responds to the need to modify, refocus, and build new capacity to meet new challenges and opportunities.

In 2012, *icipe* initiated an external review of its research, capacity building, and governance and also sought the views of some of our main stakeholders as we embarked on developing our 2013–2020 strategy. The insightful recommendations from both the reviewers and stakeholders have proven invaluable in framing this strategy and we thank those who contributed to this document for their dedication and constructive comments.

The strategy for 2020 highlights a number of critical new elements:

- Taking a stronger systems approach with our science, and, hand in hand with that, a stronger focus on delivering development outcomes for Africans;
- Expanding our influence in Africa, especially in west, central and southern Africa, and aligning more closely with African policies such as the Comprehensive Africa Agriculture Development Programme (CAADP);
- Creating new partnerships with a broader set of the most respected research institutes to ensure our science is among the very best; and, to achieve this,
- Building new capability within *icipe*, especially in socio-economics and arboviral research.

We, along with all of *icipe*'s teams and partners, look forward to responding to the challenges and opportunities ahead. We believe that science, specifically building Africa's science capability and skills to meet Africa's challenges by Africans, is one of the most important development outcomes of all. The strategy presented here supports that vision.



Dr Segenet Kelemu
Director General



Prof. Dr. Bill S. Hansson
Chairman of the Governing
Council

Executive Summary

Since its establishment in 1970, *icipe* has grown into an African regional research institute of more than 400 staff and has become a significant contributor to the science and innovation required to meet the health and food security challenges of sub-Saharan Africa. *icipe* has achieved this status while maintaining its original research focus on insects and the challenges and benefits they bring to human health, livestock and crop production, ecological systems and economies. *icipe* today employs a diverse range of science disciplines to achieve its goals, scientific excellence and global recognition. A number of its scientists have been recognised internationally for their contributions to science and to the developing world. *icipe* is an important regional and international organisation with partnerships across Africa, especially with African universities, and also with prestigious research institutes around the globe, especially in Europe and the United States of America.

icipe's programmes are delivered via four research themes—Human Health, Animal Health, Plant Health and Environmental Health—as well as a capacity building theme, Capacity Building and Institutional Development. *icipe*'s science quality is demonstrated by its impressive citation metrics over recent years and by innovation tools that have been developed and are being used by farmers, such as the 'push-pull' habitat management strategy, which simultaneously combats stemborers and the devastating parasitic weed, *Striga*, in cereal crops, and the development and scale-out of fruit fly IPM technologies in fruit production, some of which have arisen from *icipe*'s own bioprospecting research.

In keeping with its history of continuous improvement and refocusing, *icipe* has over the years initiated a number of reviews to guide change. Recent reviews recognised the quality of *icipe* research, its innovation and its excellent capacity building credentials, and building on that proud record, made a number of recommendations that form the basis of the institute's Vision and Strategy 2013–2020.

Some of the most important initiatives are those designed to help *icipe* deliver greater on-the-ground impact.

Expand research focus towards the One Health concept: *icipe* will continue its four research themes, and maintain its commitment to capacity strengthening. However, it will also expand its research focus towards the concept of One Health by integrating key research components that currently reside in one or more of the four research themes, with the aim of developing solutions that are both systemic and sustainable.

Improve adoption of technologies: *icipe* will also employ initiatives to improve adoption of technologies. It will expand its capacity building programmes beyond its current science and research focus to also include capacity building for public and private extension agents and agencies, and especially towards providing more direct training for farmers and their rural communities; and it will place special emphasis on building effective public-private partnerships as the core means of delivering impact.

Build new capability and skills: Implementing change will require *icipe* to engage additional personnel with new skills, especially in social sciences and development that will enable it to better understand and overcome the constraints to adoption; and implement improved monitoring and evaluation of its programmes, including better estimates of social and economic benefits.

Establish new S&T partnerships: New partnerships will also be necessary so that *icipe* can access the latest science and technology for Africa and at the same time broaden still further its reach and influence across the continent.

This Strategy outlines significant change while maintaining excellence in science and capacity building. *icipe*'s success in 2020 will be judged by how the institute responds and simultaneously delivers quality science, effective partnerships, and most importantly, on-the-ground impacts for African agriculture, health and economies.



Section 1: Challenges and opportunities – the environment in which we work

Africa continues to undergo rapid changes in human, crop, livestock and environmental health, impacting food security and livelihoods. At the macro level, the food crisis of 2008 awakened the world to the challenges of food security and how sensitive global – especially African – food security is to climate perturbation, production and trade.

Although food prices fell from their peaks in the final months of 2008, they have remained above the long-term trend and are likely to remain so for the foreseeable future. This has accelerated debate about contested land and water resources, including acquisition and ownership of African land by non-African institutes and agencies.

The past decade has also seen greater focus on the potential impacts of climate change on the various regions of Africa. This is particularly relevant for *icipe* as strategies developed by it to target and harness insects and related arthropods are bound to be impacted by range expansions and adaptation to new environments.

At the local scale, African smallholder farmers still struggle to access knowledge and technologies that they can afford, adapt and adopt to improve their income and lives at the same level that smallholder farmers have been able to do elsewhere in the tropical world. Research for development must continue to focus on ensuring that technologies are made available. Development investment must also be matched by ideas and actions that support adoption and provide development outcomes for smallholder farmers and the associated value chain participants.

At the same time, Africa today has a wealth of opportunity that has emerged, and it is in a better position to seize those opportunities. African education at all levels continues to improve, as does the number and quality of African scientists. Trade barriers are being dismantled and the challenges associated with supply of land and water is also spurring innovations to make agriculture more efficient.

Thomas Odhiambo recognised more than 40 years ago that science and innovation are at the heart of Africa’s future and that science would provide Africa with new ways to overcome its many challenges.

In many ways, Africa’s challenges are now more acute than ever before, but the continent has also advanced to the point where solutions are more attainable, thanks to rapid advances in science and an expanding indigenous African research and development community.

These challenges and opportunities have driven *icipe*’s strategy and investment over the past four decades. They will continue to do so as *icipe* approaches its 50-year anniversary in 2020.



Thomas Risley Odhiambo

*“Only scientific research will bring Africa to a position where it can control its destiny.”
(Thomas Odhiambo, Founder and First Director General of icipe)*

Section 2: *icipe* and what we do

Box 2.1: Why study insects and arthropods?

Insects pose major challenges to the human, environmental, livestock and crop health of Africa. Insects damage food, destroying about half of all harvested food in storage and often causing the loss of entire crops. The 'old' tropical insect vector-borne diseases of humans – malaria, dengue fever and other arboviruses, and leishmaniasis – are making a dramatic comeback on the continent, and African livestock succumb in their millions to insect- and tick-borne diseases, resulting in losses of milk, meat and traction power, with several billion dollars' worth in direct economic losses every year.

However, insects and arthropods also play beneficial roles thanks to their rich biodiversity, including ecosystem services such as degradation of organic matter, control of pests and diseases, and pollination of crops. They also provide us with food, feed, textiles, waxes and numerous other products.

icipe's institutional focus jointly recognises that pests and disease vectors on the continent are invariably linked to the vicious cycle of climate change and variability, poverty, food insecurity, and poor human and livestock health and that the systems that humans depend on are not sustainable without the contribution of insects and arthropods.

icipe was founded in Kenya in 1970 to focus on insect-based research for African challenges. That specific, tight focus was in recognition of the myriad of substantial challenges that insects and related arthropods pose for Africa and the tropics more generally (Box 2.1), and the parallel recognition that these challenges were not, and would not, be adequately addressed by scientists and research institutes overseas.

icipe is about much more than insects; rather it is about science and technology, development and capacity building. Insects and other arthropods such as ticks, mites and spiders, as well as nematodes are at the very heart of many challenges being experienced by resource-poor African communities. Yet these challenges are counter-balanced to some extent by the opportunities arising from insect conservation, their value as providers of ecosystem services and other forms of utilisation. In fact, the rich beneficial arthropod resources of Africa are among the most underutilised and threatened in the world.

icipe's history as an independent international research institute with partnerships across Africa and internationally, its research and capacity building foci make it unique. *icipe* has maintained its mission (Box 2.2) since inception. With more than 400 staff and an annual budget of USD 35 million, *icipe* is now one of the main agricultural and biological research institutes in Africa.



R&D—FRUIT FLY IPM: Methyl eugenol catches of *Bactrocera invadens* in citrus orchard in Embu, Kenya. Methyl eugenol is used in combination with protein baits, biopesticides, orchard sanitation and parasitoids in an IPM strategy for management of fruit flies in fruits and vegetables.

–Photo: *icipe*.

icipe's policy, strategy and overall governance, including finance, is overseen by its Executive Council with the Director General being an ex-officio member of the Council. The other 12 members are drawn from the worldwide community of scientists, academia and relevant professionals, who are selected taking into account geographical representation, knowledge of the scientific disciplines relevant to the work of *icipe* and expertise in institutional and financial management.

A major undertaking for *icipe* has been to map its vision and strategy for the next seven years. With that in mind the *icipe* Governing Council initiated an external review in 2012. While generally applauding *icipe*'s achievements, that review made a series of recommendations (Box 2.3). The strategy presented herein recognises *icipe*'s unique history and past successes, and responds to the key recommendations arising from the review.



NEW TOOLS AND STRATEGIES FOR PEST MANAGEMENT: Climate-smart push-pull was developed to withstand long droughts and high temperatures in 2011 and introduced to farmers the following year. From a preliminary 100 climate-smart push-pull farmers in 2012, over 30,000 smallholder farmers in the eastern African countries of Kenya, Uganda, Tanzania and Ethiopia (with more than 50% women participation) have adopted the technology. Unlike the tall and tough Napier grass used in the conventional push-pull, *Bracharia* grass is soft enough for the women to harvest for fodder. –Photo: *icipe*.

Box 2.2: Mission statement

icipe's mission is to help alleviate poverty, ensure food security and improve the overall health status of peoples of the tropics by developing and extending management tools and strategies for harmful and useful arthropods, while preserving the natural resource base through research and capacity building.

Box 2.3: Key recommendations from the external review

- Adopt a more systems approach to the research by:
 - Taking advantage of *icipe*'s 4-H themes to build a One Health approach,
 - Employing stronger consideration of whole value chains rather than only on-farm or postharvest foci;
- Focus more on development outcomes;
- Build socio-economics capability; and
- Expand *icipe*'s influence more strongly into other parts of sub-Saharan Africa.

Section 3: Our people

Of *icipe*'s 481 staff (as of June, 2014), 332 are based in Nairobi, Kenya at the Duduville Campus, 107 at the Mbita Campus in western Kenya, and a further 42 elsewhere in Africa including Ethiopia, Ghana, Uganda and Zimbabwe. Fifty-six percent (56%) are research and technical staff and the remainder form *icipe*'s outstanding support team. Our solid foundations in entomology are underpinned by the science disciplines of chemical ecology, molecular biology and biotechnology, insect pathology, taxonomy and systematics, ecology, earth observation and GIS, biostatistics and the social sciences. These skills are applied across the four research themes that *icipe* uses to focus its R4D portfolio.

Both our technical and support teams have diverse staff profiles. Thirty-four percent (34%) of *icipe*'s total staff members are women and that figure is even higher (38%) for the research and technical positions. Forty-five percent (45%) of the most senior scientists at *icipe* are women and 77% of the professional staff members are African.

In addition to *icipe*'s research, technical and support staff, there are, in 2014, 118 postgraduate and postdoctoral fellows being supported by *icipe*'s various capacity building and institutional development programmes. The current postgraduate fellows are just the latest group to undertake their training since *icipe* commenced its key role in building science capability in Africa in 1983. Between 1983 and 2012, 662 postgraduates (PhDs and MScs) from 30 African countries have completed their training primarily through the African Regional Postgraduate Programme in Insect Science (ARPPIS). The vast majority of these graduates (approximately 95 percent) are today employed in research roles across Africa with about 20% of the ARPPIS alumni being women.

Box 3.1: Segenet Kelemu

Segenet Kelemu, Director General of icipe, is internationally recognised for her ground-breaking research on endophytes in tropical grasses, and her research leadership and dedication to building African science capability. In 2006, she received the prestigious Friendship Award granted by the State Administration of Foreign Experts Affairs, authorised by the State Council of the People's Republic of China for outstanding contributions to China's economic and social development. She was the first African to receive the 2011 World Academy of Sciences (TWAS) Prize for Agricultural Sciences, shared jointly with icipe's Zeyaur Khan. Most recently, Dr Kelemu was named the 2014 L'Oréal-UNESCO For Women in Science Laureate for Africa and the Arab States, and in May 2014, she was listed as one of the top 100 most influential African women by Forbes Africa magazine.



Segenet Kelemu

Our scientists are recognised in Africa and internationally (Boxes 3.1–3.4). Over the past seven years, several have received various prestigious awards. Zeyaur Khan was a recipient of the 2011 World Academy of Sciences (TWAS) Prize for Agricultural Sciences for his discovery and wide-scale implementation of Push–Pull Technology, a pro-poor scientific innovation for enhancing food security and environmental sustainability in Africa. This prize was shared by Segenet Kelemu, at that time the Director of the Biosciences Eastern and Central Africa (BecA) Hub at the International Livestock Research Institute (ILRI), for her discovery of beneficial endophytic fungi and bacteria in the most economically important tropical forage grass family *Brachiaria* and for her outstanding contribution to our understanding of their roles in plant development and environmental fitness. Segenet Kelemu and Baldwyn Torto were elected Fellows of the African Academy of Sciences (AAS) in 2013.

It is not only *icipe*'s research team that has had such an outstanding record. *icipe*'s research is underpinned by an exceptional research support team in finance and administration, information technology, communications and physical/plant services.

A more comprehensive measure of the quality and impact of *icipe*'s published research is its citation record. Citations since inception in 1970 stand at over 36,000, but since 2009, the numbers are 17,880 with an h-index of 48. These indices demonstrate the growing and outstanding international contribution *icipe*'s research has made over the past 5 years. This science quality, together with an annual portfolio of research projects and over 100 partnerships, places *icipe* at the forefront of not only insect-related research in Africa but also globally.

Box 3.2: David Tchouassi

David obtained his PhD in 2013 as an *icipe* ARPPIS Scholar and was subsequently appointed as an *icipe* research scientist. He applies chemical and behavioural ecology, population genetics, taxonomy and arbovirology to the understanding of vector–pathogen–host interactions. David was the recipient of *icipe*'s Governing Council 2013 Research Award for his paper “Common host-derived chemicals increase catches of disease-transmitting mosquitoes and can improve early warning systems for Rift Valley fever virus” and was the recipient of the Young Investigator Award at the 61st Annual Meeting of The American Society of Tropical Medicine and Hygiene, held in Atlanta in the United States in November 2012.



David Tchouassi

Box 3.3: Sunday Ekesi

Sunday Ekesi leads *icipe*'s Plant Health theme and a continent-wide initiative on integrated management of fruit flies, which threaten the production and export of fruits and vegetables to lucrative markets.

Sunday identified the entomopathogenic fungus *Metarhizium anisopliae* isolate ICiPE 69 and led its subsequent development as a biopesticide (commercialised and marketed as Campaign® and Real *Metarhizium* 69® by Real IPM Ltd) for the management of thrips, mealybugs and fruit flies on a variety of crops. This product has been used on more than 19,000 hectares of farmland by more than 20,000 farmers across Africa.

A former Rothamsted International Fellow based in the United Kingdom, Sunday is the author of more than 70 peer-reviewed publications, nine book chapters and an awardee of over 30 successful grant proposals. Sunday sits on various international advisory and consultancy panels for the Food and Agriculture Organization of the United Nations (FAO), the International Atomic Energy Agency (IAEA), the World Bank and regional projects on fruit flies and edible insect related issues.



Sunday Ekesi

Box 3.4: Annah Njui

Annah Njui is *icipe*'s Grants, Partnerships and Projects Manager and oversees a portfolio of over eighty research projects. Annah provides “cradle-to-grave management” of the Centre’s research grants starting with proposal pipeline management in collaboration with *icipe* scientists and senior management, grants negotiation, contracting, compliance monitoring, and closeout. All of these functions are critical in ensuring compliance and delivery for *icipe*, its partners and donors.

icipe has adopted Results Based Management (RBM) as its planning and reporting tool and Annah leads the operationalisation and monitoring of the Centre’s RBM. The RBM—a performance management system that provides a clear framework for setting priorities, allocating resources and assessing results—helps the Centre and its donors better understand, plan, and report the impact of its work.

Annah and her colleagues’ overall support is a key factor in ensuring *icipe*'s research programme delivers the scientific, capacity building and development outcomes upon which *icipe*'s success is built.



Annah Njui

Section 4: Our structure and achievements

icipe delivers into four research themes which are defined by their intended outcomes; **Human Health, Animal Health, Plant Health and Environmental Health. Capacity Building and Institutional Development** is underpinned strongly in the four research themes with an outstanding programme for postgraduate training for Africa. These themes have a long history of delivering high-quality science and development outcomes. Each theme addresses major issues for Africa, such as malaria control, management of the parasitic weed *Striga* in cereals, control of a range of crop pests through development of biopesticides and other strategies, and control of tsetse flies and trypanosomiasis in livestock.

However, the research portfolio is not just about controlling diseases and reducing losses in production, but where appropriate it encompasses the entire value chain. The portfolios have a number of projects which look to build incomes and better livelihoods via the direct benefits of insects, such as beekeeping, silkworm farming and innovative new projects focusing on insects as food and feed, which harness the rapid and efficient growth and reproduction of suitable insect species.

As highlighted below, all themes match their focus on science and innovation with a parallel commitment to making a difference on the ground by employing diverse combinations of technology transfer models, partnerships,

training and communication to encourage adoption and improve livelihoods.

Box 4.1: Management of on- and off-host ticks using three ecofriendly technologies

icipe has developed simple, sustainable technologies for on-farm management of ticks and the diseases they cause. These management strategies are based on the use of biopesticides, botanicals and the behavioral manipulation of the cues that ticks use to find their hosts, targeting on- and off-host ticks.



TSETSE REPELLENT COLLAR: *icipe* is working with business partners to optimise and mass-produce these prototype tsetse repellent collars into commercial products that herders can use independently. –*Photo: icipe.*

Animal Health: This theme's goals are the development of tools and strategies that will control livestock disease by managing the two major vectors affecting livestock productivity in sub-Saharan Africa: the tsetse fly, vector of animal and human African trypanosomiasis, and ticks, which are vectors of many important animal diseases.

Box 4.2: Tsetse repellent technology for animal health

icipe's tsetse repellent technology is ready to be rolled out to tsetse-affected countries in sub-Saharan Africa in collaboration with other regional and continental initiatives. *icipe's* focus is now evolving to transferring the technology know-how to entrepreneurs in public-private partnerships that will make the technology commercially available where it is needed by livestock keepers in pastoral and agropastoral areas of Africa and also by people in areas where sleeping sickness is endemic. Further research will involve evaluating the technology for key vectors of human sleeping sickness.

Our research continues to deliver integrated pest management tools that enable farmers to control these major disease vectors by deliberately altering a few sensitive ecological parameters (Box 4.1). For example, *icipe's* well-known Ngu tsetse trap uses odour baits and potent repellents for biological control of tsetse flies.

In addition to the biophysical research, this theme has achieved considerable success in delivering on-the-ground impact in rural communities. It has done this by empowering communities and by building management and organisational capacity within *icipe* for successful implementation of disease prevention and control in the rural setting (Box 4.2). The theme's achievements in combining innovative research with community capacity strengthening are an outstanding example of *icipe's* mission of delivering benefits to the rural communities.

Plant Health: The activities in *icipe*'s Plant Health theme contribute to improving nutrition and food security through the introduction of integrated pest management (IPM) options for pre- and postharvest pests and parasitic weeds using predators, parasitoids, microbials and habitat management strategies. As with other themes, the technologies are always developed with national, regional and international research partners and in consultation with farmers and rural communities to ensure an innovation is not only effective, but is also affordable and usable by resource-limited smallholder farming systems.

Research in the Plant Health theme covers four domains:

- The **Staple Food Crop Pests** component is built on habitat management and biological control programmes for cereal pests and IPM of grain legume pests;
- **Horticultural Crops Pests'** priorities include pest management programmes for vegetables and fruits;
- **Commercial Farming Crop Pests** focuses on managing pests and diseases of coffee, cotton, cashew, sugarcane, cocoa and coconut;
- **Postharvest Pests and Mycotoxins** focuses on postharvest pest and disease management technologies for staple, horticultural and commercial crops.

Some of the successes under *icipe*'s Plant Health theme include the innovative **push-pull strategy** (Box 4.3) which simultaneously combats stemborers, the devastating parasitic weed *Striga* and improves soil fertility in cereal crops, and the development and scale-out of fruit fly IPM technologies in fruit production some of which have arisen from the theme's arthropod pathogen bioprospecting. Bioprospecting has identified a range of fungal isolates that underpin research strategies for controlling thrips, fruit flies, mites and aphids on fruits, vegetables and legumes. These discoveries are also the cornerstone of outstanding examples of *icipe*'s public-private sector partnerships for the delivery of technologies that provide concrete benefits to rural communities. For instance, the commercially available biopesticides Campaign®, Achieve® and Real Metarhizium 69® are all research products by *icipe*. These are being delivered through a Kenyan-based company, Real IPM Ltd, which manufactures, packages and distributes the products and provides appropriate training through a network of agribusiness dealers in several African countries.



LOWER IMPACT OF ARTHROPOD PESTS: The larva of *Chilo partellus* inside maize stem. The Push-pull technology is preventing crop losses from stemborers in eastern Africa, with increase in cereal harvests enough to feed an additional 27 million people in the East African region. –Photo: *icipe*.

Box 4.3: Push-pull: A novel farming technology for food security in sub-Saharan Africa

Push-pull is a novel habitat management technology that simultaneously combats stemborers and the parasitic Striga weed and improves soil fertility in cereal crop farming systems. It involves repelling stemborers from the cereal crop by intercropping with Desmodium spp. (push) and simultaneously attracting them to a trap plant, such as Napier grass (pull), planted as a border crop. Desmodium intercrops suppress Striga through an allelopathic mechanism, with the root exudates containing novel flavonoid compounds which stimulate suicidal germination of Striga seeds, dramatically inhibiting their attachment to host roots. Both companion crops provide valuable forage for farm animals while Desmodium spp. a legume, also improves soil fertility. The technology fits well with traditional mixed cropping systems in Africa, and has recently been adapted to drier conditions by incorporating drought-tolerant companion plants. To date it has been adopted by some 90,000 smallholder farmers in eastern Africa, where maize yields have increased from less than one tonne per hectare to more than three and a half tonnes per hectare, achieved with minimal inputs.

Human Health: Vector-borne diseases remain a significant public health problem throughout sub-Saharan Africa. Diseases such as malaria, leishmaniasis, human sleeping sickness, river blindness (onchocerciasis) and bilharzia (schistosomiasis) are among the most prevalent parasitic diseases in Africa. In addition, some arboviruses such as dengue, yellow fever, West Nile virus, chikungunya virus and Rift Valley fever are mainly mosquito-borne. These diseases affect both lifestyle and productivity.

icipe's Human Health theme has developed a range of integrated vector management (IVM) strategies for different ecological zones and settings that reduce the efficacy of the arthropod vectors to spread disease through a better understanding of their ecology and behaviour. *icipe* has also played a key regional role through closer engagement with the World Health Organization's Regional Office for Africa (WHO/AFRO)'s initiatives to improve

Box 4.4: Mosquito early warning and elimination systems

icipe has developed improved monitoring and vector-borne disease early warning systems tools for major mosquito disease vectors based on odours derived from humans, animals and plants.

icipe is working with Wageningen University to demonstrate proof of principle for the elimination of malaria from Rusinga Island in western Kenya. This involves more than 4000 households using the combined strategies of insecticide-treated bednets, mass trapping of mosquito vectors using odour-baited traps and individual case management of malaria cases.



A HEALTHY POPULATION: The mass-trapping of *Anopheles* mosquitoes using the newly developed Suna trap, a name derived from the Luo language for mosquito, for malaria control on Rusinga Island on Lake Victoria in western Kenya is expected to have a major impact on mosquito populations on the Island. –Photo: *icipe*.

Box 4.5: Use of biopesticides and naturally derived compounds as green alternatives to vector control

Key to *icipe*'s vector control tools is the use of biopesticides and naturally derived chemicals for disease control. The scale-out of these tools is being underpinned by an aligned capacity-building programme that is training staff at national and local levels to implement and manage the IVM programmes; importantly, strengthen collaboration within the health sector and with others whose actions and policies have key implications for vector control. So far, these IVM strategies have been implemented in more than 10,000 households in Kenya and Ethiopia.

national and regional vector control capability and through supporting national research and teaching networks in Africa.

For several decades since the 1970s, little attention was paid to vector control, and that inaction contributed to decreased productivity and regional growth across tropical Africa. However, since 2000, there has been a growing global commitment to control vector-borne diseases. *icipe*'s Human Health theme is a significant contributor to this renewed commitment and has provided new strategies that monitor and control vectors to break the cycles of transmission (Box 4.4).

icipe has developed innovative odour-baited field traps for vector monitoring programmes which also help to control low-density mosquito populations (Box 4.4). As part of its systemic approach to control strategies, *icipe* is also investigating the growing vector resistance in a family of insecticides used in indoor residual spraying and for treating bednets and developing environmentally benign biopesticides that can serve as effective alternatives to synthetic chemical insecticides (Box 4.5).

Environmental Health: The African ecosystem is facing major challenges through loss of habitat, as well as plant and animal biodiversity that provide crucial ecosystem services such as nutrient cycling, climate and disease regulation, carbon sequestration and pollination. *icipe*'s Environmental Health theme seeks to enhance food security, health and incomes of people in Africa through research that links biodiversity and its conservation with ecological function and sustainable utilisation of resources.

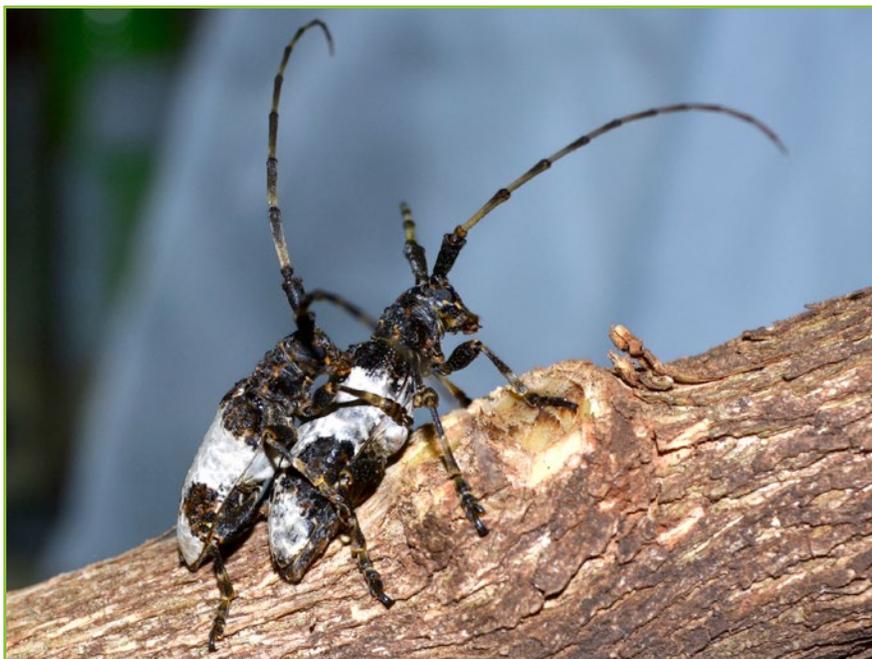
Current research includes:

- Cataloguing biodiversity and understanding how arthropod agrobiodiversity and wild habitats support agricultural production and human health through ecosystem services, and quantifying those benefits;
- Establishing modern apiculture and sericulture practices as significant contributors to rural livelihoods;
- Conserving pollinators' biodiversity for food security and environmental protection;
- Bioprospecting to develop new natural products from plants and insects for the benefit of rural communities and consumers; and
- Generating information on the impact of climate change on ecosystem services and food security (Box 4.6).

Box 4.6: Study on impacts of climate variability and change on pollinators, insect pests and natural enemies

Climate Change Impacts on Ecosystem Services and Food Security in Eastern Africa (CHIESA) Project (2011–2015) generates knowledge on the impacts of climate variability and change on pollinators, insect pests and natural enemies in the montane forest ecosystems of Kenya, Tanzania and Ethiopia. Species ecophysiological and reproductive responses to changing temperatures are documented and developed further into predictive models and risk maps to support adaptation initiatives, such as integrated pest management.

This theme's research on the potential of stingless bees and wild silkworms for commercial applications adds to *icipe*'s capacity building efforts in traditional apiculture and sericulture and supports community-driven enterprises in both areas. This theme has also had considerable success in identifying and isolating naturally occurring compounds that can be used in pest and disease management. Of particular note is the development of plant-derived products that can control mosquito larvae in stagnant water.



RISKS AND IMPACTS OF CLIMATE AND LAND USE CHANGE ON AGROECOSYSTEMS: Coffee plays a pivotal role in the economies of three East African countries—Kenya, Ethiopia and Tanzania. The *icipe* climate change project aims to reveal the impacts on the production and productivity of four key crops grown in these countries, including coffee, and the relationship between or status of their insect pests, natural enemies, pathogens, pollinators, soil engineers, decomposers, etc. Here, a pair of coffee white stemborer adults, the leading challenge to pest management in coffee in the sub-region, is seen on a coffee trunk. – Photo: *icipe/ CIRAD.*

Capacity Building and Institutional Development: Building capacity of people and institutions has been a core commitment of *icipe* since its establishment, mainly through the development of MSc, PhD and postdoctoral capabilities. The focus on postgraduate skills reflects *icipe*'s and CAADP's principles of building capacity so that national and subregional R&D innovation systems can undertake their own R&D programmes and deliver on-the-ground impacts for Africa.

Training at the postgraduate level is provided through the African Regional Postgraduate Programme in Insect Science (ARPPIS) and the Dissertation Research Internship Programme (DRIP). ARPPIS, established in 1983, is a partnership programme with African universities to give young African scientists the opportunity to undertake postgraduate study on beneficial insects and also on insect pests and vectors that threaten health and food security in Africa. The ARPPIS two-year master's programme is hosted at universities within three subregions of Africa (West Africa: University of Ghana in Accra; Eastern Africa: Addis Ababa University in Ethiopia; and Southern Africa: University of Zimbabwe), while the ARPPIS Regional Doctoral Programme is a three-year programme hosted at *icipe* that enrolls seven or eight PhD research scholars annually. These programmes not only provide capacity strengthening but also add new research capacity to *icipe* with some outstanding scientific discoveries emanating from the programmes (Boxes 4.7 and 4.8).

The DRIP programme has a wider entry and participation and encourages university postgraduate scholars from developing and developed countries to undertake training at both MSc and PhD levels, accessing *icipe*'s research facilities and supervision while expanding *icipe*'s global network.

icipe's support for graduates continues well after their formal training. The ARPPIS Scholars Association (ASA) fosters Africa-wide cooperation and networking and provides an ongoing connection between *icipe*, its research and staff. This alumni network is a key forum for personal and institutional capacity strengthening.

The African Association of Insect Scientists (AAIS), which is hosted by *icipe*, also provides a continental platform for exchange of information and experiences with peers working in Africa.

icipe's capacity building programme extends beyond the more formal science education. For many years, it has supported training and capacity building for those who facilitate the adaptation of new technologies and eventually, their adoption. Capacity building is most commonly targeted towards the use of pest and disease vector control technologies through both public and private extension service providers, by providing training



PHD RESEARCH SCHOLARS: Some ARPPIS PhD research scholars at *icipe*, Nairobi, July 2014. –Photo: *icipe*.

Box 4.7: Research on the chemical ecology of insects and plants yields discovery of stemborer-resistant trait in maize

Amanuel Tamiru obtained his PhD in June 2012 as an ARPPIS Scholar. His research on the chemical ecology of insect–plant interactions seeks to identify novel options for pest management. This approach has discovered a naturally occurring stemborer-resistant trait in some maize germplasm that enables plants to effectively defend themselves against these destructive insects. The defence mechanism involves the release of odours (semiochemicals) that attract natural enemies of the pest after the stemborer lays its eggs. The semiochemicals provide a reliable cue for parasitoids to readily locate and kill the stemborer eggs and caterpillars, preventing the crops from being damaged.

His innovative research findings, published in *Ecology Letters* where new developments and most novel researches in ecology are featured, provide a non-toxic and sustainable approach to crop protection while reducing the need for pesticide inputs.

For his outstanding research, Amanuel received the *icipe* Governing Council Award for the best published paper in 2011. He has also been awarded several other grants and awards, including a postdoctoral grant/award from the International Society of Chemical Ecology in 2014, the Rothamsted International African Fellows Award in 2010, the International Foundation for Science Research Grant in 2009, and the German Academic Exchange Service PhD scholarship award in 2008.



Amanuel Tamiru

Box 4.8: Research on mosquito–pathogen–plant interactions reveals why infected mosquitoes seek sugar meals

Vincent Nyasembe is a PhD scholar under the ARPPIS programme whose research targets the ecology of mosquito–pathogen–plant interactions. His penchant for research started with a fellowship from the Consortium for National Health Research (CNHR), Kenya, to undertake an internship programme at *icipe*, after which he received a fellowship from the World Federation of Scientists (Switzerland) and USDA/ARS–Center for Medical, Agricultural and Veterinary Research (CMAVE) to pursue his MSc studies in Medical Entomology at the University of Nairobi (2009–2012). Vincent is currently enrolled for his PhD studies at the University of Pretoria, South Africa, with a Swedish International Development Cooperation Agency fellowship at *icipe*. He recently published an innovative finding on the manipulation of the nectar feeding behaviour of the malaria vector by its *Plasmodium* parasite in the prestigious journal *Current Biology*, and was highlighted in *Nature*. [*Parasite drives host to nectar; Nature 505, 457 (22 January 2014) doi:10.1038/505457b.*]

He has also championed the development of a promising plant-based lure for the management of the malaria vector, the findings published in *PLoS One*. The publication of these findings has won him international recognition and accolades, including an invitation to participate in the Gordon Research Conference entitled “Plant Volatiles—Exploring the Plant Headspace: Functional Analysis and Emerging Applications” held in California in January 2014.



Vincent Nyasembe

directly to farmers. The formal training programmes for adoption address issues across *icipe*’s four themes and training is mostly designed and delivered with national partners as an integral part of *icipe*’s portfolio of research.

The institutional development component of this theme aims to strengthen African organisations and institutions through formal and informal means. Capacity strengthening of the individual contributes to institutional capacity as well, and so the ARPPIS and DRIP programmes and the capacity building associated with technology adaptation and adoption all feeds into institutional development. However, *icipe* also has specific institutional development initiatives. For example, the three ARPPIS MSc Subregional Centres have benefitted from support for equipment and information access, and seven ARPPIS universities have benefitted from increased access to online information through a UNESCO-supported programme negotiated by *icipe* on their behalf.

Section 5: *icipe* – its place in African research and development

As a leader and key centre in Africa's research and innovation systems for more than 40 years, *icipe* consistently endeavours to align itself with major regional research and development policies and initiatives. One of the most important current alignments is through the African Union's CAADP. In 2003 the African Union, under the New Partnership for Africa's Development (NEPAD), launched the CAADP and its four pillars that are designed to underpin regional agricultural development:

- **Pillar 1:** Extending the area under sustainable land management
- **Pillar 2:** Increasing market access through improved rural infrastructure and other trade-related interventions
- **Pillar 3:** Increasing food supply and reducing hunger
- **Pillar 4:** Improving agricultural research, technology dissemination and adoption

icipe fully supports CAADP and its principles and works to align its research themes and priorities with the aims and vision of these pillars.

Under Pillar 2, *icipe*'s research in biosecurity and invasive species supports markets by providing key knowledge via projects that focus on minimising postharvest losses in staple and non-staple crops. A further portfolio of mainly horticultural projects addresses issues of biosecurity and plant quarantine by developing the principles under which regional policies that support trade, transport and market access can be developed and enacted.



FOOD SECURITY: *Callosobruchus maculatus* on green grams. Postharvest losses along value chains of many food commodities are a persistent challenge to achieving food security. Technologies that are well aligned to demand and local product markets are needed so as to enhance food supply and foster sufficiency in nutritious, safe, and healthy food.

–Photo: *icipe*.

Many of *icipe*'s major programmes are strongly aligned with Pillar 3, through *icipe*'s focus on increased crop and animal production through various strategies, including integrated pest management, reduction in postharvest losses, insects for food and feed, and indirectly, through *icipe*'s focus on human health which aims to reduce the impact of poor community health and the ability of farmers to undertake the challenges of farming.

However, *icipe*'s most fundamental support of CAADP is through its role and leadership around Pillar 4. *icipe*'s long history of capacity building in science and technology by partnering with African universities provides young and aspiring researchers with high-quality mentoring that lays a foundation for their careers and subsequently supports research and tertiary training in Africa. The most outstanding example of *icipe*'s achievements in this domain is that one-in-four PhD holders in the Science Faculty at Kenya's Jomo Kenyatta University of Agriculture and Technology (JKUAT) have benefitted from one of *icipe*'s capacity building programmes during their training. *icipe* plays other capacity building roles beyond the postgraduate training with some of its most important being dedicated to capacity building in farming and pastoral communities to enhance and facilitate information flow and uptake of new production technologies resulting from its research.

icipe also distinguishes itself as a regional science leader through its role as co-publisher, with Cambridge University Press, of the *International Journal of Tropical Insect Science*, an international peer-reviewed journal that serves as a forum for original research findings on tropical insects and related arthropods, their management, conservation and utilisation.



CAPACITY BUILDING OF INDIVIDUAL RESEARCHERS AND INSTITUTIONS IN AFRICA: *icipe* has an agenda to address worsening climate change challenges. Sizah Mwalusepo is a PhD student studying insect pests on maize and their natural enemies in a changing climate. –Photo: *icipe*.

Section 6: Capacity building and partnerships with Africa and beyond

icipe is internationally recognised as a key collaborator in international research and development initiatives. *icipe* is one of 15 regional centres of the Stockholm Convention on Persistent Organic Pollutants (POPs) charged with undertaking capacity building and technology transfer in developing member countries to achieve elimination or reduction of the use of POPs. As the African regional centre and because the majority of the POPs are pesticides, *icipe* focuses on capacity building and technology transfer of alternatives to POPs in the management of disease vectors and pests. In 2012, *icipe* was also designated as a Food and Agriculture Organization of the United Nations (FAO) Reference Centre for vectors and vector-borne animal diseases, which include tsetse flies and animal trypanosomiasis, as well as arthropod-transmitted viral animal pathogens.

Partnerships are a crucial part of *icipe*'s research and its influence. It is a founding member of the Africa College together with Leeds University (UK) and the International Institute of Tropical Agriculture (IITA). *icipe* also has several collaborative projects with the Consortium of International Agricultural Centers (CGIAR) including the International Potato Center (CIP), IITA, and the International Maize and Wheat Improvement Center (CIMMYT).

Beyond the CGIAR, *icipe* has long-standing collaborative agreements with the World Vegetable Centre (AVDRC) and participates in the Michigan State University and USAID-funded HortCRSP program.



APPLICATION OF GENOMICS: Improved tsetse management is now within reach following description of the tsetse fly genome. Above is a tsetse fly with its abdomen engorged with blood. – Photo: *icipe*.

icipe has been a founder member of AIRCA—the Association of International Research and Development Centers for Agriculture since 2012. AIRCA is a new association of nine non-CGIAR centres, including CAB International (CABI), Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), The World Vegetable Center (AVRDC), International Center for Biosaline Agriculture (ICBA), The International Centre for Integrated Mountain Development (ICIMOD), International Centre of Insect Physiology and Ecology (*icipe*), The International Fertilizer Development Center (IFDC), International Network for Bamboo and Rattan (INBAR) and Crops for the Future (CFF). In line with *icipe*'s mission, AIRCA focuses on increasing food security by supporting smallholder agriculture and rural enterprise within healthy, sustainable and climate-smart landscapes, with one of the aims being

to provide members with higher visibility within the international donor community and to facilitate and strengthen outside participation in the new CGIAR Research Programmes.

icipe has active collaborative arrangements with some of the highest-ranked universities in the world, in particular in the United States, and across Europe. The strength and longevity of these and other collaborations, some of which have been active for well over a decade, are indicative of the quality of the science being delivered by *icipe*, and the high regard in which it is held by leading international research institutions (Box 6.1).

However, it is perhaps the many and diverse partnerships within Africa that best distinguish *icipe*. Some of the most important are with African apex bodies such as the Forum for Agricultural Research in Africa (FARA) and the African Academy of Sciences (AAS), as well as subregional research organisations (SROs) such as the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the West and



BIOPESTICIDES DEVELOPMENT AND COMMERCIALISATION: Campaign® and Achieve® are research products of *icipe*'s Partnership with Real IPM, a private company in Kenya. –Photo: *icipe*.

Central African Council for Agricultural Research and Development (CORAF/WECARD), CCARDESA and NASRO. A further set of prominent partnerships in Africa has been developed through *icipe*'s long and outstanding history of supporting research, and developing African research capacity in the agricultural and biological sciences. Since 2007, 171 MSc graduates, primarily from Kenya, have been trained at *icipe*, while 157 students (52 ARPPIS full fellowships and 105 DRIP interns) have carried out their PhD studies at *icipe* with co-supervision by *icipe* senior researchers. A further 17 have been engaged at *icipe* as part of its programme to support postdoctoral studies in Africa. These 17 postdoctoral fellows come from seven African countries. This commitment to build research capacity has been developed through partnerships with African universities. Altogether *icipe* has formal partnerships with 34 African universities, with different levels of engagement/collaboration, and it is from these universities that *icipe* sources graduates for its ARPPIS and DRIP programmes. The partnerships with six universities; Pretoria and North-West universities (South Africa), University of Ghana (Ghana), University of Nairobi and Jomo Kenyatta University of Agriculture and Technology (Kenya), and Makerere University (Uganda) are key, through which many of *icipe*'s capacity building programmes are delivered. The ARPPIS graduates are now a sizeable body, and one that fosters research, careers, and has the potential to influence policy on research for development, capacity building and trade. The *icipe* alumni are an outstanding African community that has been built through over more than 30 years of dedicated capacity building and long-lasting commitment by *icipe*'s management, the Governing Council, and donors. *icipe* has developed a platform which aims at tracking all the alumni all over the world to contribute to society: <http://www.arppis-platform.org/>

The most recent emerging partnerships being assembled are those with the private sector as *icipe* further strengthens its commitment to ensuring that innovations and new technologies are adopted for the benefit of communities, the broader private sector and for the region. Over the past five years, *icipe* has adopted public-private partnership models to assist in delivering the outcomes of its research. The most prominent of these is currently that with the Kenyan-based company, Real IPM Ltd, but other similar partnerships have been developed with Morocco's Elephant Vert Company, Kenya's Farm Track Consulting and Kenya Biologics Ltd to deliver various biopesticides and fruit fly attractant products as *icipe* moves to a position of employing a far wider set of partners to ensuring research outputs with the best possible opportunities to be adopted.

Box 6.1: Collaboration with CIRAD and IRD

icipe has a special research partnership with the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) and the Institut de Recherche pour le Développement (IRD), with a number of CIRAD and IRD scientists working in the main programmes of *icipe*.

Thibaud Martin is Director of Research at CIRAD, working on horticultural crop protection to reduce the use of chemical pesticides. Thibaud, based at *icipe* in Nairobi, is a chemist who has extensive experience in entomology and agronomy in cotton and vegetable fields in Central and West Africa, where he spent most of his professional career.

At *icipe*, he leads research on use of agronets for horticultural pest



Thibaud Martin

management, through understanding of insect and mite behaviour, and plant-insect/ insect-insect interactions.

Section 7: *icipe* refocusing strategy for 2013 – 2020

icipe has an enviable record of delivering science and capacity building into Africa's agricultural and biology innovation systems across sub-Saharan Africa. *icipe*'s science is of high quality, and its portfolio unique. However, *icipe* must continuously realign and refocus to maintain and improve on its research capability to take advantage of new research technologies, address emerging challenges and deliver development impacts for Africa.

Africa faces some major challenges such as land use change, habitat fragmentation and as a result, land degradation which results in losses of ecosystem services. Overlaying short-term challenges are the longer time scale projected impacts of climate change that will increasingly affect food security in sub-Saharan Africa. *icipe* recognises that its strategic plan and subsequent research agenda must respond to the impacts of both human- and climate change-induced in order to deliver sustainable solutions for emerging environmental challenges.

In preparing this strategy, *icipe* undertook an external review of its science, impacts and priorities, seeking input from a wide range of its most important stakeholders. The review took account of current and emerging challenges, new technologies and opportunities, *icipe*'s science capability and history of achievement. Thomas Odhiambo's vision that science and innovation are at the heart of Africa's future is central to *icipe* and to its mission to alleviate poverty, ensure food security and improve the overall health status of peoples of the tropics (Box 2.2). In keeping with that mission, the 2013–2020 strategy has as its core a greater focus on delivering development outcomes, a stronger systems approach to our science, and an expansion of our influence more widely in Africa.

In line with the recommendations from this review, *icipe* will maintain its four research themes and its focus on the 4-H Paradigm, continuing to deepen the focal areas of the four themes as outlined in Section 4. It will also continue to expand its successful capacity building and institutional development programmes, such as ARPPIS and DRIP.



EQUITABLE PARTICIPATION: *icipe* and partners have developed Naturub® balm and ointment (inset) from *Ocimum kilimandscharicum*, which is a popular indigenous medicinal herb in western Kenya. Many women have taken up cultivation of the plant. The 'wet' leaves from the herb generate three times the income that farmers previously obtained from the sale of maize. –Photo: *icipe*.

The 2013–2020 Strategic Plan will also implement a number of new initiatives and investments in response to the review recommendations. Some of the most important key new initiatives are summarised below:

Delivering greater impact – Socio-economic capability, impact and gender: Over the next seven years, *icipe* will devote more resources to transferring science outputs, delivering impact and quantifying development outcomes for Africa based on its outstanding biological science achievements. This stronger focus on development outcomes will be achieved through building new skills, implementing a stronger systems approach to our research, and by extending *icipe*'s influence more widely across Africa. To this end, *icipe* will build a stronger socio-economic research team that will strengthen the focus on development outcomes by encouraging a whole-of-system approach. Where appropriate, more emphasis will be placed on a whole-of-value-chain approach for particular commodities and products, and quantification of the economic and livelihood benefits of current and emerging research investments. During 2013–2020 *icipe* will, as a key strategy, place particular

focus on supporting a larger suite of research projects, training and scale-out investments that are designed to benefit women and children either directly or indirectly. This will be achieved by taking gender into consideration at all stages of research design, from setting research priorities to delivery of development outcomes in both the research portfolio and in the institute’s capacity building programmes. *icipe* already has research outcomes which have had enormous impacts on the lives of women. For example, weed and pest management using *icipe*’s push–pull technology benefits women, as it greatly reduces hand weeding – a practice generally undertaken by women in Africa. Similarly, *icipe* supports research and development in silkworm farming and beekeeping, both enterprises that are primarily owned and operated by women.

Multidisciplinary science under the One Health concept:

icipe will take advantage of its established 4-H themes and its strengthened socio-economics capability to embrace a more comprehensive systems approach in its research. Each of the current 4-H themes has delivered under its own banner, but one of the priorities for 2013–2020 will be to build on the 4-H themes and through integration, create a new One Health portfolio of research that enables stronger systems-based development outcomes for Africa that provide benefits for people, their crops and livestock, and the environment (Figure 1). One of the objectives of the social-ecological systems approach is to improve the understanding of disease ecology to prevent spillover from animals to humans for example, to refine our understanding of livelihood practices underpinning disease transmission and to better define mitigation strategies. The approach necessitates transdisciplinary research, community participation, and special consideration of social diversity, including gender. To realise this goal, *icipe* will seek opportunities to expand collaboration across all aspects of healthcare for humans, animals and the environment for more sustainable livelihoods.

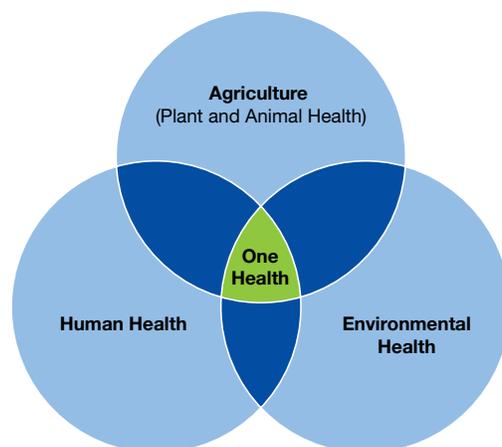


Figure 1. BUILDING ON THE 4 H THEMES TO CREATE A ONE HEALTH MODEL: The One Health option includes parts of the 4-H themes— human, plant, animal and environmental health, with beneficial outcomes for people, their crops and livestock, and the environment.

Human health and integrated vector management: Malaria, dengue and other vector-borne diseases are expected

to be significantly influenced by climate and environmental change. The impacts will, in the first instance, be due to the direct effects of certain climatic factors such as temperature. In the case of malaria, an increase in the ambient temperatures would lead to a corresponding increase in the lifespan of anopheline vector populations; while, at the same time, shortening the incubation period of *Plasmodium* parasites within the mosquitoes. Such changes in entomological parameters will inevitably escalate the transmission of malaria among vulnerable communities. Climate also impacts vector populations and disease epidemiology indirectly, through its influence on



CLIMATE, ENVIRONMENTAL CHANGE AND MALARIA: Because the transmission of malaria is expected to intensify, children (such as these two playing on a bank in Mwea Rice Irrigation Scheme in central Kenya) will be most at risk. –Photo: *icipe*.

human ecology and behaviour. In this regard, changes in agricultural practices, such as expansion of irrigation and increased use of pesticides, are likely to precipitate malarial vectors adjusting to the changing conditions. To address these new challenges, *icipe*'s research will focus on ecosystem-based integrated vector management (IVM) strategies, by building new scientific capability and by considering potential ecological and behavioural changes of vectors in various agricultural and livelihood scenarios. Multisectoral collaboration and transdisciplinary research will be the key to this 'One Health' strategy that will aspire to develop appropriate policies to link science and socio-economic development for Africa. This approach will require improved ecological modelling capability through incorporation of innovative geo-spatial monitoring tools, to explore, for instance, decision support for better IPM practices and interventions, risk of species invasion, impacts of climate change and variability, disease vector control and chemical ecology.

Addressing the threat of emerging infectious diseases: In recent decades, there has been an increase in the number and intensity of emerging infectious diseases (EIDs), with viral diseases such as Severe Acute Respiratory Syndrome (SARS) and avian influenza highlighting the relationships between human and animal health. This increase in infectious diseases is enhanced and compounded by habitat degradation, climate change, increasing population density, and higher trade flows, which brings greater movement of humans and animals across borders. *icipe* recognises these interconnections, and will use its expertise to address One Health research, with contributions from human, animal, environmental (including geospatial, and biodiversity sciences), and plant health, and social sciences.

Animal health and trypanosomiasis: Research on vectors of trypanosomiasis and tick-borne diseases will continue to be the main focus of the animal health theme. New and expanded capability in genomics, bioinformatics, and behavioural and chemical ecology will be used to develop and implement new technologies. The animal health team will build systems-based solutions that can translate improvements made in livestock and human health



CAPACITY TO IDENTIFY AND MONITOR ECONOMICALLY IMPORTANT PESTS: Thrips and the tospoviruses they transmit can cause high losses to value crops such as onions, French beans and tomato. *icipe* scientists have developed user friendly software (insets), that will enhance the capacity of quarantine and agricultural extension officers and researchers for diagnosis and monitoring of invasive and indigenous thrips such as *Megalurothrips sjostedi* (bean flower thrips). Research by *icipe* scientists has also led to the identification of thrips-transmitted tospoviruses such as *Iris yellow spot virus* and tomato yellow ring virus infecting onions and tomato, respectively. –Photo: *icipe*.

to improved food security and poverty reduction. These technology packages will be developed and tested at both the farmer and community levels so as to encourage and enable adoption of technologies. Associated capacity building for vector control specialists, managers in livestock IDVM and producers will continue to be given highest priority to facilitate changes in practice that will be necessary to translate this exciting new science to development outcomes.

As one of the few institutes in Africa working on vectors of trypanosomiasis, *icipe* will continue to develop and optimise technologies for effective integrated control of tsetse flies and the diseases they transmit. The repellent technology developed by *icipe* is ready to be rolled out to several tsetse-affected countries in sub-Saharan Africa, in collaboration with other regional and continental initiatives and in partnership with the African Union’s Inter-African Bureau for Animal Resources (AU-IBAR). The repellent technology will be commercialised through public–private partnerships.

Plant health and IPM: A range of IPM strategies for control of major pests of cereal, horticultural and commercial crops will form the foundation of the Plant Health theme’s work in 2013–2020. The theme will build on the biocontrol of stemborers using their natural enemies (mostly larval endoparasitoids, *Cotesia* spp.), and at the same time investigate mechanisms underlying the host recognition and acceptance by the stemborers and their parasitoids. In grain legumes, the focus will be on managing thrips, with new research to identify semiochemical-based attractants for bean flower thrips and use of novel biopesticide application strategies. In vegetables, *icipe* will elucidate the chemical communication involved between parasitoids, leafminer flies and host plants to improve parasitoid responses to leafminer attacks.

Adoption of fruit fly IPM technologies is directly increasing producer income and generating new livelihood opportunities. By 2020, *icipe* aims to understand and begin to capitalise on the fruit fly responses to kairomones



DISSEMINATION OF RESEARCH FINDINGS: The diamondback moth (DBM), *Plutella xylostella* can destroy a cabbage crop to a level where it is no longer marketable; some strains are resistant to insecticides. *icipe* research has led to the introduction of several DBM natural enemy wasps suited for high, lowland and semi-arid conditions. *icipe* researchers have shared information and knowledge on diamondback moth parasitoids with farmers in Manica district, Mozambique; and the Centre has expanded implementation of the technology to other African countries such as Rwanda, Zambia and Malawi. –Photo: *icipe*.

from host plants and industrial by-products recently developed for attracting fruit flies. Building on recent successes between *icipe* and the private sector, especially with Real IPM Ltd, a producer of biopesticides that are sold across Africa, *icipe* is exploring the possibility of similar arrangements with other private sector companies to bring locally-developed fruit fly attractants to market.

The push–pull technology developed by *icipe* for stemborer and *Striga* control in maize is underpinning new research, with similar models being developed for other crops and climates. Among the most outstanding of these new initiatives is a partnership with Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), which will adapt push–pull IPM strategy for smallholder cotton farms constrained by insect pests in Kenya and northeast Brazil. The habitat management strategy will be based on suitable attractive trap plants and repellent intercrops for cotton bollworm complex in Kenya and cotton boll weevil in northeast Brazil. The chemical ecology of the tritrophic interactions will be investigated while exploiting the innate inducible defence systems through recruitment of effective local natural enemies.

Entomopathogenic fungi (EPF): Considering the increasing interest in the development of EPF-based biopesticides, *icipe* will continue its partnership with the private sector in developing new products with potential markets. Application strategies through dissemination of EPF in crops will be investigated by identifying powerful arthropod attractants (semiochemicals) that are compatible with the microbes. It has been recently discovered that many EPF play additional roles in nature, as endophytes, antagonists of plant pathogens, and even plant growth promoting agents. *icipe* will explore the role of fungal endophytes in plant defence to develop novel biological control agents, and elucidate the underlying mechanisms by which fungi interact with insect hosts and plant pathogens.

Insects for food and feed: Two major constraints to the expansion of the livestock and fish industries are the limited land availability for grain production and the overexploitation of marine habitats, which reduces the abundance of small pelagic forage fish from which fish meal and fish oil are mostly derived. Indeed, the growing scarcity of resources to produce these ingredients has doubled food prices during the last five years because feed cost (representing 60–70% of production costs) is becoming far too prohibitive. It is not sustainable to continue to rely on fishmeal and pulses as protein source in feed production. Insects could provide the solution. To date, insects have not been considered as a sustainable and viable food and feed resource, yet they could make a direct

significant contribution to food security. Entomophagy, the consumption of insects, is common in many countries and it is estimated that about 1900 insect species already form part of the traditional diets of at least 2 billion people worldwide. Therefore, insect farming could make a significant contribution to food security.

The use of insect protein as an alternative to protein sources from fish or plants is potentially both attractive on economic grounds and because they would replace over-exploited feed-sources such as fish. In addition, insects often have higher or comparable protein content than conventional fish and soybean-based feeds. Some prospective feed insects may offer additional benefits by being able to be farmed on organic waste



EDIBLE INSECTS: Winged termites (Order Isoptera) are commonly eaten in Africa. –Photo: *icipe*.

materials with additional significant environmental benefits. A key new addition for *icipe* in the 2013–2020 strategic plan is to comprehensively explore the potential use of insects as an alternative protein source for food and feed, by identifying suitable insect species and their feed sources, and examining cost-effective automated mass-rearing facilities that provide a reliable, stable and safe product. A key component of this research will be to inform policy and the general public on issues of food quality and safety, and the associated environmental benefits and risks.

Refining capacity building and institutional development: While the established ARPPIS and DRIP programmes have helped develop the research careers of over 200 African scientists, *icipe* will expand the programmes geographically within Africa. By 2020 *icipe*'s Capacity Building and Institutional Development (CB&ID) programme will extend much more strongly into West and Central Africa, including Francophone West–Central Africa and into southern African countries, which are currently less well represented.

icipe will broaden its African partnerships, and those with selected institutes of the North. Our capacity building partnerships are primarily with universities but our research programmes are through partnerships with national agricultural and extension systems (NARES), medical institutes, NGOs and a small number of private companies. Over the next seven years *icipe* will expand this network to more strongly include NARS, subregional organisations (such as ASARECA, CORAF-WECARD, NASRO and CCARDESA) and a wider range of key development partners, especially partners that can undertake key roles in delivering development outcomes. It will also broaden its scope of universities and research institutes not only in Africa but also build partnerships with a select set of universities and R4D agencies from the developed world.

In developing a revised human and institutional capacity strengthening plan, *icipe* not only recognised the need to deliver both formal and informal training, but to broaden its target audience to better incorporate the needs from across value chains in addition to its more customary focus on the African innovation systems. *icipe*'s programmes and projects from 2013 to 2020 will place greater emphasis on assisting their partners through



INCREASING AGRICULTURAL PRODUCTION FOR MORE NUTRITION: *Bactrocera invadens* invaded Africa from Sri Lanka in Asia. Detected in Kenya and Tanzania in 2003, this fruit fly has migrated through the movement of infested mango and other host fruits to many countries in West and Central Africa. Shepard Ndlela is a PhD student working on development and implementation of pre- and postharvest management measures for control of *B. invadens* on mango. These include release of parasitoids and use of food baits to control fruit flies in the field, and hot water treatment of harvested mangoes. –Photo: *icipe*.



PRESERVING BIODIVERSITY AND ENVIRONMENTAL SUSTAINABILITY IN WESTERN KENYA: Kakamega women farmers harvesting honey from stingless bees *Hypotrigona gribodoi* hive. *icipe* has trained farmers in the meliponary culture of stingless beekeeping and improved their knowledge to use bees for pollinating their horticultural and agricultural crops. –Photo: *icipe*.

training of trainers and working with qualified institutions, NGOs and the private sector in delivering training.

In October 2012, an independent review of the CB&ID programme recommended that capacity strengthening be confined to three result areas: (a) capacity building and professional development of African scientists and professionals; (b) institutional development by nurturing and strengthening of African higher education institutions (including existing *icipe* subregional centres) and (c) promoting innovation on insect science in collaboration with regional and national agricultural research and advisory services and the private sector. *icipe* has adopted these recommendations and is currently modifying its CB&ID theme to operationalise these changes during the 2013–2020 period. A key component of this will be a new comprehensive monitoring and evaluation plan that will enable *icipe* and its stakeholders to value the long-term investment in capacity strengthening, in all its forms and for all its various target groups, in Africa.

icipe has initiated a strategic plan to modernise its research and development infrastructure through construction of new, and renovation of existing, research facilities.

With generous support from the European Union, the construction of an African central reference laboratory for bee pests and diseases commenced in mid-2013 at *icipe*'s headquarters, as well as at four bee health satellite stations in Burkina Faso, Cameroon, Ethiopia and Liberia. *icipe*'s new Martin Lüscher Emerging Infectious Diseases Laboratory, also in Nairobi, which includes a Biosafety Level 3 laboratory, will be completed in 2014.

The major upgrades in facilities planned for 2013–2020 include those of the Mosquito and Tsetse insectaries at Thomas Odhiambo Research Station, the Centre's main outpost located on the shores of Lake Victoria, and a series of research laboratory upgrades at Headquarters in Nairobi.

Finally, thanks to the Swiss Agency for Development and Cooperation (SDC), *icipe* is embarking on a 'Greening *icipe*' programme. Over the next seven years, *icipe* will reduce its environmental impact through the adoption of a range of measures to reduce its consumption of resources, and commence harvesting and using its own solar energy and rainwater.

Section 8: **Implementation and success: What would be the successful implementation of this strategic plan in 2020?**

By 2020, *icipe*'s new strategic plan will be assessed as successful if it has achieved the following primary goals of science: (a) having delivered measurable development impacts for rural communities through adoption of new technologies across sub-Saharan Africa, and (b) having demonstrated that our science has been translated to new food and nutritional security, biosecurity and health policies for Africa and the tropics in general. The areas of policy development and trade, and trade barriers are crucial for biosecurity research and *icipe* in Africa.

Additionally, enhancement of *icipe*'s capacity building roles, and stronger focus across sub-Saharan Africa in particular, will also be key to our success over the next seven-year period in relation to the CB&ID programme. While the wider geographic spread is a key part of the new strategy, another is the furthering of partnerships in Africa and beyond, especially with the North to enhance Africa's access to the best possible science, innovations and mentoring.

Our success will be further judged by our science quality and, through building new capability in socio-economics and ecology, and by our scientific base being recognised as being far broader and more systems oriented.

To measure our science and development outcomes *icipe* will, over the course of this strategic plan period, invest in both internal and external evaluations and reviews that will provide the evidence of our success, and importantly, the key learning on how we, as a research for development institute can continuously improve the lives of African rural communities.

Abbreviations and Acronyms

AAIS	African Association of Insect Scientists
AAS	African Academy of Sciences
AIRCA	Association of International Research and Development Centers for Agriculture
ARPPIS	African Regional Postgraduate Programme in Insect Science
Arbovirus	arthropod-borne virus
ASA	ARPPIS Scholars Association
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AU-IBAR	African Union's Inter-African Bureau for Animal Resources
AVDRC	The World Vegetable Center (Shanhua, Tainan, Taiwan)
CAADP	Comprehensive Africa Agriculture Development Programme
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza (Cartago, Costa Rica)
CB&ID	Capacity Building and Institutional Development Programme
CCARDESA	The Centre for Coordination of Agricultural Research and Development in Southern Africa
CFF	Crops for the Future (Selangor, Malaysia)
CIMMYT	The International Maize and Wheat Improvement Center (Mexico DF, Mexico)
CIP	International Potato Centre (Lima, Peru)
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CNHR	Consortium for National Health Research (Nairobi, Kenya)
CORAF/WECARD	West and Central African Council for Agricultural Research and Development
DAAD	German Academic Exchange Service
DRIP	Dissertation Research Internship Programme
EIDs	emerging infectious diseases
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária
EPF	entomopathogenic fungi
FAO	The Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
GIS	Geographic information system
IAEA	The International Atomic Energy Agency
ICBA	International Center for Biosaline Agriculture (Dubai, United Arab Emirates)

ICIMOD	The International Centre for Integrated Mountain Development (Kathmandu, Nepal)
IDVM	integrated disease and vector management
IFDC	The International Fertilizer Development Center
IFS	International Foundation for Science
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute (Nairobi, Kenya)
INBAR	International Network for Bamboo and Rattan (Beijing, China)
IPM	integrated pest management
IRD	Institut de Recherche pour le Développement
ISCE	International Society of Chemical Ecology
IVM	integrated vector management
JKUAT	Jomo Kenyatta University of Agriculture and Technology
LMF	leafminer flies
NARES	national agriculture research and extension systems
NARS	national agricultural research system
NASRO	North Africa Sub-Regional Research Organization
NEPAD	New Partnership for Africa's Development
NGO	non-governmental organisation
POPs	persistent organic pollutants
R&D	research and development
R4D	Research for development
RBM	Results Based Management
SARS	Severe Acute Respiratory Syndrome
Sida	Swedish International Development Cooperation Agency
SSA	sub-Saharan Africa
TRO	Thomas Risley Odhiambo
TWAS	The World Academy of Sciences
UNESCO	The United Nations Educational, Scientific and Cultural Organization
USAID	The United States Agency for International Development
USDA/ARS - CMAVE	United States Department of Agriculture/Agricultural Research Service - Center for Medical, Agricultural and Veterinary Entomology
WB	The World Bank
WHO/AFRO	World Health Organization Regional Office for Africa

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Vision and Strategy 2013-2020

Addressing Africa's Challenges and Opportunities

icipe – Working in Africa for Africa

icipe – African Insect Science for Food and Health – was established in 1970 in direct response to the need for alternative and environmentally friendly pest and vector management strategies. Headquartered in Nairobi, Kenya, *icipe* is mandated to conduct research and develop methods for pest control that are effective, selective, non-polluting, non-resistance inducing, and affordable to resource-limited rural and urban communities. *icipe*'s mandate further extends to the conservation and utilisation of Africa's rich insect biodiversity.

icipe focuses on sustainable development, including human health, as the basis for development, and the environment, as the foundation for sustainability. Working through a holistic and integrated approach through the 4H paradigm – Human, Animal, Plant and Environmental Health – *icipe* aims at improving the overall well-being of communities in tropical Africa by addressing the interlinked problems of poverty, poor health, low agricultural productivity and degradation of the environment.



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