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EXTERNAL R&D REVIEW 2002 – 2007

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African Insect Science for Food and Health

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FOREWORD

External reviews of research institutes have become current practice during the last two decades. Despite the different objectives of such reviews, e.g. to analyse and monitor strengths and weaknesses of management, overall strategies, financial status and policy, programmes and research projects, the overall goals of reviews should be to improve performance and competitiveness of Centres like *icipe* in a changing world. A multitude of factors such as funding policies of donors, stakeholder demands and recognition of emerging problems may have strong impacts on strategic decisions, structures and programme priorities of research Centres like *icipe*. The last review of *icipe* was accomplished in 2002. The objectives were to analyse the strategy of the Centre and to contribute to the strategic planning for the next five to ten years. The present review was commissioned by the Governing Council (GC) in accordance with the Sponsoring Group of *icipe* (SGI). The goals are to analyse the research and capacity building programmes and to realign programme priorities and the implementation agenda. (More details are given in the terms of reference in Annex 1.)

It is important to underline that this review has put emphasis on evaluating principal research projects, training and capacity building programmes, technology transfer mechanisms and impacts in the field. Based on our analyses we have attempted to formulate our views, draw conclusions and express general and specific recommendations which we offer to the management and staff of *icipe*, to the GC and the SGI. We hope that our review will contribute to the development of new and improved programmes that may better comply with the changing demands and hopefully strengthen *icipe*'s comparative advantages. We do not claim to be complete in all respects in the evaluation, nor do we believe that all our recommendations can be taken up and implemented immediately and without challenges. One of our goals was also to bring up new ideas and views which might be taken up, discussed and, if considered interesting, followed-up and adopted to suit circumstances of the Centre. We also acknowledge that a few weeks' work, although intensive, is not enough to see and understand everything about *icipe*. Thus, there will certainly be things we have missed and misunderstood.

The review was made by three different people (see CVs), all with different academic and societal backgrounds and professional careers. It is obvious that individual value judgements and priorities are not necessarily identical and, although the team was very small, these differences have created a broad spectrum of views and opinions and led to fascinating discussions in the evenings when we met and reviewed experiences made during the days. These meetings allowed us to share and align views, discuss problems, draw common conclusions and formulate important recommendations in a very open and trustful ambience. Our programme visits in Kenya and Ethiopia were very intensive and sometimes challenging, but not long enough to start writing our report. We revisited our notes whenever possible in the evenings, met with the Director General and staff to get more precise information to specific project questions and to put our experience in the context of the programmes of the Centre. Thus, the report is the synthesis of project visits, individual and group discussions with *icipe* staff, presentations made by *icipe* staff, meetings with the DG of the Centre, information compiled from stakeholder and partner visits, reading of *icipe* internal documents and scientific literature published by *icipe* scientists and, finally, of personal impressions and judgements.

We would finally like to thank *icipe*, especially the Director General Christian Borgemeister and all his colleagues, staff and students for the very constructive collaboration and strong support throughout our assignment. The many open and frank discussions and demonstrations of *icipe*'s work made our stay rewarding and rich. Likewise, we gratefully acknowledge the very positive collaboration, open discussions and expressions of views by *icipe*'s stakeholders, clients and partners that we met during our visits. We hope that this report will contribute with constructive ideas to *icipe*'s future programmes.

August 2007
Franz Bigler (Team Leader), Jan O. Lundström and Ebbie Dengu

1. EXECUTIVE SUMMARY

1.1 Success in implementing the vision and strategy

(a) The team **concludes** that the current programme areas reflect *icipe's* mission and mandate, and the 4-Hs concept is still up-to-date and relevant to cover the full breadth of *icipe's* mission. As the only international Centre working primarily on arthropods in SSA, *icipe* is at a clear advantage in addressing the complex arthropod-related challenges of food security, vector-borne diseases (of people and livestock) and protection of the environment, including biodiversity conservation. The many integrated pest and vector management and insect-based income-generating technologies should be continued by the Centre, including the capacity building programmes which are of immediate relevance to future strategies for contributing to solutions of food insecurity and malnutrition, disease, poverty and environmental degradation. *icipe* should continue to combine basic and applied research to develop, introduce and adapt new tools and strategies for arthropod management that are environmentally safe, affordable, socially acceptable and applicable by the target end-users.

Stakeholder consultations during the review confirmed *icipe's* reputation of an African Centre of Excellence in arthropod science from basic to applied research and beyond. As *icipe* has to set programme priorities, it became obvious during our review that not all stakeholders are fully satisfied with *icipe's* research agenda and that some stakeholder groups are keen to get more immediate results from "problem-solving" research. Despite this conflict, *icipe* should maintain and strengthen high quality research in modern arthropod science which makes the Centre unique and distinct from other African research centres.

icipe's capacity building and training programmes have an excellent reputation in Kenya and Ethiopia and are much appreciated by all stakeholders that were consulted.

(b) The team **recommends** that *icipe's* primary geographic focus remain on tropical Africa and that its immediate subject areas concentrate on arthropod science. Activities going beyond arthropods in SSA may best be accomplished by collaboration with high quality partners and linkages which are chosen based on a number of established quality criteria. Cooperation in research and capacity building should be strengthened by jointly developing research proposals with partner universities and to give visibility to partner institutional contributions by apportioning credit in publications and publicity material.

The future plans over the next five years were considered very ambitious and would require setting more stringent priorities to the programme plans and to single projects. This would help decision making under uncertainties of funding and demonstrate stability for the core competences necessary to grow the organisation and maintain its purpose.

Wider and rapid dissemination of technologies (upscaling) is needed in some projects and will only be possible through training of extension staff with stronger involvement of national and local extension services that would in turn train the end users. Widespread dissemination through training of end users is not *icipe's* core-business, and it should thus seek to achieve this through strategic partnerships.

Rigorous evaluation of projects should be made in relation to core science competences of *icipe* and of competences and role of carefully chosen partners. Projects with a scope far beyond *icipe's* competences, for example farming programmes and cropping systems, should not be managed under *icipe's* leadership.

(c) The team **appreciates** *icipe's* efforts to strengthen and expand its activities to other African regions such as Central and West African countries to better comply with its mandate and in fulfilling recommendations of the review in 2002.

icipe's strategy to develop full IPM and IVM packages and partnering for holistic approaches for problem solving is fully compatible with its mandate and represents one of the programme strengths if adequate linkages with the right partners are established in other African regions.

1.2 *icipe*'s results in research and capacity building 2002–2006

Results of research and capacity building can be measured with different indicators such as number of peer reviewed and non-peer reviewed publications, impact factors of publications, research proposals submitted/accepted with financial resources allocated, supervision of MSc and PhD students with publication outcome, (invited) presentations held at meetings, and workshops organised. *icipe* has compiled and made available to the review team some of these figures for the period 2002–2006 (see Annexes) .

(a) Research

Scientific publications are the primary output of a research institute and they are a major contribution to improve competitiveness, increase the scientific value of institutes and convince potential donors to provide financial support.

The average number of peer reviewed publications per *icipe* scientist as first and co-author is around two from 2002–2006, except for 2006 when the mean was increased to three. If the non-peer reviewed articles are added, the average increases to approximately three, respectively four in 2006. Although we did not analyse impact factors of the journals in which articles of *icipe* were published, it is **recognised** by the review team that a considerable number of articles produced by *icipe* scientists as first and co-authors were published in high ranking journals.

Another indicative result on success is the proposal development with the total amount of funds granted as summarised in Annex 3. The division on Animal Health was obviously less successful and needs more in-depth analysis and attention.

Despite the fact that a few *icipe* scientists have an excellent record of scientific publications, the team **concludes** that—*icipe* being a Centre of Excellence for insect science—more emphasis should be given to scientific publications including impact factors of the journals in which papers are published.

Proposal development and consecutive funding is crucial for *icipe*'s future programmes.

The team **recommends** to *icipe*'s management to evaluate specific incentives for successful project developments resulting in substantial funding, development impact and outstanding publications.

It is important to acknowledge that core science competences and innovation of an institute are often more associated with outstanding individual scientists than with the number of scientists. It is therefore important to find incentives (e.g. allocation of core funds) on a long-term to retain and recruit outstanding scientists in core research areas.

(b) Capacity building

icipe's Capacity Building and Institutional Development Programme has four major components: Higher degree training for leadership in scientific research and policy formulation. The postgraduate training is held at PhD and MSc levels through the African Regional Postgraduate Programme in Insect Science (ARPPIS) and the Dissertation Research Internship Programme (DRIP); non-degree training mainly targeted to practitioners in the national agricultural and health research and extension systems; professional development programmes, whereby postdoctoral fellows, research associates and visiting scientists come to *icipe* to develop and share expertise; and interactive on-site training through collaborative research work carried out with *icipe*'s national partners.

The ARPPIS and DRIP programmes have achieved outstanding results with 74 PhD and 120 MSc degrees conferred to *icipe* students over the years 2002–2007. More details of the ARPPIS and DRIP programmes are given in the ARPPIS report of 2005–2007. Most of these scientists have remained in the African research community.

The team **concludes** that capacity building programmes are recognised as one of *icipe*'s strengths contributing to human resource development in insect science. The CB&ID programme has provided a framework for individual scientists and more than 30 African universities, and other non-African research institutions, which are involved in the network on insect science and biodiversity conservation.

Stakeholder feedback from Kenyan institutions to the review team was very positive with regard to ARPPIS and DRIP. MSc and PhD students who have achieved their degrees at *icipe* within ARPPIS and DRIP programmes are considered to be better trained in entomological science compared to those students who did not visit these programmes.

The team **recommends** a continuation of the capacity building programmes at the four levels whereby more emphasis should be given to cooperation with more African universities in different regions including the francophone part of SSA for the ARPPIS and DRIP programmes.

icipe should evaluate carefully and design at an early stage of the projects a road-map on how

capacity building and training are best achieved taking into account that training of local people and dissemination of knowledge generated by *icipe* staff should be delegated as early as possible to national and local institutions in order to have free capacity for innovative activities.

1.3 Impact of *icipe*'s research and capacity building programmes

The review team **recognises** that *icipe* has had a continuous impact on different levels in science, capacity building and training, product and market development and to the public.

(a) Impact in insect science and related topics is best made apparent by the number and quality of scientific articles in peer reviewed journals, book chapters and edited books. From 2002 to 2006, 341 peer reviewed articles, 78 other publications of scientific value and 8 books were published by *icipe* scientists. In total, 112 MSc and PhD students supervised by *icipe* staff finalised their theses in the same period. The review team **recognises** the important contributions of *icipe* scientists to insect related issues worldwide and in particular to research topics like molecular biology, chemical ecology, applied ecology and conservation biology in SSA.

The *icipe*-published international peer reviewed journal *International Journal of Tropical Insect Science*, co-published by Cambridge University Press, plays an important role in distributing relevant insect science of tropical regions.

The review team **concludes** that *icipe*'s contribution to insect related science for tropical Africa is unique and covers most important aspects going from basic research to applied problem solving, and thus fully meets development priorities in SSA.

(b) Some of *icipe*'s outstanding accomplishments are associated with its role in capacity building and training in insect science and related topics. It should be mentioned again that *icipe*-trained young scientists achieve a very high level of education in insect science and most of them remain active in SSA. Another fact is that *icipe* has organised an impressive number of training courses and *icipe* staff has contributed to such courses organised by other institutions. Most of these courses address practical problems encountered by farmers, advisory persons, as well as by private and government organisations. Hence, thousands of stakeholders have got direct and indirect training from *icipe* staff in knowledge transfer in plant, animal, human and environmental health issues.

The review team **concludes** that these facts set *icipe* apart from capacity building and training programmes offered by other institutions in tropical insect science and merits special support in the future. However, the team **recommends** that *icipe* envisages higher impact in African regions where similar programmes are not yet established by taking full advantage of opportunities for cooperation with other research centres that have competence and capability in insect science.

(c) Technology transfer for product and market development has had high impact in the field and has yielded direct and indirect problem solving for the rural poor with regard to better food production (e.g. maize and vegetables), lower vector transmitted human and animal diseases and new income opportunities from commercial insects and medicinal plant-based products. Much of *icipe*'s contributions on product and market developments are not yet widely enough known outside the local communities and should get more recognition of its sustainable benefits by stakeholders and donors. The review team **recommends** that *icipe*'s management establishes an overview of all major successes in the field of technology transfer, product and market developments with its sustainable impact on rural and urban populations in SSA. This overview could be used to convince donors of *icipe*'s commitment to meeting development priorities in SSA.

The programmes should build on its working models and put in place systematic lesson learning and sharing framework to answer some of the questions on scaling up and sustainability issues in product and market development. The review team **concludes** that it is necessary to capture policy and institutional insights that contribute to sustainable utilisation of technologies and products. For example, the programmes should draw up lessons on policy and institutional changes required to scale up successful pilot studies on natural resource based community enterprises in fragile and threatened ecosystems.

(d) *icipe* produces an impressive array of brochures, books, press releases and other information and PR material of interest to the public and stakeholders. These products are important to provide information on successful projects and outstanding results in insect science and hence, to increase

icipe's recognition in Africa and overseas. Additionally, there is a possibility to further develop *icipe*'s homepage to make it more up-to-date, attractive and informative as an efficient way to disseminate information and attract students and researchers. This may also be an alternative way of keeping the present donors informed about ongoing research and development, and to inform and attract new potential donors.

In conclusion, *icipe* has had and will continue to have an impressive impact on all topics of its activities, and it contributes substantially to improve the livelihood of rural and urban poor people in SSA. This view was also shared by all interviewees that we have consulted during our visit.

1.4 *icipe*'s partners and collaborations

The review team recognises that *icipe* has an impressive number of partners and linkages worldwide, and some of *icipe*'s partners are highly qualified with a world reputation adding great value to *icipe*'s programmes by synergistic effects. This is of prime importance for *icipe*'s recognition in Africa and elsewhere, and donors may view and apply such criteria increasingly. However, it is essential to be aware that partners at all levels have to add value in terms of scientific quality, developmental impact and funding. Collaboration should not become a goal by itself, but should add value to *icipe*'s programmes.

The review team **recognises** that *icipe* has over 200 signed Memoranda of Understanding (MoU) with institutions in Africa and overseas. To meet the challenges of the future, *icipe* needs MoU with strong partners that add value to the scientific competences, increase innovation, show potential for scaling up innovations and have positive impact on programme funding. In other words, *icipe* has to choose partners based on qualitative criteria that respect increasingly the overall values added to programmes.

The review ream **concludes** that a number of MoU are not in force anymore, were never implemented, or they were not formally signed. Such MoU are either meaningless with no further consequences, or they bear an inherent risk of unfulfilled expectations with a potential loss of credibility among partners. *icipe*'s management has initiated a process of reducing the number of MoU and to strengthen those which are of strategic and scientific value for *icipe*, and as such may also increase chances in programme fund raising.

The review team **recommends** *icipe* to draw up a list of quality criteria to identify possible areas of strengthening partnership and to select partners accordingly in future programmes.

University partners in Kenya felt that currently capacity building is limited to the student rather than to the institution. They propose to strengthen jointly developed research proposals with partner universities rather than just inviting research students to work on predetermined research areas. This would ensure institutional development necessary for the university to provide effective supervision of students in the partnership programme. This would also ensure that training courses are tailor-made to address emerging needs and challenges in the environment. The review team **recommends** to strengthen joint development of research proposals and to give visibility to partner institutional contributions by apportioning credit in publications and publicity material.

1.5 New opportunities for future programme design

Advances in science follow often unpredictable patterns with different disciplines growing at different times and rates, depending largely on factors such as critical breakthroughs, expected market potential of emerging products, recognition of problems by the society at large and expected contribution to problem solving. Based on our experience we have attempted to identify some of the ongoing trends that have an obvious significance to *icipe* and we **recommend** *icipe* to consider the suggested areas of emerging opportunities in future programmes. This is not to say that successful ongoing programmes should not be continued; however, if less successful programmes are terminated and new avenues in research and capacity building are initiated, we suggest consideration of the following new areas:

- **Global climate change** is a reality and there is scientific consensus that this will have a major impact on food production, vector-borne diseases and changes in biodiversity, and this will strongly influence livelihood of people in Africa, in particular in rural areas. *icipe* has amassed such a wealth of unique expertise and experience in arthropod-borne problems and biodiversity in SSA that it should attempt to feed in this knowledge into models and help to improve predictions in critical climatic zones. This could be done in collaboration with qualified groups developing models for SSA.

- **Invasive alien species** are considered to be the second most important factor of biodiversity change after landscape degradation. Research in building up information on invasive alien species, understanding of invasions and ability to predict and control invasions in sensitive environments would have a high impact on biodiversity conservation and pest and vector-borne disease control. More attempts should be made to market these services and products to stakeholders. Export companies and plant quarantine services of African countries could make use of *icipe*'s international network in plant health and experience in region-wide problem solving.
- **Diagnostic tools** could play a major role in understanding taxonomy, ecological interactions, population biology and behaviour. These diagnostics will also play an important role in understanding and surveying invasive alien species and spread of arthropods under climatic changes in SSA. With respect to these technologies, *icipe* has to take strategic decisions on which ones are affordable and will give the Centre a leading role in the region.
- **Genetically modified plants** (GMP) are now commercially grown on more than 100 million hectares worldwide and the trend is clearly indicating that GMP cultivation will increase, especially in developing countries. The controversy around GMP requires biosafety research and capacity building which is independent of commercial interests, scientifically sound and should answer questions and uncertainties in the public, the scientific communities and by regulatory authorities. *icipe* would have to play a key role in generating such data, and thus contribute substantially to science-based information on GMP in SSA.
- We suggest that the researchers at *icipe* look into the possibility of initiating surveillance of **mosquito-borne viruses and sandfly-borne protozoa**. A successful widening of the research agenda to include mosquito-borne viruses and sandfly-borne protozoa will strengthen *icipe*'s position as a leading African entomological research institution, and could thus add in the quest for sustainable funding.
- The recent surge in high quality **geo-coded data from satellite censors** has made it possible to address the complex topics of large-scale risk assessment for occurrence of vectors and outbreaks of vector-borne diseases. Such information could be very useful in directing vector control to potentially affected areas prior to a vector-borne disease outbreak, in strategic planning for medical and veterinarian actions, etc. However, the sophisticated data from satellites will only be useful if matched with reliable and high quality environmental data from the ground suitable for the research questions to be addressed. We suggest that *icipe* should explore this avenue of research possibilities further and establish collaboration with appropriate high quality partners.
- The urgent need to preserve a high biodiversity in sensitive landscapes and ecosystems in order to sustain **ecosystem services** such as biological pest and vector control, pollination and soil functions requires more research and convincing key examples that show economical, ecological and social benefits resulting from ecosystem services provided by arthropods. We suggest that *icipe* looks for more opportunities in future programmes to strengthen research in assessing, maintaining and improving biodiversity that contributes to higher ecosystem services and ultimately to economical benefits of rural populations.
- We suggest that **upscaling** of integrated pest and vector management and development of methods for integrating community-based vector control in very large regions and in several countries should be given highest priority.
- Introduction of **economic and social sciences** into research at *icipe* has been achieved with some success since 2003. Studies in economics and social science are extremely important for policy making and for *icipe*'s strategic decision-making. Social scientists are needed to make an integral contribution to the design and implementation of research projects and transfer of technology processes. The review team thus sees a need for further strengthening the competence in economics and social science at *icipe*.

Besides the above recommendations on possible new opportunities and directions of future programme design, we **conclude** that there is need for a hierarchy of key indicators for measuring direction and level of success of programmes or thematic areas in a manner that facilitates strategic adjustment where necessary. This is particularly

so where there is a large number of small research projects and therefore the need to keep track of their contribution to the overall programme aim.

1.6 Programme agenda and priorities for the next years

It should be obvious from the preceding sections and from the full report that *icipe* has many strengths in its ongoing programmes which should be preserved. Though, as a consequence of new challenges due to changing development agendas of donors, emerging problems in developing countries and new technology development, *icipe* is continuously forced to adapt its research and capacity building programmes and to set new priorities in order to comply with the demands of the future.

The review team **concludes** that *icipe*'s programmes focus on research for development using insect science as an entry point to tackle sustainability in plant health, human and animal disease vector management and in environmental health in a holistic approach.

We **propose** that arthropod science remains the core competence of *icipe*, and we would encourage *icipe* to seek more targeted collaboration with high quality partners in complementary research fields (e.g. agronomy, plant, animal and soil sciences, social science and economics) that would strengthen *icipe*'s comparative advantages over other research institutions. To comply with development needs in SSA, we believe that *icipe* may best contribute to sustainable solutions by offering sound scientific bases and applications in insect behaviour, applied systems ecology, chemical ecology, molecular biology, biological control, IPM and IVM, conservation biology and insect taxonomy.

The review team **recommends** *icipe* to strengthen in future programmes the suggested new research areas with respective opportunities discussed in this report in chapter 6 and summarised in this section.

The review team **concludes** that technologies and systems developed by *icipe* and transferred through adaptive research are often location-specific and adapted to a particular livelihood system. Too heavy involvement in dissemination and extension on such local levels can bind too much resources and energy of *icipe*, and reduce the international comparative advantages of the Centre. The review team **recognises** that such local dissemination processes need sometimes support of *icipe* staff for a short while and can be beneficial. However, the team **recommends** to *icipe* to include dissemination and extension plans for new programmes where the ultimate objective is building capacity and technology transfer and to involve from the very beginning (planning phase) local and national partners that will take over extension at an early stage and thus leave more capacity to *icipe* for innovative research.

The development of community-based enterprises in high value natural products is generating science-based working models with potential for high returns to communities, raising awareness on the importance of biodiversity and conservation to livelihoods and building capacity of African scientists and institutions. There is scope to strengthen the programme in these areas in collaboration with private partners and organisations that take the responsibility for market development of resulting products. We **recommend** that future programmes review and address the following key issues and questions in order to make a significant contribution to its overall goal on sustainable utilisation of agricultural resources and important natural ecosystems: (a) What institutional capacities are being built in business support services to these enterprises, for example who will continue to provide business support services as *icipe* withdraws? (b) What are the ownership and financing structures (this has a bearing on sustainability and replicability) that are being tested and validated in these community based enterprises? (c) What replication models or strategies are envisaged beyond the current enterprises, for example, in medicinal, honey, sericulture etc. products and how are these being developed as part of the overall scaling-up strategy?

2. INTRODUCTION

The **mission** of *icipe* has recently been reiterated in its 'Vision and Strategy 2007–2012' paper. It 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.*"

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

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

Since its foundation in 1970, mission, mandate and objectives formulated above were the guiding principles within the scope of *icipe*'s subjects in research and capacity building, despite the fact that the question of subject matter scope—arthropods or beyond—was addressed repeatedly with good arguments for both, to limit the scope to arthropods, i.e. respecting the Charter's original mandate, or to widen the scope to related subjects such as disease and weed management, soil conservation and research in plant–plant interactions. The dilemma is obvious and was addressed in several documents including the review report 2002. A too restricted interpretation of the Charter would hinder *icipe* to develop integrated and holistic approaches for pest and disease vector problems which need to integrate related subjects into science and capacity building. A good example of a successful programme with a number of related subjects to arthropods is the 'push-pull' technology in maize which was developed by *icipe* in collaboration with national and international partners. The tools

applied to elaborate the complex technology of 'push-pull' includes, besides pest control, weed and soil science, economics and social science. New developments and tools in plant and animal science, e.g. biotechnology and genomics, would not be accessed and integrated into existing technology if *icipe* would not bridge the gap between pure arthropod science and subjects outside the original mandate. It is not an easy endeavour for *icipe* to find the right balance between being a Centre of arthropod specialists or one of more generalists. The strategic review of 2002 recommends *icipe* to continue with its focus on arthropods and related subjects in which the Centre has a high reputation and a strong comparative advantage. This review reinforces this recommendation from the 2002 review.

The geographic scope of activity of *icipe* as formulated in the Charter was originally thought, or could be interpreted, as to go beyond Africa and to cover the tropical zones around the globe. In reality, *icipe*'s activities have essentially focused on eastern and southern Africa, with an increasing tendency over the last few years to expand more to Central and West African countries. Limiting the geographic scope to tropical Africa may be one of the keys for the recognition and success of *icipe* as being the leading insect science Centre in sub-Saharan Africa (SSA).

What makes *icipe* unique? Over the past, *icipe* has amassed unique expertise, experience and a record of accomplishments to give the Centre a competitive advantage in solving tropical arthropod-related problems. As an international organisation established in Africa, *icipe* has a number of comparative advantages such as:

- Being the only international research Centre working on arthropod research and development in the tropics—An independent centre in Africa for Africa;
- Using holistic and integrated approaches to improve health of communities by addressing the interlinked problems of poverty, low agricultural productivity, poor health and degradation of the environment;
- Having an outstanding record in capacity building—from postgraduate research and training to training of trainers to practitioners.
- Undertaking basic and applied research leading to successes in scientific achievements and applications of insect science for development of technologies and products which farmers are using.

Since its foundation, *icipe* has undergone numerous changes, and it successfully mastered to cope with new challenges in governance, management, research and capacity building, competition with other research Centres and donor priorities. These changes reflect the rapid processes of the very dynamic global environment in which international research Centres like *icipe* operate today. As part of these ongoing processes, *icipe* considers the regular monitoring and evaluation of the performance of its research and training programmes as an important activity to regulate quality and relevance, as well as to ensure compliance to its mission and mandate. From an institutional standpoint, both the Centre's Governing Council (GC) and the Sponsoring Group of *icipe* (SGI) have important roles to play in this exercise. The donors constituting the SGI use *icipe*'s GC-commissioned periodic external review as an instrument to evaluate the scientific programmes, and administrative and financial management of the Centre. The GC appoints the review members and provides terms of reference for the review team.

As a result of the last Strategic Planning Review in 2002 ('Focus on the Future'), in which the next extensive review was recommended after approximately five years, the GC of *icipe* commissioned an external review in January 2007. It was agreed that the review would focus on research, thus evaluating the research and capacity building agenda of the Centre. According to the terms of reference (see Annex 1), the programme review involves studies of relevant documentation, as well as visits and reviews of ongoing work in *icipe*'s laboratories and field sites at stations in Kenya and Ethiopia. The review team also consults with a broad range of partners and stakeholders. After consultation with potential reviewers, the GC instituted three reviewers covering together the Centre's '4-Health Programmes' (Plant, Human, Animal and Environmental Health). After a three-day preparatory visit of the review team leader at *icipe*'s Headquarters (HQ) in Nairobi in May 2007, the team spent together a total of 30 days in June 2007 at the Centre's HQ, at *icipe*'s Mbita Point Station in western Kenya, several other research stations of *icipe* across Kenya and at the Centre's office in Addis Ababa, Ethiopia. Prior to the visit, *icipe*'s management provided a bunch of relevant documents to each reviewer and offered all necessary infrastructure and assistance during the review work. The team has had the opportunity to conduct over 60 interviews and interactions with external partners, e.g. government representatives, managers of government and private organisations, scientists from universities and other research organisations, advisors and

farmers. Much emphasis was also given to interactions with *icipe* scientists and visits of labs and field sites where external stakeholders were again visited and interviewed. This allowed the team to capture a broad view of the Centre's activities and to understand how *icipe* is judged from out- and inside.

Although we have attempted to evaluate and analyse principal projects in the 4-H Programmes, the review team is aware that not all ongoing activities of the Centre could be reviewed during the visit and by studying the documents. It became clear during the review process that *icipe* is embedded in a complex network of national and international research and capacity building structures and that the Centre has many more links to stakeholders, institutions and partners than those which are visible at a first glance from the outside. The review team has attempted to take account of the complex network and structure in which *icipe* is operating and has tried to analyse and evaluate opinions and views expressed in internal and external interviews. As a result of all this, we have attempted to formulate recommendations and conclusions in a coherent way that may serve *icipe*'s GC, donors, management and staff to better judge future priorities of the programmes, to best comply with future demands of stakeholders, to improve quality and output of the Centre and thus, to make *icipe* more competitive in the dynamic environment in which it has to operate now and in the future.

3. THE GENERAL FRAMEWORK OF PROGRAMME RESEARCH AND CAPACITY BUILDING

In this chapter, we have attempted to capture the essence of *icipe*'s framework of the programme research and capacity building today, i.e. the Centre's vision, strategy, programme planning, priorities, structures and funding, without claiming to completely cover all aspects.

A programmatic review of *icipe*'s agenda is a tool for evaluating how the Centre is positioning itself to meet the new challenges and how the programmes are in tune with its institutional mandate. It was agreed that the review would be research-focused, evaluating the research and capacity building agenda of *icipe*. Strategic issues should be considered by the review only if they have an immediate bearing on the research and capacity building programme planning, with a potential time frame for the next five to seven years (see terms of reference in Annex 1).

Research and capacity building programmes are embedded in *icipe*'s institutional and management structures which are based on principles designed to serve best the mandate and to achieve the Centre's objectives. The ultimate frame for developing research programmes is given by *icipe*'s vision and strategy that is leading to programme priorities and planning, and eventually to programme funding and the resulting programme structure.

3.1 Vision and strategy

As a result of the Strategic Planning Review in 2002, *icipe* examined its research agenda and programmes and developed a 10-year Vision and Strategy for 2003–2012, which outlines major steps to be taken in order to comply with the recommendations of the Review in 2002 and to prepare the grounds for future directions within the scope of *icipe*'s mission (see Introduction). Recently, management and scientists of *icipe* revisited the Vision and Strategy 2003–2012 paper as part of a mid-term revision and formulated an updated Vision and Strategy 2007–2012 (Meeting the Needs of a Changing World) document in which strategic future plans in research and capacity building of the Centre are outlined and *icipe*'s role within the context of the millennium development goals (MDGs) in the 21st century is discussed. Since the MDGs are commonly accepted as a framework for measuring development progress in the 21st century, it has a bearing on *icipe*'s vision and strategy which should be in line with these global commitments

and the Centre should aim to contribute to achieving these goals in Africa. A short analysis given in the document shows that *icipe*'s present and future activities are in line with and should greatly contribute to all major MDGs in all of the four activity areas of human, animal, plant and environmental health (4-H paradigm).

icipe's research carried out under the operative 4-H paradigm is formulated in the Vision and Strategy 2007–2012:

(a) *Plant Health research contributes to improved sustainable food security strategies and environmental health through the development of integrated pest management (IPM) for field and horticultural crops and storage pests*.

(b) *Human Health research contributes to the reduction of malaria and other vector-borne diseases by developing tools and strategies that control the vectors and break the cycle of transmission, and that can be integrated with other disease management efforts*.

(c) *Animal Health research aims to increase livestock productivity through development of integrated strategies and tools for livestock vector control, thus leading to greater availability of meat, milk, hides and draught power*.

(d) *Environmental Health research concentrates on conservation and sustainable utilisation of the agricultural production base and important natural ecosystems by encouraging and utilising arthropod diversity; cataloguing and sharing biodiversity data and discovering endemic wealth by bioprospecting for useful natural products*.

For each of the 4-Hs, the strategic future plans up to 2012 are presented in chapter 3 of the same document. The main message filtered out of this chapter is that the programme strategy continues to follow up and further develop the present programmes; however, there are some new and interesting ideas formulated which need further consideration (see chapter 6 of this report). The fact that the future plans are very ambitious, and probably not all ideas can be implemented within the next period, would justify to setting priorities to the strategic plans. This would help to take decisions under uncertainties of funding and demonstrate stability for the core competences which would stay at all costs.

icipe's capacity building and institutional development activities have the strategic objective to develop the much needed, well trained and highly motivated human resource capacity that is able to respond to the arthropod-related development needs in SSA.

Sustained capacity building efforts are necessary to improve indigenous capability at all levels, and institutional capacity to optimally use that capability. This implies the need for sustained human resource development in areas of scientific, technical, operational and research management, backed up with overall institutional development for the productive use and expansion of that resource pool. It was also realised that a focus on capacity development at the higher levels of the national systems needed to be backed up with training of extension workers and the beneficiary communities to facilitate the technology adoption process. *icipe* recognised that it would not have the capacity to train significant numbers of end-users and nor did it consider it desirable. Wider and rapid dissemination of the technologies would only be possible through training of extension staff in the national systems, who would in turn train the end users. In general, there has been a major increase for demand of more of the capacity strengthening activities of *icipe*, especially the graduate programmes.

Conclusion: As the only international Centre working primarily on arthropods in SSA, *icipe* is at a clear advantage in addressing the complex arthropod-related challenges of food security, vector-borne diseases (of people and livestock) and protection of the environment, including biodiversity conservation. The many integrated pest and vector management and insect-based income-generating technologies should be continued by the Centre, including the capacity building programmes which are of immediate relevance to future strategies for contributing to solutions for food insecurity and malnutrition, disease, poverty and environmental degradation. *icipe* should continue to combine basic and applied research to develop, introduce and adapt new tools and strategies for arthropod management that are environmentally safe, affordable, socially acceptable and applicable by the target end-users.

The capacity building and institutional development efforts should be maintained on all levels and strengthened on postgraduate levels with the aim of training young African scientists for arthropod-related problem solving and research management, and offering them novel opportunities to establish linkages with the scientific communities around the world.

3.2 Programme planning and priorities

Programme planning within the frame of *icipe*'s vision and strategy is a continuous and flexible process which is primarily driven by initiatives of the scientific staff of the Centre when recognising new and emerging problems, by initiatives of stakeholders contacting *icipe* for problem solving and by project calls of funding agencies where *icipe*'s activities fit in.

Apart from the periodic external reviews normally carried out every five to six years, projects are reconciled with available funds within an annual process; however, there is no institutionalised medium- and long-term programme planning procedure at *icipe*. The Finance department estimates the amount of the core funds committed for the next financial year and these are allocated between administration and science. The major financial resources of scientific programmes are though provided by project funds.

For the purpose of a well managed programme planning that respects the strategy and priorities of *icipe*'s research and capacity building, the management has instituted a 'Proposal Routing Form' that the scientific staff use as a guideline in which the procedure of proposal development and routing is laid down. The form constitutes a very useful tool to overview and manage individual project proposals, to coordinate projects among different activities with internal and external partners and to guarantee high quality proposals emerging out of a team process. The guidelines offer the possibility for urgent proposal submissions in cases where proposals may need to be submitted to funding agencies at very short notice. Another useful tool is the 'Guide of Overheads and Institutional Cost Recovery' which was recently established and dispatched to all scientists at *icipe*. This document facilitates budget planning in individual projects taking into account funding policy and conditions of donors.

Programme priorities within the strategic 4-Hs are influenced basically by three dimensions: (1) the subject matter scope, (2) the geographic activity scope and (3) the coverage of the range of the R D continuum (from basic research to development activities and capacity building). Each dimension has direct bearing on management, administration and core competences of *icipe* with interactions on external partners and stakeholders. Under the assumption of limited funds, the three dimensions are themselves directly interlinked insofar as the restricted financial and human resources of *icipe* do not allow for widening one dimension without limiting another one. The only possibility to cope with these restrictions would be to increase core and/or programme funding. For the time being and under a realistic scenario, *icipe* has to choose very carefully strategic and programme priorities by using selected criteria which would allow ranking of individual projects within the programme structures.

Conclusion: The review team recommends to *icipe*'s management to consider establishing a medium-term programme planning process (e.g. every 2nd year) in which the entire *icipe* scientific staff would be involved. This would facilitate the planning process, and strengthen the willingness of the entire staff to respecting the programme priorities and to understand core funding distribution within the Centre.

Programme priorities have to be made very carefully by applying a number of selected criteria which would enable the Centre to make an *ex-ante* impact evaluation of each project proposal.

3.3 Programme structure and funding

icipe's research operates under the 4-H paradigm formulated lastly in the 'Vision and Strategy 2007–2012' document. Other research groups with cross-cutting themes feed into more than one division, as for example the groups on behaviour and chemical ecology, molecular biology, biotechnology, bioinformatics and social science. *icipe* scientists are collaborating with numerous national and international partners across Africa and elsewhere in the world and most of them have established long lasting collaborations contributing to the Centre's network with over 80 institutions worldwide.

Cutting across the 4-Hs are also *icipe*'s capacity building activities which have complemented its programme with collaborative arrangements with universities and research institutions in Africa and many developed countries.

Over the years 2002–2006, the total budget of *icipe* ranged from US$ 10.3 to 12.4 per annum. Total average funding of the Centre has slightly increased in 2006 and 2007 in comparison to the years 2002–2005, whereby core funds were more or less stable over the entire period 2002–2007, but restricted (project) funding was remarkably improved over the last two years. One of the problems *icipe* is faced with since many years is the low proportion of core funding in the total budget (roughly 30% on average). To mobilise more financial resources from core donors is one

of *icipe*'s management challenges for the future. Under the assumption that donors' support policy has shifted from unrestricted core funding to preferably support projects or thematic issues, it might be very difficult for the future to increase the proportion of core funds. The dependency on short-term contributions from a number of uncoordinated project funding agencies is one of the most compromising uncertainties of *icipe* (like for most other international organisations) with immediate implications to the research and capacity building programmes. Falling short in project funding bears the risks to become 'opportunistic' in fund raising and thus endanger the Centre's programme strategies and priorities and to operate in an environment with relatively short lasting projects which often do not give the necessary time flexibility for successful development. Part of core funds should be used to support increased innovative research for which project funding is not usually available.

Conclusion: The review team perceives and considers the present structure as being transparent and functional and thus well suited to pursue and achieve *icipe*'s mandate and objectives.

Sustainable funding is a constant and serious problem and a higher proportion of financial core resources would stabilise *icipe*'s situation and allow for more medium- and long-term programme planning and increasingly for 'high risk' innovative research. The Centre should seek to enlarge its group of core fund investors that have confidence in *icipe*'s ability to meet the needs of the development agenda.

4. PROGRAMME ASSESSMENT 2003–2007

The last review of *icipe* was performed in 2002 in which major emphasis was put on future strategic planning. Issues related to the programme were touched in the 2002 review only when they were directly linked to strategic planning underpinned by recommendations and comments. The main task and objective of the present review is to assess and evaluate the programmes of the last five years, to analyse progress, strengths and weaknesses of the 4-H divisions from 2003–2007 and to make recommendations for improvements. Despite the fact that the reviewers have spent a total of 30 days for the programme assessment, consisting of many project review visits in labs and fields, assisting at trainings in farmer field schools, demonstrations of practical work, discussions with and interviews of partners like farmer advisors, private industry partners, ministry representatives and university scientists, it was not possible to see and visit all projects and, more importantly, to perform an in-depth analysis of the entire programme.

4.1. Plant Health Division

icipe's Plant Health Division (PHD) contributes to improving food security, environmental health, and thus livelihood of people in SSA through developing sustainable pest management options for pre- and post-harvest pests. The overall goal is to improve staple and horticultural food production by preventing quantitative and qualitative yield loss due to insects and mites. More holistic approaches of food and feed production are developed by *icipe*'s PHD for production systems where arthropod pests, diseases, weeds and poor soils are limiting factors of sustainable productivity.

4.1.1 Research

STAPLE FOOD CROPS

Habitat management in cereals (push-pull): Production of maize, sorghum and millet in SSA is constrained, among other factors, by stemborers, the parasitic striga weed and poor soil fertility. The 'push-pull' technology involves intercropping maize with the legume desmodium *(Desmodium unicatum)* while Napier grass *(Pennisetum purpureum)* is planted around the maize crop. Desmodium produces volatile semiochemicals which repel stemborer moths from maize crop ('push') while green leaf volatiles released by Napier grass attract the moths ('pull'). Most of the stemborer eggs are laid on the Napier grass on

which the larvae fail to develop due to inferior plant quality of the grass, leaving the maize crop protected. Desmodium roots produce a number of chemicals, some of which stimulate striga seed germination while others inhibit their attachment to the maize roots, thereby reducing the striga seed bank to almost nil after 5 to 6 years of continuous maize production under 'push-pull'. Nitrogen fixation by desmodium reaches around 180 kg/ha and year and covers almost the full nitrogen requirements of the maize crop. Napier grass and desmodium provide high quality fodder for livestock which allows especially small farms to increase milk and meat production.

icipe is now addressing new research questions related to intercropping of other legumes, for example different bean species which are traditionally interplanted with maize to satisfy to a great extent protein consumption, especially of the poor in rural areas. Very interesting and promising field trials are underway to investigate the potential of 'push-pull' systems for semi-arid zones with more drought tolerant desmodium varieties and bean species interplanted with sorghum and millet. These experiments are highly relevant for smallholders where land is a minimum factor for production, legumes interplanted with maize crucial for human consumption and drought tolerance a prerequisite for adoption of the system in other climatic zones and on poor soils.

Related to these field experiments are highly relevant studies of volatile semiochemicals produced by different legumes and grass species that could replace desmodium and Napier grass which suffers recently from phytoplasma disease. Studies of the possible insect vectors (leafhoppers, planthoppers) of the disease are in progress and are expected to yield the first applicable results soon. Testing resistant germplasm of Napier grass (in collaboration with ILRI) is another promising way of controlling the disease with an integrated approach. Since Napier grass is propagated by cloning, the disease is easily spread over whole regions and thus endangers not only the maize push-pull system but also sustainable fodder production for livestock. Studies of other grasses or plants with similar properties as the Napier grass in attracting stemborer moths and killing the larvae is highly important for the sustainable use of the push-pull system which relies now fully on the Napier grass as 'attractant'.

An important limiting factor for disseminating the push-pull system is often the shortage of desmodium seeds despite the fact that vegetative propagation of desmodium has become a common way of interplanting this legume. Although technology and methods for the production

Following the successful biological control of the notorious Diamondback moth, worldwide the most important pest of brassicas, farmers in the Highlands of East Africa can now grow their cabbage and kale without using insecticides

of seeds and development of local markets are now being developed in collaboration with local seed companies, availability of seeds remains a bottleneck. This problem should be given more attention as it is a major cause of the limited spread of the push-pull system.

One other reason of the limited spread of the push-pull system might be the fact that desmodium is not an edible plant for humans and replaces beans which are traditionally interplanted with maize. Smallholders without ruminants may not adopt the push-pull method because beans constitute a major source of protein that cannot be compensated by a higher consumption of dairy products and meat. Socio-economic studies should be conducted to test this hypothesis and to elucidate related issues.

Other questions recently addressed by *icipe* are related to the socio-economic factors including gender issues of technology diffusion and adoption. Such studies are very relevant and timely for developing and supporting new and more efficient ways of disseminating the push-pull system in different farming structures and regions. Adoption of new technologies related to push-pull systems is dependent on a number of socio-economic factors which still need to be studied in detail. One such question worth investigating in collaboration with appropriate partners would be the impact of increased fodder production in push-pull systems on animal protein consumption and the nutritional status of urban populations, especially children. This production system could be compared to a traditional maize–bean system where beans constitute the major protein source.

IPM and biological control of cereal pests: Ongoing taxonomic, genetic and ecological research of stemborers elucidates in more detail

the distribution, diversity and the complex interactions between species and strains on crop plants and wild hosts in different climatic regions. Better in-depth knowledge of the taxonomic/ genetic relatedness and ecological features may be keys for identifying sites and ecosystems in which other promising natural enemies can be released and integrated with IPM strategies of stemborers. Additional tools, not yet fully explored, but with a possible potential for increasing the success of biological control are geographical information systems (GIS) and remote sensing coupled with information on climate data for identifying and characterising locations and habitats prone for introduction of new natural enemies. The technology of these tools is now improved to such a level that their potential for use in biological control should be investigated in collaboration with partners experienced in the field.

Mycotoxins produced by different fungi pose a threat to animal and human health. Stemborer attack of stalks and cobs and storage insect pests increases fungal infestations (mould) leading to high mycotoxin levels in maize. A threat for staple food in SSA is the invasive larger grain borer (LGB), *Prostephanus truncatus,* attacking maize, sorghum, cassava, etc. Biological control is a promising tactic to reduce LGB populations and should be the first choice of direct control options. Ongoing studies on the identification and testing of strains of the non-indigenous predator *Teretrius nigrescens* which are adapted to different climates are an important prerequisite for successful releases and establishment. Integration of biological control with other methods is probably the key for developing sustainable storage of healthy staple food. Socio-economic reasons may hamper development of improved storage systems. In view of preventing quality degradation of stored staple food it is of prime importance to study, in parallel with control tactics and other available or novel technologies, economic and social aspects of food storage. Studies on the role of women in preventing storage loss and management of staple food may be of special interest as women are often responsible for these issues in traditional societies. Technology transfer and capacity building should therefore be addressed primarily to women. These topics should be strengthened in future projects on storage pests and mycotoxins.

HORTICULTURAL CROPS

Biocontrol of diamondback moth (DBM): Major work is ongoing on biological control of the diamondback moth (DBM), *Plutella xylostella,* and IPM in crucifers. The introduction of two parasitic wasps, *Diadegma semiclausum* and *Cotesia plutellae,* between 2001 and 2003 into Kenya, Tanzania and Uganda has proved to be an outstanding success in highland growing conditions and substantial control of DBM was achieved in mid-altitude semiarid zones. DBM has since ceased to be an important pest in these zones and chemical control is not applied since for most of these climatic zones. Field visits and discussions with subsistence farmers in these areas have convincingly demonstrated that DBM is not considered an important pest anymore by farmers, and formerly weekly applied chemical treatments against DBM have dropped substantially resulting in additional economic benefit and cabbage production with no chemical residue at harvest. Control of other key pests like cabbage aphids still needs to be established in an IPM approach. Spot-treatments with selective pesticides and full treatment of young cabbage plants in nurseries applied before planting are economically and environmentally effective tactics in an IPM system of cabbage pest control. Improved results of biological control in lowland conditions still need to be developed, and to this end, prospects for more efficient parasitoids are performed. Cabbage and kale are such important vegetables for subsistence farmers and for local markets that efforts for environmentally friendly control methods should further be developed by *icipe*.

Fundamental research in DBM is ongoing to elucidate mechanisms of adaptation to non-crucifer host plants such as peas. Understanding of the genetics and ecological factors responsible for such phenomena is crucial for developing efficient strategies against this key insect pest.

IPM of fruit flies: The African Fruit Fly Initiative (AFFI) was established with the objective of improving the income and nutrition of smallholder families in Africa and increasing their export earnings by enhancing yield and quality. AFFI is filling knowledge gaps about pest status of fruit flies, their distribution and providing improved fruit fly management. The initiative has operations in Kenya, Tanzania, Uganda, Benin, Ghana, the Sudan and South Africa. The new fruit fly species, *Bactrocera invadens,* was detected in Kenya and control packages consisting of bait sprays, insect pathogens and traps were developed by *icipe*. Control packages combined with orchard sanitation (deep-burying of infested mango fruit) has shown a 70 to 80% fruit fly control in farmers' field trials. This IPM package was subsequently implemented to commercial orchards where

it has demonstrated good control with a high percentage of healthy mango fruit. During a visit of commercial mango growers in Embu district I assisted discussions with farmers and demonstrations of the IPM package which is now promoted by local trainers and mango growers because of economic and ecological advantages over the traditional fruit fly control programme with pesticides still being the main pillar of fruit fly control in conventional orchards. Innovative research is still ongoing with optimising improved application of entomopathogenic fungi against adult fruit flies and larvae. Intensive collaboration with fruit fly scientists overseas has given access to novel attractant panels with promising catches during the off-season when fly populations are at a low level.

IPM and biological control of red spider mite in tomatoes: The red spider mite (RSM), *Tetranychus evansi,* an invasive species accidentally introduced from Latin America, is currently the most serious pest on tomatoes in East and Southern Africa and in other countries of SSA. Current control practices involve regular pesticides applications with long-lasting activity resulting in pesticide contamination of farmers and farm workers, residues on the produce and negative impact on the environment. An IPM strategy was developed by *icipe* focusing on classical biological control, host plant resistance, improved crop management and improved pesticide application technique. Surveys for natural enemies of RSM were conducted in Latin America. The predatory mite, *Phytoseiulus longipes* was imported into Kenya and finally released for field trials in early 2007. First results on establishment and efficacy are expected in the coming months. Other biological control agents, including mite pathogenic fungi from Brazil were tested for virulence on *T. evansi*. Resistance mechanism in RSM-resistant tomato varieties was investigated and breeding programmes including crosses of commercial varieties with wild tomato species have yielded highly resistant breeding lines. Lines that have shown resistance in the laboratory were tested in the field and compared to susceptible varieties; however, differences were small and none of the lines can be regarded as resistant under high RSM attack in field conditions. Efficacy of currently used acaricides was tested because farmers complained about low efficacy. It was shown that not all acaricides performed well and often application technique and equipment is poor leading to low efficacy. Farmers' information and training in improved use of pesticides has resulted in more efficient applications, better pest control and less environmental pollution.

IPM and biological control of leafminers: Leafminer flies (*Liriomyza* spp.) have become important pests of horticultural crops and potatoes in tropical and subtropical Africa. Experience from other parts of the world has shown that leafminers can develop resistance against insecticides and are thus difficult to control with classical methods. Natural enemies are important for regulating leafminers, and augmentative releases of parasitoids in greenhouses and of classical biological control in field crops have proven to be successful. Field surveys have shown that leafminer incidence has increased on snow pea and potatoes. In collaboration with the International Potato Centre (CIP), *icipe* started studies of the interrelationship of host plant, leafminers and parasitoid species in African countries and in Peru. *icipe* will contribute to research on entomopathogens with selected fungal strains of *Metarhizium anisopliae* against leafminers. This project was started last year and has a great potential to contribute to environmentally friendly control of serious insect pests that can hardly be controlled in a sustainable way with pesticides alone.

Economic impact assessment: Horticultural industry is currently the third most important foreign money earner of Kenya after tourism and tea production, and the export industry of horticultural products offers employment for approximately 2 million people. Vegetable, flower and fruit production for local markets and for export contribute substantially to poverty alleviation and to overcome nutritional deficiencies. The export market is served by large-, medium- and small-scale farms and the number of commercial horticultural farms is increasing. Local markets are satisfied mainly by smallholder farms. Increasing use of pesticides with related production costs and decreasing productivity has endangered the development of horticultural production in recent years. A second hurdle for export products was set by the EU legislation on pesticide residue in 2005 and by European industry standards like EurepGAP which require documentation and certification of the production. *icipe*'s research has demonstrated that alternative pest control methods can replace pesticides totally or partially and can solve residue and certification problems encountered. Economic impact and opportunities of alternative pest control methods and EurepGAP standards on farm performance and smallholder farmers' health and medium to large-scale producers were studied in recent years. Such studies are extremely important for policy making in the producer countries, but as well for *icipe*'s strategic decision-making related to pest

control and their compliance with standards for export markets. Studies on economics and social aspects of alternative pest control tactics as the one conducted on the economic impact of the biological control of DBM are of great importance for *icipe* as they can contribute to higher adoption by farmers if advantages over pesticide-driven pest control can be demonstrated.

LOCUSTS AND MIGRATORY PESTS

Research in chemical ecology and behaviour at *icipe* of the desert locust, *Schistocerca gregaria,* identified environmentally friendly and low cost desert locust control tools from the chemical communication system of the insects in their gregarious phase. One of the most interesting results from *icipe*'s research was the finding that different pheromone blends mediate the aggregation behaviour of nymphal and adult stages. Exposure of nymphs to the adult blend, and vice-versa, resulted in a loss of aggregation behaviour. The major component of the adult pheromone (PAN) elicits an immediate arrestment of the marching behaviour of the hopper bands. Affected individuals become disoriented, hyperactive, feed less and gradually solitarise and the stressed insects become susceptible to enhanced predation and other mortality factors. PAN has been confirmed in field experiments as an effective hopper control agent and as a tool for enhancing the sensitivity of hoppers to biopesticides (Green Muscle) and conventional insecticides. Combined with PAN, these can be used at lower dosage of their recommended rates, enabling a more economic use of biopesticides and an environmentally less hazardous use of conventional pesticides.

Ongoing research is investigating the characterisation of nymphal and adult aggregation pheromones of the migratory locust, *Locusta migratoria capito,* from Madagascar. Other studies focus on developing an IPM management structure for a sustainable locust control combining preventive tactics (surveys, monitoring) and environmentally friendly agents such as mycopesticides and insect growth regulators.

4.1.2 Technology transfer and capacity building

STAPLE FOOD CROPS

Technology transfer and capacity building have got a high priority in the push-pull programme and are now very well developed at all levels, from higher degree training to interactive on-site training of farmers' advisors. MSc, PhD and postdoctoral students are conducting their lab and field research and a number of international visiting scientists are spending their sabbaticals in the programme. Long established international collaboration with highly qualified scientists from all over the world has created an impetus in habitat management as part of sustainable production systems.

Besides the many farmers' field schools (FFS) in different regions of west Kenya and Uganda, other extension systems such as training of local farmers' trainers have largely contributed to the dissemination. Early contacts and collaboration with government research and extension services has led to a deep involvement of government institutions. Ongoing training and extension enable further technology transfer and capacity building. Worth to mention is special women training for future farmers' trainers. Last but not least, the push-pull system of *icipe* continues to get attention from national and international radio, TV stations and newspapers.

In the stemborer project 3,600 extension agents and farmer advisors have received training. With such technology transfer and capacity building, the spread of the push-pull system, presently adopted by more than 10,000 farm families, on approximately 5,000 acres (or 2,000 hectares) in total in 2006 (pers. commun. Z. R. Khan), could be much more rapid if adequate quantities of desmodium seed are available in the market (discussed above, see 4.1.1).

One advantage of classical biological control over other pest control techniques is the relatively limited need of technology transfer and capacity building on farmer's and advisor's levels. Established natural enemies exert their control function independently of direct measures by humans, although targeted management of habitats can substantially contribute to increased pest control. Technology transfer and capacity building in classical biological control and IPM is emphasised by training of scientific staff (MSc, PhD and Post doc students) which has resulted in an expanded network of IPM and BC specialists in SSA.

HORTICULTURAL CROPS

In IPM and BC of crucifer pests, emphasis was given to training MSc and PhD students and to instructing local farmers' trainers who have now acquired knowledge to advise farmers on biological control and IPM in cabbage. Discussions with cabbage growers during the

review team's field visits made clear that DBM is not considered a pest anymore since the two parasitoids were released and have successfully established. Intensive collaboration among scientists from African and European countries has resulted in selecting more efficient biotypes of parasitoids.

Five FAO-funded fruit fly training courses were held at *icipe* since 2004. AFFI group training courses and mobile fruit fly schools were organised for training leaders and national fruit fly teams. Over 200 fruit growers, extension personnel and quarantine specialists were trained in fruit fly management and phytosanitary skills in Kenya, Tanzania, Uganda and Sudan. A visit of mango orchards in Embu region has shown great enthusiasm of mango growers about the IPM approach developed by *icipe* and government advisors proposed to expand the experiments to other regions as well. Teaching material and training curricula on survey methods, handling of attractants, basic taxonomy and application on fly suppression were provided. Several African and visiting scientists from Europe were trained in fruit fly taxonomy and ecology.

IPM training of trainers and extension specialists for tomato pests was conducted in Zimbawe and Kenya and a pilot farmers' field school with technical backstopping by *icipe* was established. Further training is planned once the predatory mite *P. longipes* is established to include biocontrol in the training courses. Improved crop management through pruning and staking and proper acaricide application has greatly improved RSM control. A number of MSc and PhD students have been trained and have finished their theses in the RSM programme.

Smallholder participation in the Kenyan horticulture export industry is threatened by a lack of efficient extension service. A project was conducted by *icipe* to explore the possibility of establishing private service providers that can ensure that farmers comply with new regulations and rules. The training course involved close collaboration with the Kenyan horticultural export sector and small-scale growers groups. Private service providers and farmers were trained by *icipe* in IPM. The training facilitated farmers and advisors to adopt IPM and to comply with EU market and EurepGAP requirements. Another considerable result of the training for EurepGAP standards by *icipe* is the commitment of EurepGAP to assist Kenya in developing 'KenyaGAP', a standard adapted to the needs of Kenyan growers. This initiative resulted in the nomination of a Kenyan representative in the EurepGAP committee. The training curriculum developed for the first phase was reviewed later and adapted to the needs of the private service providers. Thanks to the constant support of government bodies and export associations by *icipe* staff, Kenya is now in the comfortable situation of being the first SSA country with horticultural export standards complying with EU regulation and EurepGAP.

Under the horticulture programme a total of 151 IPM trainers, 29 private sector business providers and 50 key personnel from horticultural exporters were trained since 2002.

LOCUSTS AND MIGRATORY PESTS

Training of graduate students from Madagascar at MSc and PhD levels is one of the key aspects of the locust projects. Presently two PhD students from Madagascar are registered at the Jomo Kenyatta University of Agriculture & Technology in Nairobi and are located at *icipe* for conducting their scientific studies. *icipe* is presently working closely with FAO to expose other national locust control organisations to PAN to facilitate its widespread registration and use.

4.1.3 Products and market development

The push-pull system continues to yield a number of high value publications in peer reviewed scientific journals. Training materials (e.g. push-pull curriculum for farmer field school), specific folders, brochures and instruction leaflets have contributed to a broad range of intellectual products as a result of the push-pull programme. These products are nowadays the guiding documents on all levels of training and capacity building.

In recognition of desmodium seed shortage, a major bottleneck of rapid spread of the push-pull system, *icipe* has established collaboration with a local seed company and signed a Memorandum of Understanding. This step is important in the whole value chain of the programme as it opens additional chances for local seed markets and assists the farmers to adopt the push-pull system more rapidly.

Another tangible product results from the desmodium and Napier grass crop produced with the push-pull method. In collaboration with the International Livestock Research Institute (ILRI), *icipe* has developed a functional silage system for smallholders which allows the farmer to store high quality surplus fodder for ruminants during the high production (rainy) seasons and thus bridge fodder shortage during the dry seasons. This system contributes substantially to fodder

security for ruminants of smallholders and thus constitutes a major source of continuous protein supply for the poor.

A number of teaching materials on horticultural crops such as manuals and training curricula, for example on DBM, fruit flies, tomato IPM, were produced and provided to local trainers and mobile farmers' field schools. The horticultural unit published six IPM handbooks since 2002, namely for mango, tomato, crucifers, okra, French beans and cut flowers.

In close collaboration with the entomopathology unit at *icipe*, screening for more virulent strains of the fungi *Metarhizium anisopliae* continued and yielded two highly virulent isolates to pupating larvae of the invasive fruit fly, *Bactrocera invadens*. More screenings are on-going for highly virulent and persistent strains in the soil and in baiting stations. Negotiations with business partners have taken place to commercialise fungal pathogens, traps and baits developed by *icipe*.

PAN is now officially registered as a plant protection agent for desert locust control in the Sudan. Collaboration with FAO's locust programme will most probably facilitate *icipe*'s efforts for wider use of PAN and possibly lead to registration in eight more locust affected countries.

4.1.4 Overall assessment and recommendations

Research on push-pull systems has yielded a number of extremely valuable results and continues to be of high quality (in scientific terms) and high value (in terms of poverty alleviation). Despite the fact that the principles of the system are not novel anymore, push-pull has still a remarkable potential of scientific novelty and applicability of results. Among these are the discovery of new push-pull plants with new volatile compounds and interactions, impact of new plants on nitrogen fixation and sustainable soil fertility and recognition of major socio-economic factors guiding adoption of the system. Technology transfer and capacity building in the push-pull programme are of high value and managed in a professional manner in collaboration with national extension services. Adoption of the push-pull system is still low in terms of acreage despite the obvious advantages of the system.

Research conducted at the present time will probably yield solutions to the questions of replacing/combining desmodium with beans, provide first results of drought tolerant desmodium, replace Napier grass by other grasses, cure Napier grass from phytoplasma and provide first answers to the socio-economic issues.

Recommendation: One of the priorities should be to discover bottlenecks for widespread dissemination of the push-pull system and the still low adoption by smallholders. The high value and still unexplored potential improvement of the push-pull programme make it worth to continue with high priority in Kenya and to put emphasis on spread to other SSA countries.

icipe's internal collaboration would be strengthened, especially for the taxonomy and genetics of stemborers on grasses around maize fields and wild habitats, if the group at Mbita would closely collaborate with the group in Nairobi studying taxonomy and genetics of stemborers. The weak link between the two groups may be a result of the geographically distant locations of Mbita and Nairobi.

Research on IPM and classical biological control of cereal stemborers has contributed to the overall knowledge of stemborers in SSA and the findings have yielded a considerable number of scientific papers over the last years. It is estimated that 11.5 million cereal farming households in 11 countries in East and Southern Africa are beneficiaries of the 20-year programme with a total economic benefit estimated at US$ 1.8 billion for the entire region and of US$ 183 million for Kenya alone.

Recommendation: An overall structure and plan for implementing new information from studies on genetics, taxonomy and ecology of stemborers, and priorities for developing new approaches of IPM and explore for other biological control organisms of cereal pests should be developed urgently. GIS applications, remote sensing and spatial landscape analysis could open new opportunities for identification of 'hot-spots' of biological control and explore species habitats under global climate change scenarios.

Recommendation: Socio-economic studies of storage loss in staple food could provide deeper insight into societal mechanisms and patterns, increase knowledge and open new avenues for sustainable staple food pest control. As funding constraints of the staple food programme may limit future research, better focused projects (e.g. IPM of mycotoxin producing fungi) may be convincing for potential donors.

Research and capacity building in IPM of horticultural crops has resulted in effective control of key pests with positive impact on food production, income of small- and large-scale farmers, provision of local markets and export

industry with high quality produce complying with international standards. IPM and especially biological control of major pests has provided substantial improvements to the environment, farm workers' health and pesticide residue problems. Results from analyses of economic and social aspects of production systems and IPM strategies for horticultural crops are crucial components in decision making by local and national governments because export markets are accessible only if the produce comply with international quality standards. In this respect, *icipe* has provided invaluable assistance to the Kenyan government in implementing EU and EurepGAP rules into local horticultural production systems and to train people at all levels for improving the value chains in horticulture.

Recommendation: Services provided by *icipe* staff, for example training for quarantine inspection skills or EurepGAP standards, should be funded adequately by organisations requesting such services and being able to pay for them. Agreements and tariffs should be negotiated by *icipe*'s management. *icipe* should also investigate other models of service providing such as outsourcing services to private service providers with financial participation of *icipe*.

With the discovery of PAN and the development of locust IPM, *icipe* has contributed substantially to a more economic and environmentally friendly control of migratory pests. Ongoing studies within the chemical ecology group at *icipe* are promising for detecting novel volatile compounds of the migratory locust in Madagascar which may be further developed into a product similar to PAN. The same is true for *icipe*'s studies with Green Muscle strains identified and tested against locusts from Madagascar.

Recommendation: It is necessary for the R&D work on pheromones and Green Muscle against locusts in Madagascar to enter at an early stage into negotiations with private service providers that prepare the registration dossiers for submission in Madagascar in close collaboration with *icipe* staff.

4.1.5 Outlook

- Low local production of desmodium seeds seems to be one of the bottlenecks for low spread of the push-pull system. If this is a major reason, more efforts to aid in selecting high seed yielding varieties should be undertaken. As this is not the primary task of *icipe*, more private seed companies and/or plant breeders should be involved in such programmes. This could be in close collaboration with ILRI which holds the germplasm for desmodium.
- Research in drought tolerant desmodium varieties and other drought tolerant legumes for interplanting with sorghum and millet for other regions in sub-Saharan Africa (SAA) is extremely important now, but also in view of future impact of climate change to cereal production systems. Related to such novel crop systems it will be important to understand the mechanisms behind trophic interactions at different levels (e.g. volatiles involved), impact on soil fertility (N fixation, erosion, organic matter) and socio-economic factors that facilitate or hinder technology adoption in different societies in SSA.
- Finally, a study of the overall impact of push-pull systems on the economy of farmers and the nutritional and health status of people, especially children, would be highly informative and constitute a new challenge in many respects.
- Funding problems of IPM and biological control of stemborers may force to a more focused programme in the future. The awareness of health risks caused by mycotoxins has increased in recent years in Europe (EU regulation for mycotoxin levels in food products since 2005) and elsewhere and it is thus justified to pay more attention to programmes which have the potential to reduce such toxic compounds.
- It must be expected that increasing international trade and tourism will accelerate spread of invasive insect pests in SSA and that 'new' pests may emerge due to changing production systems and climate change. The challenge for *icipe* will be to sense such changes and invasions in order to investigate in time these organisms and develop IPM strategies which comply with the needs of smallholders, export industry and government bodies. Biological control and use of 'volatile cues technology' will continue to play a major role in the future tool box of IPM.
- Horticultural products contribute substantially to satisfy nutritional demands of people in SSA and they have still a great potential for exports into countries with high value markets. Increasingly, production and product standards will set hurdles to exports. Organisations which are not able to comply with such standards may

have very limited chances to compete in international markets. *icipe* should optimise collaboration with export companies and offer services against adequate payment of *icipe* staff.
- *icipe*'s activities in horticultural research and capacity building should continue to put emphasis on developing IPM packages for crops in which pests are not controlled with sustainable methods. Efficient technology transfer and capacity building on all levels in the value chains of horticultural production are a great strength of *icipe*'s projects and has given *icipe* a high reputation and recognition among stakeholders like the Kenyan and Ethiopian Ministries of Agriculture, the horticultural export association and smallholders. These efforts should continue and if possible extend to other SSA countries.
- Economic and social analyses play a major role in understanding market mechanisms and behaviour of farmers and other stakeholders. In order to respect best the needs and expectations of smallholders and commercial producers, socio-economic studies should become an integral part of each project.
- The two highly qualified *icipe* research groups of chemical ecology and arthropod pathology have a great potential for identifying and developing new volatile compounds and fungal pathogens against migratory locusts in SSA. This potential should be strengthened by closely collaborating with high quality partners and private service providers in other African countries with the aim of product registration and best protection of *icipe*'s intellectual property rights.

4.2. Animal Health Division

Over two-thirds of the population in the developing world are small-scale farmers, many of whom are dependent on livestock for their everyday survival. Improvement of livestock health and productivity thus provides a significant opportunity to improve the livelihoods of these poor people and to help them escape the poverty cycle. It is also important to meet the increasing demand for livestock products and to enhance traction power of oxen for improved agricultural productivity. The main focus of *icipe*'s animal health programme is to develop methods and techniques to control populations of tsetse flies, to reduce their blood-feeding on cattle, reduce the bovine trypanosomosis transmitted by tsetse flies and to implement these measures on a large scale. The research and development scope is fairly diverse including identification and testing of repellents and attractants, design of traps for flies and of dispensers for biological control agents, design of durable repellent dispensers for long term use on cattle, molecular characterisation of trypanosome parasites, functional studies of midgut enzymes in tsetse flies, test of potential biocontrol agents for tsetse, design of a trapping system to monitor the occurrence of tsetse flies, studies on growth and mortality of sheep and goats under high tsetse challenge, the financial implications of rearing sheep and goats under natural trypanosomosis risk, and the development of an adaptive tsetse population management scheme for a community in Ethiopia. Additionally, some effort was diverted into studies on tick attractants and repellents, biological control agents effective against ticks, development of baited traps to attract and contaminate ticks, and to characterise protective antigens from the midgut of ticks. The review team had access to extensive documentation on the research and development enterprises for the appropriate time period, met several of the researchers personally, and also visited field study areas in Kenya and Ethiopia with possibilities to meet and communicate with the cattle owners in the areas where control measures are tested.

4.2.1 Research

TSETSE FLIES AND TRYPANOSOMOSIS

The occurrence of trypanosomosis transmitted by tsetse flies is a major mortality factor in cattle in several countries of SSA. The trypanosome, before killing the oxen, strongly reduces their working capacity thereby also reducing the farmers' ability to maintain their agricultural activities. The animal health programme scientists performed basic research to further refine the tsetse fly repellents that have been developed within the group, to construct a durable and efficient repellent dispenser for use on cattle, to assess the toxicological profile of repellents to cattle, to monitor the prevalence of trypanosomosis in cattle and tsetse populations, to map the farmers' perception of the importance of trypanosomosis for cattle health, to evaluate the farmers' understanding of the transmission of trypanosomosis, to evaluate the usefulness of tsetse repellents and baits in 'push-pull' tactics for tsetse and trypanosomosis suppression, to characterise olfactory receptor proteins in tsetse flies, to study the ability to interfere in the first phase of the trypanosome infection of the tsetse fly,

and to characterize the genetic variability among isolates of *Trypanosoma evansi*. The research has been successful with major developments in tsetse chemical ecology leading to a deeper understanding of the complexity of behavioural responses and how they relate to olfaction cues—both repellents and attractants and blends of them. Major outcomes of these studies are the patented synthetic tsetse fly repellent, and the waterbuck blend tsetse fly repellent, both of which have potential for commercialisation.

Repellents, attractants and trap design: The tsetse group team evaluates repellents to savanna tsetse, test electroantennographically active compounds on *Glossinia morsitans* in two-choice wind tunnel experiments, studied attraction of tsetse to traps baited with different blends of odour baits in different vegetation types, compare the odour composition of the preferred (buffalo and ox) and non-preferred (waterbuck) hosts of savanna tsetse, develop a multipurpose trap for tsetse and other biting flies, and design repellent collars for tsetse control.

Molecular studies on Trypanosoma: The tsetse group team has genetically characterised *Trypanosoma evasi* by several methods, created protein-protein interaction map of the *Trypanosoma cruzi* ribosomal protein, studied the involvement of tsetse midgut lectin-trypsin complex in *Trypanosoma* infection, characterised proteolytic lectin from the midgut of *Glossinia fuscipes*, and performed comparative studies of midgut trypsin/lectin activities and trypanosome infection rates in tsetse flies.

Biological control methods: There is a very distinct need for control measures against tsetse flies, and ideally new control method should meet the requirements of not causing environmental hazard. The tsetse group team has identified entomopathogenic fungi as potential biocontrol agents for tsetse flies, and designed a low-cost fungus-contamination device for control of the flies.

Monitoring of tsetse fly populations: A prerequisite for evaluating the success of tsetse control measures is an efficient and systematic monitoring of the tsetse populations, but population measurements have been hindered by the lack of efficient traps and trapping systems. The tsetse team has designed the NGU trap and a trapping system to monitor the spatial and temporal occurrence of tsetse flies, and studied the seasonality and diel activity of *Glossinia morsitans submorsitans* in Ethiopia.

Cattle fitted with tsetse repellent collars. icipe is working with business partners to further optimise and mass produce these prototype repellent collars into commercial products

More applied research within the animal health programme is focused on community-based tsetse fly and bovine trypanosomosis control, with major field studies performed in both Kenya and in Ethiopia. The community members were trained on how to make traps, how to use traps and how to maintain the traps, and they then established and maintained traps over extended periods of time. The results in Kenya show a tremendous reduction in the population of tsetse flies. Development of a different trapping system maintained by community members is being used in Ethiopia. The distinct reduction in tsetse populations and in the incidence of bovine trypanosomosis has provided the farmer community with a vision of a prosperous future in a previously hostile environment. The success is so distinct that it might be wise to look into the environmental health aspects of greatly expanding the cattle industry into the previously untouched and virgin savanna of southwest Ethiopia.

Community based tsetse and trypanosomosis control: Farmers are strongly affected by the occurrence of trypanosomosis, and could thus be motivated to perform their own control if provided with critical knowledge and reliable methods. The tsetse team has studied livestock farmers' perception of the epidemiology of bovine trypanosomosis in Kenya, the growth and mortality of sheep and goats under high tsetse challenge, the financial implications of rearing sheep and goats under natural trypanosomosis risk, the eco-social effects of community participatory tsetse and bovine trypanosomosis control, and has developed an adaptive tsetse population management scheme for Luke community in Ethiopia.

TICKS AND TICK-BORNE PATHOGENS

Ticks are vectors of several protozoan, bacterial and viral diseases, and thus are important targets for research on control methods and strategies. There is a special need for development of simple sustainable technologies for on-farm management of ticks and the diseases they transmit. These on-host and off-host tick population management strategies might be based on biological pesticides, botanical repellents and behavioural manipulation of the cues ticks use to find hosts, mates and preferred feeding sites. *icipe*'s research on ticks and tick-borne animal diseases is focused on testing the blends of repellents and attractants from preferred and avoided vertebrate hosts, constructing a device for infecting ticks with a biological control agent, and monitoring the epidemiology of the tick-transmitted East Coast fever of cattle.

Biological control and infection device: The tick group team has studied the effects of combining two fungi species on the mortality of the tick *Amblyomma variegatum*, the visual evaluation and recognition of host by the tick parasitoid *Ixodiphagus hookeri*, characterised the cattle and tick odours used in host habitat and host finding by the tick parasitoid, and designed a prototype baited trap for attracting and infecting ticks with fungi.

Tick repellents and attractants: The tick group team has shown that attractive and repellent host odours guide ticks to their respective feeding site, and studied the attraction of the tick *Amblyomma variegatum* to the attraction–aggregation–attachment pheromone with or without carbon dioxide in the field.

4.2.2 Technology transfer and capacity building

Research and knowledge generated within *icipe* had a significant impact on practical application of research results and the adoption of *icipe* technologies and systems.

- The *icipe* odour-baited NGU trap technology has been deployed in a 500 km^2 in Luke, Ethiopia, reducing tsetse populations by 99% and resulting in reduction of disease incidence by 20%; the number of cattle increased by three times, and milk yields doubled; more than 1500 farmers have adopted the technology.
- In Mwea, Kenya, *icipe*'s NGU traps reduced tsetse numbers from over 70 to less than 10 flies per trap and day, resulting in improved livestock health and productivity, and minimising the conflicts between farmers and wildlife.
- The trapping technology developed by *icipe* is being widely used by several NGOs in eastern and southern Africa for monitoring and suppressing tsetse fly population.

The capacity building includes the ARPPIS regional doctoral programme, the ARPPIS Sub-regional Masters Programme, the Dissertation Research Internship Programme (DRIP), the Professional Development Scheme, and training courses organised by *icipe* as well as participation of *icipe* staff in training courses organised by other institutions. The training of PhD and MSc students was performed at *icipe*, although these students had to be registered at a university to receive their degree. In total seven PhD students initiated their research work at *icipe* during the years 2002 to 2006 and they were registered at Kenyatta University (3 students), Moi University (1 student), University of Pretoria (1 student), University of Wageningen and Nairobi University (1 student) and Jomo Kenyatta University of Agriculture & Technology (1 student). In total two MSc students initiated their work at *icipe* during the years 2002 to 2006 and they were both registered at University of Nairobi.

Capacity building in the form of training courses was provided for a total of 999 participants from 23 African countries. In total this capacity building included three training courses in 2003, three in 2006 and one in 2007.

4.2.3 Product and market development

The ability of researchers to gain access to funding of their suggested research and development studies is a sign of success on the 'research and development market' and the products are mainly intellectual (reviewed scientific papers, reports, recommendations, etc.), but could also be physical (chemicals, tools, etc.). Development within the research market takes time and relies on the researchers' long term ability to produce good standard research results and to convince donors of the value of the suggested studies. The tsetse and bovine trypanosomosis research team in the animal health programme at *icipe* has been very successful in the 'research and development market' and, in addition, has research based products in the pipeline for commercialisation. Such products are the synthetic tsetse fly repellent, a collar dispenser for the repellent, and

a trap for riverine tsetse (vectors of human African trypanosomiasis).

Proposals and success: The Animal Health Division submitted a total of 22 proposals during 2002 to 2007 and 4 of 17 evaluated proposals were provided funding. The 24% success rate gives indication of good scientific standard. A further five proposals are under review.

External financing: The Animal Health Division at *icipe* has been successful in project financing with US$ 922,716 from external sources (IFAD, WHO-TDR, SDC, IFS, WHO, BioVision Foundation, EU Inco, Gates Foundation) providing about US$ 185,000 annually.

Publications: In the years 2002 to 2006 the research results were published in a total of 32 reviewed papers (2002:11, 2003:6, 2004:5, 2005:5, 2006:6), two books (2003:2), and four book chapters (2002:1, 2004:3). In addition, researchers at the Animal Health Division registered a patent on a synthetic tsetse fly repellent.

4.2.4 Overall assessment and recommendations

In general the basic and applied research and development activities in the Animal Health Division keep a very good standard and are innovative. Most promising for future development are the community-based tsetse fly and bovine trypanosomosis suppression methods based on efficient and large scale trapping of tsetse.

Recommendation: A priority should be to find the most appropriate means of scaling up the community-based strategies to cover whole regions, initially in Kenya and Ethiopia, and subsequently also in other countries within the tsetse fly infested areas of SSA.

Also promising is the development of tsetse fly repellents based on odour blends from attractive and non-attractive host animals, and the development of appropriate repellent dispensers to be used on the cattle.

Recommendation: Invest in more up-to-date equipment for analysis and chemical characterisation of odours to increase the speed and efficiency in finding new and interesting substances. The development of repellent dispensers should be given high priority, since these dispensers form a basis for using new repellents on cattle.

It should be stressed that success in the control of vectors and vector-borne diseases will ultimately rely on the constant development of multiple suppression and control methods and techniques—history has shown over and over again that the battle will continue and that there is no final solution.

Recommendation: Continue with a relatively diverse research scope to be able to find new and truly innovative ways to control insects and other arthropods involved in animal health.

4.2.5 Outlook

- The very successful trials with community-based control of tsetse and trypanosomosis in cattle should be up-scaled and expanded to new geographic areas. This will probably need some refinements of strategies to avoid some of the structural problems that may occur in a large organisation.
- More in-depth studies on vector arthropod repellents and attractants probably have potential for exiting new findings, but to be efficient and effective may require more up-to-date laboratory equipment. Especially important for such studies is also the innate capacity to keep live insects indoors for experimental purposes.
- For broadening the scope of the Animal Health Division, we suggest the initiation of a research team with focus on vector-borne animal diseases transmitted by nematoceran flies. Examples of such pathogens and insects are Rift Valley fever virus, the culicine mosquito vectors, the blue tongue virus and the sandfly vectors.

4.3 Human Health Division

Vector-borne diseases remain a significant public health problem throughout SSA. Diseases such as malaria, leishmaniasis, human African trypanosomosis and onchocerciasis are among the most prevalent arthropod-borne diseases in the region. In addition, several mosquito-borne arboviruses such as dengue viruses, yellow fever virus, chikungunya virus and Rift Valley fever virus are among the re-emerging diseases that pose a threat globally. An increase in community productivity cannot occur without a healthy workforce, and the human health group team therefore focus on improving the health of people so that they can be more active in economic development. Though some efforts have been made to reduce morbidity and mortality due

Although many communities in Africa are vulnerable to malaria, the majority of them, especially in the rural areas, still lack the necessary information to protect themselves against the deadly disease. icipe has been in the forefront in empowering communities across Africa, from children to adults, by enhancing their access to knowledge through integrated malaria management strategies.

to these diseases, they continue to increase in intensity and geographic coverage because of insufficient action to break the transmission cycle. Since the 1970s little attention was given to vector control and this resulted in a dramatic decrease in human and financial resources in many African countries. However, a growing national and international interest and commitment in increasing the efforts to control these vector-borne diseases have surfaced in the last decade. The integrated approach for controlling vector-borne diseases is gaining support at all levels, and *icipe* can contribute by developing methods and techniques for environmentally friendly control of vectors, to monitor the vector populations and their transmission potential, to develop integrated vector management strategies for use in diverse ecological settings, and by innovative research along previously unknown lines that may lead to new control strategies. Because of the short generation times of both the vector and the pathogen species and their respective and impressive capability of developing resistance and to adapt to changing environments, there is a continued need for research and innovations to maintain a control over such devastating human infections.

Based on the knowledge that since long time malaria is the most important vector-borne disease of humans in Africa, the main focus of the human health programme at *icipe* is to develop methods and techniques to control human malaria transmitted by *Anopheles* mosquitoes, to provide a coverage of the several human influenced habitats where malaria transmission occurs in Kenya, and to implement feasible measures for vector and malaria control on a large scale. The geographic and ecologic strategy is based on knowledge of the various ecological contexts, often those created by human activities, where the transmission of malaria is more or less intense. The research and development and implementation scope is accordingly very diverse including studies on *Anopheles* repellents and attractants, trap design and sampling strategies for adult mosquitoes, larval ecology and control, geographical information systems, blood meal hosts, mosquito plant feeding, population structure and gene flow, geographical, spatial and temporal distribution, experimental infection and transmission, mosquito predators, models and simulations, oviposition and egg survival, community-based and integrated vector control, adulticides, mosquito diversity, mosquito ecology, malaria ecology and epidemiology, human infection and attractiveness for vectors, biological control agents and devices, and others. The review team had access to extensive documentation on the research and development enterprises for the appropriate time period, met several of the researchers personally, and also visited field study areas in rice-growing areas of the Mwea region, the Mbita campus at the Lake Victoria region and the urban cities of the coastal region, with possibilities to meet and communicate with the mosquito scouts, communities and with medical doctors in the areas where control measures are tested.

4.3.1 Research

HUMAN MALARIA AND ANOPHELES *VECTORS*

The Human Health Division scientists perform fundamental research on malaria transmission and the malaria vector in several ecological settings including rice agroecosystems in central Kenya where communities are surrounded by extensive rice fields that provide larval habitats for *Anopheles* mosquitoes, the highlands of western Kenya where natural swamps and the pits left in the ground after removal of clay for brick-making provide abundant larval habitats for *Anopheles* mosquitoes, and the urban centres of the Kenya coast where a very large number of man-made depressions and containers provide the larval habitats for *Anopheles* mosquitoes. Within these ecologically diverse settings the research is focused on assessment of the seasonal distribution and productivity of the different *Anopheles* larval habitats, the population dynamics of adult female *Anopheles* mosquitoes, the species and diversity

of culicine mosquitoes and the succession of anopheline and culicine mosquitoes.

Repellents and attractants: The malaria group team has studied host-specific, plant-derived and synthetic repellents and attractants, and has been able to find useful repellents, one of which is highly efficient against *Anopheles*.

Trap design and sampling of adults: The malaria group team has developed exposure-free bed-net traps for sampling of malaria vectors, and has evaluated the efficacy of several traps and techniques for sampling of mosquitoes.

Larval ecology and control: The malaria group team has characterised the *Anopheles* larval habitats in rural and urban areas in Kenya and Eritrea, the importance of human-induced land cover changes on mosquito larval habitats, the larval habitats of anopheline and culicine mosquitoes in rice agroecosystems in relation to cropping, the impact of larval habitat management on *Anopheles* populations, the influence of soil quality and fertiliser use on production of *Anopheles* larvae, testing the efficacy and efficiency of new *Bacillus thuringiensis israelensis* and *Bacillus sphaericus* formulations against anopheline larvae, laboratory evaluation of larvicidal botanicals against *Anopheles gambiae*, and testing *Bacillus thuringiensis israelensis*, *Bacillus sphaericus* and Temephos against anopheline larvae in Eritrea.

Geographical information systems: The malaria group team has linked field-based ecological data with remotely sensed GIS data in malaria endemic urban areas of Kenya, tested the capability of multi-spectoral thermal data for identification of *Anopheles gambiae* larval habitats, tested the capability of environmental data for identification of *Anopheles* larval habitats, evaluated the link between topography and malaria transmission heterogeneity in western Kenya highlands, developed a geographic sampling strategy for studying relationships between human activity and malaria vectors in urban Africa, and designed a grid-based infrastructure for ecological forecasting of riceland *Anopheles arabiensis* larval habitats.

Blood meal hosts: The malaria group team performed a blood meal analysis for anopheline mosquitoes sampled along the Kenya coast and evaluated the effect of digestion on the success of amplifying human DNA in arthropod blood-meals.

Plant feeding: The malaria group team found a discriminative feeding behaviour of the main malaria vector *Anopheles gambiae* on endemic plants in western Kenya, an influence of sugar availability and indoor microclimate on survival of *Anopheles gambiae*, and tested the feeding and survival of *Anopheles gambiae* on plants growing in Kenya.

Population structure and gene flow: The malaria group team studied the population genetic structure of *Anopheles arabiensis* mosquitoes in Ethiopia and Eritrea, of *Anopheles gambiae* mosquitoes on Lake Victoria islands, the behavioural determinants of genetic flow in malaria vector populations and the dynamics of gene introgression in the African malaria vector *Anopheles gambiae*.

Geographical, spatial and temporal distribution: The malaria group team studied the spatial and temporal heterogeneity and distribution of *Anopheles gambiae* and *Anopheles funestus* mosquitoes and *Plasmodium falciparum* transmission along the Kenya coast, the spatial distribution of *Anopheles gambiae* and *Anopheles funestus* and malaria transmission in a part of Kenya, the distribution of anopheline mosquitoes in Eritrea, the seasonal abundance, vector behaviour and malaria transmission in Eritrea, defined the link between malaria vectors and environmentally disturbed habitats during the dry season in Kenya, and provided records of *Anopheles arabiensis* breeding on the Mount Kenya highlands indicating indigenous malaria transmission.

Experimental infection and transmission: The malaria group team studied the development of *Plasmodium falciparum* in experimentally infected *Anopheles gambiae* under ambient microhabitat temperature in western Kenya, the resistance of early midgut stages of natural *Plasmodium falciparum* parasites to high temperatures in experimentally infected *Anopheles gambiae*, the development of *Plasmodium falciparum* in the midgut of *Anopheles gambiae* feeding on some common plants in western Kenya, and found a quantitative trait loci controlling refractoriness to *Plasmodium falciparum* in *Anopheles gambiae* from a malaria endemic region in Kenya.

Mosquito predators: The malaria group team assayed midguts of dragonfly nymphs for *Anopheles gambiae* larval DNA, studied the ecological limitations on aquatic mosquito predator colonising in the urban environment, found a spider that feeds indirectly on vertebrate

blood by choosing female mosquitoes as prey, and showed the use of *Anopheles*-specific prey-capture behaviour by the small juveniles of *Evarcha culicivora*, a mosquito eating jumping spider.

Models and simulations: The malaria group team constructed a greenhouse-enclosed simulation of a natural *Anopheles gambiae* ecosystem in Kenya, an individual-based model of *Plasmodium falciparum* malaria transmission on the coast of Kenya, and a simulation model of African *Anopheles* ecology and population dynamics for the analysis of malaria transmission.

Oviposition and egg survival: The malaria group team studied the development and survival of *Anopheles gambiae* eggs in drying soil, found that semiochemicals of microbial origin mediate oviposition site selection in the African malaria mosquito *Anopheles gambiae*, and studied the daily oviposition pattern of *Anopheles gambiae* on different types of substrates.

Mosquito diversity: The malaria team group studied mosquito species diversity and abundance in relation to land use in a rice-land agro-ecosystem in Mwea in Kenya, investigated the mosquito species succession and physico-chemical factors affecting their abundance in rice fields, and gathered information on mosquito vector behaviour, diversity and species richness in rice agro-ecosystem in Kenya.

Mosquito ecology: The malaria team observed that for the first time ever, *Anopheles gambiae* were found breeding in tree holes that were previously unreported habitats for malaria vectors. They also estimated population density, dispersal and survival for *Anopheles gambiae* and *Anopheles funestus* along the Kenyan coast using mark-release-recapture methods, tested the application of the pupal demographic survey methodology to identify the key container habitats of *Aedes aegypti* in Malindi district in Kenya, and studied mosquito mating behaviour.

Malaria ecology and epidemiology: The malaria group team showed that low recovery rates stabilises malaria endemicity in areas of low transmission in coastal Kenya, observed high seasonal variation in entomological inoculation rates in a semi-arid region of unstable malaria in Eritrea, discerned *Plasmodium falciparum* gamete carriage in asymptomatic children in western Kenya, studied the seasonality of *Plasmodium falciparum* infection and risk factors for gamete carriage in rural western Kenya, and studied *Plasmodium falciparum* disease manifestation in human and transmission to *Anopheles gambiae*.

Infection and attractiveness for vectors: The malaria group team showed that malaria infection increases the attractiveness of infected humans to mosquitoes, studied the relation between body size of *Anopheles* mosquitoes and *Plasmodium falciparum* sporozoite rates, studied the influence of age and previous diet of *Anopheles gambiae* on the infectivity of natural *Plasmodium falciparum* gametocytes from human volunteers, observed that the prevalence of *Plasmodium falciparum* gametocytes in human blood increases the gravidity of *Anopheles gambiae*, studied self-reported malaria and mosquito avoidance in relation to human behaviour in a city, described the malaria prevalence and associated risk factors in Eritrea, and showed the moderate effect of artemisinin-based combination therapy on transmission of *Plasmodium falciparum*.

Biological control agents: The malaria team group tested the infection of malaria and filariasis vectors with an entomopathogenic fungus.

Other studies: Besides work pertaining directly to a predator (*Evarcha culicivora*), a jumping spider that specialises on *Anopheles* spp., the malaria team has been active in supporting basic research on predator–prey relationships. This additional work has resulted in publications on the interrelationship between spiders and ants, on how mosquito-eating predators are affected by spider-eating predators, on the predators' sensory systems and on the predators' decision-making processes.

Agroecosystem approach to malaria control: More applied research within the human health division is focused on strategies to strengthen cooperation between community, government departments and international and non-governmental organisations towards malaria control, to evaluate the impact of integrated anti-malaria interventions on vector populations and malaria incidence, to assess peoples' behavioural change towards malaria control actions, and to study the feasibility of rotating the cultivation of rice and soy bean as a method of simultaneously increasing household income, improving nutrition and reducing the larval habitats of the malaria vectors.

Community-based and integrated vector control: The malaria team described the rationalising historical success of malaria control in Africa in terms of mosquito resource

management, evaluated spatial targeting of *Culex quinquefasciatus* aquatic habitats on modified land cover and recommends implementation of an integrated vector management approach at community level to control malaria, initiated collaboration with seven institutions working on urban malaria in Africa, the Middle East and the Americas, and designed and implemented community-based vector control projects in Nyabondo, Mwea and Malindi in Kenya.

Adulticides: The malaria group team tested the field efficacy of thermally expelled or live potted repellent plants against African malaria vector in Kenya, studied the fumigant toxicity of the essential oils of some African plants and constituents of *Conyza newii* against *Anopheles gambiae*, and evaluated the trial with permethrin-impregnated bed-sheets *(shukas)* in an area of unstable transmission in Kenya.

4.3.2 Technology transfer and capacity building

Research and knowledge generated within *icipe* had a distinct impact on practical application of research results and the adoption of *icipe* technologies and systems.

- After conducting two regional training workshops on integrated vector management for senior managers of malaria control programmes from 35 countries in Africa, five countries have already adopted the strategy and have established an integrated vector management (IVM) focal point within their ministries, underlining the policy decision in those countries to support IVM.
- After introduction of community-based IVM in Nyabondo, Mwea and Malindi (all Kenya), malaria prevalence in the study sites was reduced by more than 50% within two years.
- The research and the knowledge generated within *icipe* played a major role in rejuvenating vector research and control portfolio within the donor communities as well as in African Ministries of Health and National Malaria Control Programmes.
- In addition, *icipe* played a key role in forming a policy against indiscriminate use of pesticides for malaria control, e.g. the debate on re-introduction of DDT.

The capacity building includes the ARPPIS regional Doctoral Programme, the ARPPIS Sub-regional Masters Programme, the Dissertation Research Internship Programme (DRIP), the Professional Development Scheme, and training courses organised by *icipe* as well as participation of *icipe* staff in training courses organised by other institutions. The training of PhD and MSc students was performed at *icipe*, although these students had to be registered at a University to be able to receive their degree. In total 35 PhD students initiated their research work at *icipe* during the years 2002 to 2007 and they were registered at Kenyatta University (10 students), University of Ghana (1 student), Egerton University (1 student), University of Illinois (2 students), University of Tulane (1 student), University of Miami (2 students), University of Dar es Salaam (1 student), University of Wageningen (1 student), University of Nairobi (3 students), Virginia Technical University (1 student) and Jomo Kenyatta University of Agriculture & Technology (1 student). In total 7 MSc students initiated their work at *icipe* during the years 2002 to 2007 and they were registered at Kenyatta University (3 students), Egerton University (1 student), University of Dar es Salaam (1 student), University of Nairobi (2 students) and Jomo Kenyatta University of Agriculture & Technology (3 students). In addition, two Master of Public Health students (University of Nairobi) and one Master of Arts student (Kenyatta University) were performing their studies at *icipe*.

Capacity building in the form of training courses was provided for about 350 participants from 16 African countries. In total this capacity building included four training courses in 2002, one in 2003, three in 2004, two in 2005, and one 2006.

One of the major developments is the integrated vector control through community participation, which is a project that includes research, technology transfer, capacity building and the often sought sustainability dimension. The review team visited such communities in Mwea (surrounded by rice fields) and Malindi (urban area), and was impressed by the long-term motivation the research team had created in these communities.

4.3.3 Product and market development

The ability of researchers to gain access to funding for their suggested research and development studies is a sign of success on the 'research market' and the products are mainly intellectual (reviewed scientific papers, reports, recommendations, etc.), but could also be physical (chemicals, tools, etc.). Development within the research market takes time and relies on the researchers' long term ability to produce good standard research

results and to convince donors of the value of the suggested studies. The Human Health Division at *icipe* has been highly successful in the 'research and development market' in the period 2002 to 2007, as shown by the very high success rate at the international scientific arena. At least one product, the efficient repellent against *Anopheles* mosquitoes, is interesting to commercialise.

Proposals and success: The Human Health Division submitted a total of 38 proposals during 2002 to 2007 and 18 out of 30 evaluated proposals were provided funding. The 60% success rate, which by most standards is very high, is a sign of excellent scientific standard. A further 8 proposals are under review.

External financing: The Human Health Division at *icipe* has been very successful in project financing with US$ 5,552,045 from external sources (WHO, NIH, IDRC, SDC, Global Fund, FNIH, BioVision Foundation and the Finnish Govt) providing about US$ 1,110,409 annually.

Publications: In the years 2002 to 2006 the research results were published in a total of 85 reviewed papers (2002:12, 2003:21, 2004:26, 2005:10, 2006:16) and one book chapter (2005:1).

4.3.4 Overall assessment and recommendations

The characterisation of *Anopheles* larval habitats by *icipe* researchers was a major step towards the renewed interest in mosquito larval control as a method to reduce malaria transmission.

Recommendation: The large variation in larval habitats for a mosquito species, and the potential for variation in preferred larval habitat between geographic populations of a species, are important to characterise efficient larval control. Preferably such studies should initially involve populations in geographically distant populations to discern the maximum expected habitat preference variation.

The Human Health Division research and technology focus is appropriate and in line with current thinking in basic insect vector research as well as with current thinking on research for development within a multi-stakeholder context.

Recommendation: Continue with the development of appropriate methods to scale up the presently highly successful community-based *Anopheles* and malaria control methods used in a few areas in Kenya to include major part of the country, and evaluate the prerequisites for implementing these methods in other African countries.

The studies on plant feeding in *Anopheles* mosquitoes provide a basis for innovative ideas on how to control malaria transmission around human settlements. Information on the preference for feeding on certain plant species and on the avoidance of others could be used to design new control measures.

Recommendations: Continue with long term studies on the plant feeding preferences of the *Anopheles*, and characterise the olfactory cues that are used by the mosquitoes to localise the host plants. The distinct need of female mosquitoes for regular refilling of sugar provides a very interesting avenue towards innovative methods of *Anopheles* and *Plasmodium* control, provided that the basis for plant choice/avoidance is firmly established.

Linking field-based ecological data on the habitats of mosquito larvae or adult mosquitoes of vector species with remotely sensed GIS data is useful for establishing remote sensing systems to produce risk maps of disease transmission. The recent surge in high resolution satellite data, both from passive and active sensors, provides an invaluable source of largescale environmental data and have to some extent been incorporated into the studies performed by the malaria team.

Recommendation: Develop the risk mapping by remote sensing further for the appropriate *Anopheles* vector species, and utilise the risk maps to focus the community-based control measures to key areas.

Experimental infection and transmission studies with *Plasmodium* in *Anopheles* have been performed by the *icipe* researchers. Such studies are extremely important for the detailed knowledge of the prerequisites for transmission.

Recommendation: Continue with the experimental studies to show the potential of using sugar feeding on specific plants as a method to control the plasmodium infection already in the vector.

The mosquito fauna composition and diversity is usually not very well studied in Kenya and in most other African countries. The high prevalence of malaria in many African countries and the associated morbidity and mortality, leave little capacity for research on the mosquito vectors on several other mosquito-borne human infections. However, the *icipe* research team has performed some basic mosquito fauna studies in agricultural areas of Kenya, with the aim of gathering information on the behaviour of potential vector

species of malaria and other mosquito-borne infections.

Recommendation: Continue with the investigation on the mosquito fauna and expand the studies to include also more natural environments where the risk of some mosquito-borne viruses might be high. In addition, handle the mosquitoes in such a way that they could be used for virus isolations and thus provide valuable data on spatial and temporal occurrence of the pathogens.

Especially impressive is the ability of the research team(s) to work simultaneously along several lines of research and development projects, and to maintain a high level of collaboration among scientists at *icipe* and with scientists in other institutions. The diversity of projects within the Human Health Division may be the platform needed for a creative scientific environment.

Recommendation: To maintain the creative scientific environment and even increase the research standards within the Human Health Division it is recommended that the researchers increase their presence at international scientific meetings, and establish further contacts with appropriate research teams.

4.3.5 Outlook

At present, malaria is the most prominent of the vector-borne diseases in Africa, but other vector-borne diseases are also causing morbidity and mortality as recently exemplified by the outbreak of Rift Valley fever in both humans and cattle in East Africa. Rift Valley fever, and other mosquito-borne viruses such as the dengue viruses, chickungunya virus, o´nyong-nyong virus and West Nile virus, has potential to cause devastating epidemics but their presence, ecology and epidemiology are relatively poorly studied in most parts of Africa. The Human Health Division at *icipe* should take the opportunity and initiate a mosquito-borne virus group to focus on assessment of geographical and temporal distribution of the culicine mosquito fauna of the relevant countries, isolation and characterisation of viruses from mosquitoes to define potential vector species, experimental vector competence studies to define vector competence of potential vectors, etc. The researchers in the malaria group are evidently thinking along this line as shown by their broad focus on both anopheline and culicine mosquitoes for community-based integrated control operations, and their studies on *Aedes aegypti* in Malindi.

Additionally, the Human Health Division may also consider increasing their knowledge and competence in the field of sandflies and sandfly-transmitted leishmaniasis, which may also develop into a new research group. These are infections that are very common in some parts of Africa, causing significant human morbidity and mortality, and that are not very well studied. Thus, there is a need for more detailed knowledge on vector species, their distribution and temporal occurrence, methods to control them, etc.

For all the vector-borne human diseases there is a common problem with unpredictability on the spatial and temporal occurrence of vectors, pathogens and human disease. The present strong development of remotely sensed geo-coded data from both passive and active sensors carried by satellites provides an arena for risk-assessment at almost any scale. The malaria group has already been involved in such studies and for the future this might be a very fruitful area of further development. Remote sensing for malaria and other vector-borne human infections will in the future probably be performed by governmental institutions in many African countries. However, the development of such remote sensing systems is more likely to be performed by scientists and should be very suitable for the *icipe* research teams.

4.4 Environmental Health Division

The main thrust of the Environmental Health Division (EHD) is on adaptive research and demonstrating the value of commercial insects and biodiversity in livelihoods of communities in fragile ecosystems and those around major conservation forest areas. The aim of using this approach is to build knowledge and capacities of communities for conservation and sustainable utilisation of the natural resource base upon

Over 10,000 farmers have been trained to rear silkworms, both wild and domesticated, such as the indigenous African one adorning this woman's arm, from which wild silk is obtained

which successful agriculture and human health is dependent. Currently, the Environmental Health Division (EHD) is pursuing this aim through three key complementary programmes—commercial insects, applied bioprospecting and biodiversity conservation—that are testing and validating technologies in insect and biodiversity related community-based enterprises in apiculture, sericulture and medicinal plant products. The review team reviewed documents on these programmes and was able to visit and discuss with representative communities engaged in these enterprises to build a view of the research work, technology transfer and capacity building as well as the products and market linkages created.

4.4.1 Research

COMMERCIAL INSECTS—APICULTURE AND SERICULTURE

Research in environmental health has been directed at resolving practical problems in the apiculture and sericulture value chain in different ecosystems and to enhance productivity and quality of products from these insect based enterprises. The key products include honey and beeswax products, mulberry and wild silk cocoons and silk products. Some of the research include work on selection of productive races of honeybee, rearing of queen bees and tree species for wild silk moths designed to enhance quantity and quality of sericulture and apiculture products in fragile ecosystems and forest conservation areas. The research outputs in apiculture are already showing tangible benefits in terms of numbers of producers participating, quantities and quality of honey produced and returns to the producer. The work on mulberry and wild silk still has a long way to go before significant tangible results in terms of production and productivity increases at the community level are realised. A critical review of the sericulture work will be necessary to determine appropriateness and conditions that would lead to significant tangible benefits at the community level.

CONSERVING AND MANAGING BIODIVERSITY

icipe is part of Africa's Global Biodiversity Hotspot[1] initiative designed to alleviate poverty and conserve forests in 25 hotspots which include the East African Coastal Forests and Eastern Arc Mountains of Kenya and Tanzania. *icipe* was the lead consultant in preparing the Ecosystems Profile, a document that guides conservation action for this East African Hotspot. On the basis of the ecosystems profile document the Critical Ecosystem Partnership Fund (CEPF—a branch of Conservation International) is investing US$ 7million (2004–2008) for conservation activities in the East African region.

Current research is focused on nature-based enterprises (butterfly farming, honeybees, sericulture) and carbon assessment in the coastal forests of East Africa designed to benefit local communities. For example, there are two students (ARPPIS PhD and MSc, University of Nairobi) research projects looking at the influence of forest proximity on beekeeping enterprises, and on forest pollination services. Both of these projects are at Arabuko-Sokoke Forest, where a portfolio is being put together for the ways in which forest insects benefit local communities.

The programme is also investigating eco-system services (especially carbon storage and pollination services) offered by forests in support of livelihoods in fragile environments. *icipe* has undertaken studies on carbon storage in Kenya. This is an important area of study especially given the topical issue of climate change and the potential opportunities from carbon trade. The programme is working on proposals aimed at developing mechanisms that help vulnerable communities to adapt to climate change related phenomena of extreme variability in weather patterns that often cause severe droughts and flooding.

APPLIED BIOPROSPECTING

Research in this programme has two main thrusts, one community-based and the other aimed at discovering useful products from biodiversity in pharmaceuticals and agricultural pest control. The community-based work is supporting medicinal and aromatic plant-based enterprises for communities living adjacent to major forest areas for example Kakamega, Taita Hills, Lower Tana River, Shimba Hills and East Usambara Mountain Forests in Kenya and Tanzania. The underlying reason is that by creating alternative sources of income through medicinal and aromatic plants this would reduce the pressure on the forests that are threatened with deforestation. The forests are important as they are home to useful insect, plant, animal and microbial species, many of which are unique, rare and endemic to these forests. The research work which involves

1 Internationally recognised and designated biodiversity conservation areas that are under threat. The 25 hotspots cover only 1.4% of the Earth's surface yet contain more than 60% of all terrestrial species.

domestication of useful plants and extraction of essential oils or products is undertaken in partnership with KWS, University of Nairobi and the communities concerned. A lot of work has been done on *Ocimum kilimandscharicum* and its products and *Mondia whytei* and its products, and a number of publications were produced (see list of publications 2002–2006). The work on medicinal and aromatic plants is already having significant impact at the community level for example, as witnessed by the review team in Kakamega where community awareness on the value of forests, income earned by communities and a sense of self confidence in breaking new ground in value addition was evident. Medicinal and aromatic products from these communities are already penetrating national supermarket chains in Nairobi and Kisumu.

4.4.2 Technology transfer and capacity building

COMMERCIAL INSECTS

The programme is focusing on testing and validating apiculture and sericulture technologies in different locations and improving productivity and quality of products from these insect-based enterprises. The underlying argument of the programme is to build people's understanding of the distribution and value of biodiversity and how it is linked to their livelihoods through community natural resource based enterprises. One of the key delivery strategies of the programme is to develop processing and marketing centres for honey and silk. These centres equipped with processing facilities are used as focal points for training producers and bringing together different stakeholders in the apiculture and sericulture value chain. The project approach is to build the capacity of the community to be able to own, operate and manage their enterprise as a business entity and not to be mere suppliers of raw materials for commercial business partners. This approach has been endorsed by the Ford Foundation and IFAD as an innovative model that empowers communities to fully participate in the management of the value chain process. It is recognised that technology transfer in smallholder communities is part of the empowerment process and therefore takes time to realise more widespread impact. *icipe* and its partners are in the process of transferring the technology to the community through technology transfer agreements.

The review team was able to visit Mwingi and Gede Centres and discussed with producers and some of government staff (Livestock, National Museums and Forest Departments) involved in the technology transfer processes with farmers. Training was provided by *icipe* for the different stages of honey and silk value chain. Technical backstopping is available from *icipe* to resolve production and processing constraints in the value chain; in addition, further investigations are underway for more productive honeybee races as well as stingless bees. The quality and packaging of honey produced by these community enterprises was considered to be of a very high standard. In both Centres visited, the sericulture enterprises are still relatively insignificant and perhaps raise questions of appropriateness of the enterprise especially in respect of the growing of mulberry trees in some of erratic rainfall areas. The wild silk production is innovative especially in fragile and dry ecosystems, however conditions for achieving critical levels of production for viability of the enterprises are still to be demonstrated by the programme.

BIODIVERSITY CONSERVATION

The core of the programme is around the biodiversity hotspots in East African coastal forests and the eastern mountains of Kenya and Tanzania and promotion of nature-based enterprises that enhance income earning opportunities, training and appreciation of the value of conserving biodiversity, especially of the neighbouring forests. The programme has established complementary relationships with local partners well grounded in their areas of operation, for example East African Wildlife Society, Forestry Department, National Museums of Kenya and Kipepeo in the Taita Hills and Arabuko-Sokoke forests. *icipe* provides the technical training and backstopping in the community insect-based enterprises while the local partners provide the local producer mobilisation.

Communities interviewed in the coastal forests indicated enhanced appreciation and recognition of the value of forests to their livelihoods as a result of the interventions and training on nature-based enterprises like butterfly farming, honeybees and sericulture. However, they also raised a number of issues, for example the producers in Chawai forest felt the biggest problem of their area was the low fertility of their soils and therefore low yields in their crops. Environmentally friendly ways of increasing soil productivity would increase yields and improve livelihoods significantly and reduce pressure on the natural forest.

Another issue was that although the Kipepeo producers in the Arabuko-Sokoke Forest communities, now numbering about 800, were

bringing in as much as US$100,000 per year from butterfly sales they faced market saturation problems. For example, the farmers delivered about 200,000 pupae but only about 50,000 were exported. The butterfly enterprise is dependent on export markets, links and timely delivery of the pupae to exhibition houses in Europe and the USA.

MEDICINAL AND AROMATIC PLANT-BASED ENTERPRISES

This programme is promoting medicinal and aromatic plant-based enterprises in communities living adjacent to the biodiversity rich forests of Kenya, Uganda and Tanzania. The enterprises are aimed at improving livelihoods of the communities, conserving the forests by relieving some of the economic pressure on forest resources and reducing soil erosion. The enterprises emerging out of research include *Ocimum kilimandscharicum* and *Mondia whytei* and their related products, *Azadirachta indica* (neem products) and resin from pine trees (*Pinus patula)*. The technology package includes training on cultivation of these plants, harvesting and primary processing at the community level.

In Kakamega the *icipe* is working with a local community-based organisation, the Kakamega Environmental Education Programme, to promote environmental awareness and cultivation of *Mondia whytei* a multipurpose medicinal plant as a cash crop. The mondia roots have been traditionally used in these areas for chewing and can be found in local markets. The *icipe* innovation is in the domestication of this wild creeper and development of a commercial enterprise in buying raw roots, processing and product development for high value urban markets. Although there is no hard data on the extent of production and sale of mondia roots as a result of the intervention responses from the project participants indicate that there is potential for mondia to make a significant contribution to household income.

The review team was able to visit the *icipe* work with the Muliru Farmers Conservation Group, Kakamega that is developing a community-based enterprise in the cultivation, processing and marketing of *Ocimum kilimandscharicum* and its products. The Group is currently unable to meet demand of seed for farmers that want to join the cultivation and supply of *Ocimum* leaves to the processing centre. On average cultivation of *Ocimum* by the community generated equivalent of US$ 300 per acre which is more than what they earned from other crops like maize, beans and tea (programme socio-economic survey, 2007). *icipe* has invested in building the processing centre, equipping it and training the core-group to manage the enterprise. However, the organisational sustainability and financial viability of the enterprise are still to be demonstrated. While *icipe* has established suitable commercial partnerships at the finished product end (working with commercial companies for packaging and marketing), there was no appropriate business partner to nurture the enterprise at the raw material supply and primary processing end of things. That means *icipe* takes on this role (where it may not be the best equipped for the role) rather than backstopping a competent business development support service organisation or product related company.

A related issue in technology transfer is the ownership structure and financing of the enterprise and how this affects viability and sustainability of the community enterprise. As the level of capital investment and business turnover becomes significant it will be necessary to tackle these issues as part of capacity building.

4.4.3 Product and market development

The EHD programme has developed a number of high quality products that are already on the market in Kenya and these include honey, silk fabric, Mondia tonic and the Naturub range of herbal products. The programme has worked with community enterprises and commercial companies to produce these products that are targeted at local and export high value markets. For example, between 2004 and 2006 over 115,000 units of Naturub balm and ointment and Mondia Tonic were sold, generating additional revenue of US$ 43,000 for the two community-owned enterprises in Kenya. Expected revenue for these products in 2007 is about US$ 40,000. In 2008, two new enterprises for Naturub balm and ointment will become operational, one in Uganda and one in Tanzania.

The bioprospecting programme is working in partnership with international pharmaceutical companies to discover, develop and commercialise useful products in industry, agricultural pest control and malaria control from biodiversity. Examples of these high tech products include commercial enzymes from insect-derived and other micro-organisms for use in alternative fuel production, and for other industrial, health and nutrition markets as well as insecticidal, fungicidal and herbicidal products from plants, micro-organisms and arthropods.

In 2006, 18.5 tons of mulberry silk cocoons were produced in six countries (Kenya,

Madagascar, Uganda, Egypt, Ghana and Northern Sudan). The cocoons were processed into yarn, generating an additional net income for the participating farmers of US$ 192,000. For 2007 it is estimated that 25 tons of mulberry silk cocoons will be produced.

Uganda is at present the most successful example of *icipe*'s activities leading to the revival of the local mulberry silk production (from 1 ton of cocoons in 2000 to 11 tons in 2006, with an expected 14 tons in 2007), followed by Kenya and Madagascar. The approach of the programme is to help establish community-owned marketplaces and link them to the traders.

For wild silk, *icipe* is the first to ever develop means of producing wild silk, produced by indigenous silkmoth species, in Africa. There is significant demand for wild silk not only from the tourist/ souvenir and fashion industry in East Africa, but also from overseas. The price of wild silk is three times higher than for mulberry silk, depending on the type of market, and at present the demand is three to four times higher than the supply, indicating a real growth potential. *icipe* started only in 2000 its work on wild silk and much of the previous efforts were devoted to the development of feasible wild silk production systems for individual farmers. These are now in place, and in future an increase from the two tons of wild silk moth cocoons produced in 2006 in Kenya and Uganda is expected. Wild silk activities of *icipe* were expanded in 2007 to Madagascar, the Sudan and Yemen. Finally wild silk is the focus of a new joint research activity with Oxford University with a view to medical applications, i.e. as a scaffold to regenerate tendons. It has so far shown great promise: For instance *Gonometa* sp. silk from Mwingi forest in Central Kenya has one of the highest tensile strengths of all insect silks tested to date by the Oxford group.

In 2006, 100 tons of honey have been processed and sold through four marketplaces developed by *icipe* in Kenya, Madagascar, Uganda, and Southern Sudan, generating an additional income for the participating farmers of US$ 2.7 million. In 2007, we shall have five new marketplaces in Kenya, three in Uganda, three in the Sudan, one in Tanzania, two in Madagascar, one in Yemen, and one in Egypt. Hence, we are confident that the 2007–2008 production will be in the range of 150–200 tons.

In addition, the programme has been working with Kipepeo in Gede (covering 50 villages) which now exports more than US$ 100,000 in sales of butterfly pupae per annum to exhibition houses in Europe.

4.4.4 Overall assessment and recommendations

The programme's research and technology focus on basic problems in insect-based enterprise value chains and capacity building is appropriate and in keeping with the current thinking on research for development to work more in multi-stakeholder innovation systems involving government, private, producer and community-based organisations. Stakeholder feedback shows that *icipe* has a credible programme and is well recognised for its human resource development and ways of working with partners and communities.

Recommendation: The programme should build on its working models and put in place systematic lesson learning and sharing framework to answer some of the questions on scaling up and sustainability issues.

The overall goal of *icipe*'s R&D activities in environmental health is conservation and sustainable utilisation of the agricultural production base and important natural ecosystems, by encouraging and utilising arthropod diversity, cataloguing and sharing biodiversity data, and discovering endemic wealth by bioprospecting for useful natural products. The realisation of this goal will depend on breakthroughs in the R&D work as well as the policy and institutional frameworks necessary to spread the emerging innovations.

Recommendation: It is necessary for the R&D work to capture policy and institutional insights that contribute to conservation and sustainable utilisation of agrobiodiversity and important ecosystems through insect science based research work. For example, the programme can draw out lessons on policy and institutional changes required to scale up successful pilots on natural resource based community enterprises in fragile and threatened ecosystems.

From 1996 to 2006 a total of 14,000 farmers/ beekeepers, 600 government extension workers, 55 network partners (from 24 African countries); 12 PhD and 8 MSc students (from five African countries) were directly reached by the *icipe* programme. However, one of the key underlying arguments of the EHD is to preserve the natural resource base (e.g. hotspots) by building an understanding and sense of value of biodiversity to community livelihoods through natural resource-based enterprises that bring tangible benefits to these communities. It is not clear, for example whether 14,000 farmers trained over 10 years is an indicator of good or low performance and the

extent to which it contributes to conservation and sustainable utilisation.

Recommendation: There is need for a hierarchy of shared key indicators for measuring direction and level of success of the programme or thematic area in a manner that facilitates strategic adjustment where necessary. This is particularly so where there is a large number of small research projects and therefore the need to keep track of their contribution to the overall programme aim.

The programme works in partnerships especially in the technology transfer process and development of community-based enterprises. However, at the community level, *icipe* appears to be the main business development service provider, for example in medicinal plants and honey processing. This would raise questions on capacity building, sustainability and scaling up.

Recommendation: It is recommended that the programme reviews and addresses the following questions in order to make a significant contribution to its overall goal on conservation and sustainable utilisation of agricultural resources and natural ecosystems:

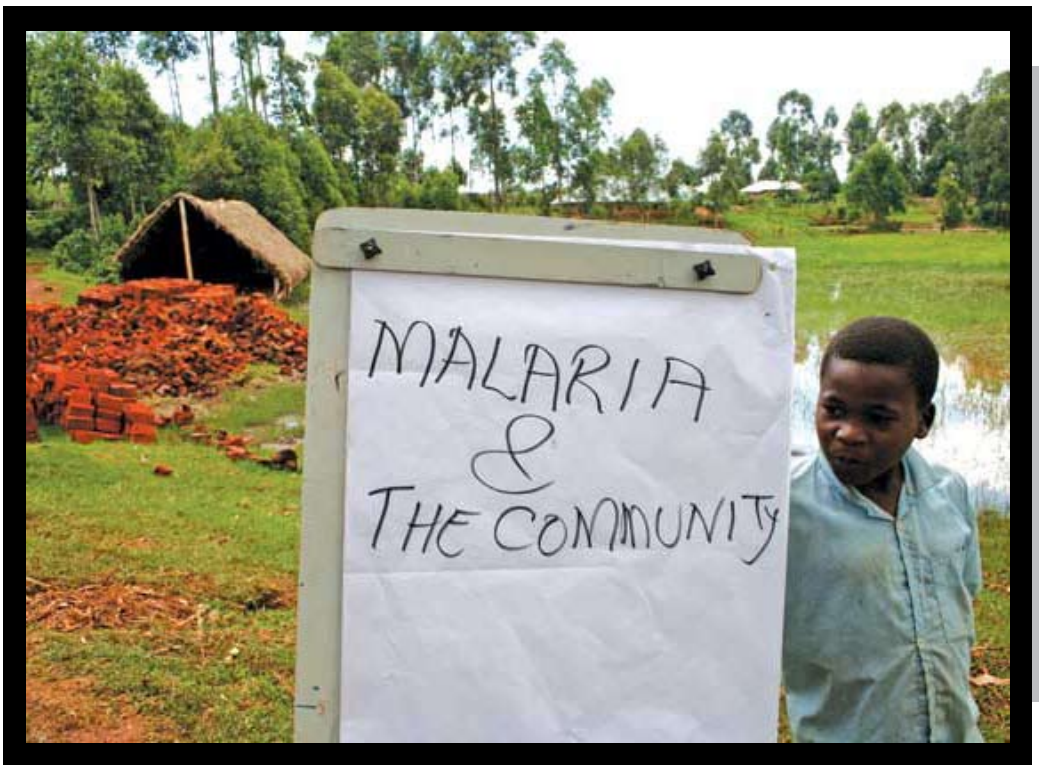
- What institutional capacities are being built in business support services to these enterprises, for example who will continue to provide business support services as *icipe* withdraws?
- What are the ownership and financing structures (this has a bearing on sustainability and replication) that are being tested and validated in these community-based enterprises?
- What replication models or strategies are envisaged beyond the current enterprises, for example in medicinal, honey and sericulture products?

4.4.5 Outlook

The Environmental Health programme is engaged in a key area of environmental sustainability by addressing the management of fragile ecosystems and maintenance of biodiversity through research and development work that supports natural resource-based community enterprise development. This work is designed to achieve a paradigm shift in the community and local authority thinking towards conservation and utilisation of natural resources and biodiversity on which rural livelihoods depend. The programme has appropriately identified the key entry points and needs to build on and consolidate these in partnership with key stakeholders that have potential for scaling up promising innovations in apiculture, sericulture, biodiversity and medicinal and aromatic plants. Key entry points are:

- Providing science-based working models of community enterprises that have potential to contribute to livelihood security and change community and local authority approaches towards the fragile and threatened ecosystems.
- Increasing institutional, human resource and technological capacities in insect science and biodiversity to plan and implement policies, programmes and activities that contribute to environmental sustainability. This points to the need to increase joint programmes with key partners with potential to leverage widespread change.
- Providing informed positions on the impact, opportunities and threats of climate change to communities in fragile and threatened ecosystems that the programme is working with.

5. PARTNERSHIPS AND STAKEHOLDERS



Partnership and stakeholder issues are critical success factors in research, capacity building and market development of *icipe*. The strategic decision of being the leading international insect science institute in SSA was confirmed and strengthened in the strategic review of 2002. The review team recognises that *icipe*'s focus should remain in insect science and related biodiversity issues and not be broadened to other fields. The strength of focusing on insects and mites may be jeopardised if pest problems incur IPM solutions and new crop production systems for which *icipe*'s scientific competences may be too narrow. In such situations, *icipe* has to seek strong partnership and collaboration as done already in the past. The review team was able to visit approximately 30 partners and collaborating institutions in Kenya and Ethiopia and has attempted to assess how *icipe* is viewed by these partners. The interviews were conducted with the aid of a simple questionnaire which allowed the team to catch the major statements and discussion points.

5.1 Institutional and project agreements

One key factor to success for a specialised institute like *icipe* lies in its ability to identify and enter into appropriate collaboration with partners and networks for research, technology transfer and capacity building. Linkages and partnerships can be established on national, regional and international levels depending on tasks and objectives. The review team noted that *icipe* has a large number of partnerships, and over 200 signed Memoranda of Understanding (MoU) with institutions in Africa and overseas. To meet the challenges of the future, *icipe* needs Memoranda of Understanding with strong partners that add value to the scientific competences, increase innovation, show potential for scaling up innovations and have positive impact on programme funding. In other words, *icipe* has to choose partners based on qualitative criteria that respect increasingly the overall values added to programmes.

The review team recognises that a number of Memoranda of Understanding are not in force anymore, were never implemented, or they were not formally signed. Such Memoranda of Understanding are either meaningless with no further consequences or they bear an inherent risk of unfulfilled expectations on collaboration among partners with a potential of losing credibility. Similar comments and recommendation were already stated by the

2002 review team (p. 56). *icipe's* management has initiated a process of reducing the number of Memoranda of Understanding and to strengthen those which are of strategic and scientific value for *icipe*, and as such may also increase chances in programme fund raising.

5.2 Research

There is no doubt by the review team that *icipe*'s strategic decision to focus on arthropod science is a strength and qualification of the institute. However, IPM solutions require most often close interaction with other crop management disciplines like disease and weed control, soil management and fertilisation. Farmers may need full crop management packages which are beyond the competences of an insect science institute, and therefore it is crucial for *icipe* to collaborate with high quality partners complementing *icipe*'s strength and building synergies. Similarly, the rural and urban populations need integrated full packages for insect vector and disease control which is beyond the competence of *icipe* and would require collaboration with high quality partners that complement *icipe*'s competences.

icipe's 10 major partners in research and scientific collaborations inside and outside Africa are listed per division and groups in Annex 2. More detailed information on type of collaboration is given in different *icipe* internal documents (e.g. *icipe*'s partners and donors 2006–2007, agricultural entomology research at *icipe* 2007, *icipe* key collaborators 2007). From the summarised information it can be concluded that many of *icipe*'s partners are well-known scientific institutions or individual scientists with high international recognition.

Information on peer reviewed and other publications of scientific value (e.g. book chapters), and the number of proposal development of the four research divisions and for capacity building programme is given in Annex 3. The total number of 341 peer reviewed articles and 78 other publications of scientific value from 2002–2006 contributes substantially to the international scientific reputation of *icipe*. The mean number of publications per year and scientist was roughly two (peer and non-peer reviewed) from 2002–2005 and increased considerably in 2006. If taking into account additional non-scientific publications produced for technology transfer and capacity building (see 5.3), the average per scientist is reasonable. More details on scientific publications from 2002–2006 including authors, titles and journals per division are compiled in an internal report of April 2007. From the summary tables of this report it can be seen that the production of publications is quite different between divisions and groups and it would be interesting to analyse the reasons and then draw conclusions.

Stakeholder feedback from visits of partner institutes in Nairobi and Addis Ababa ranged from "very satisfied" to "not fully satisfied" in scientific collaboration, but most of them being "very satisfied". More in-depth analyses of the questionnaires revealed that institutional and programmatic collaboration is considered excellent by most partners, and all of them wish to continue and to strengthen partnership with *icipe*. In particular, national partner institutions in Kenya and Ethiopia consider *icipe* scientists outstanding in the African entomological scientific community. This is not to say that no critical voices were raised by private commercial partners that are regularly exposed to practical insect pest problems, and they therefore expressed a clear need of a more focused 'problem-solving' research approach by *icipe*.

5.3 Technology transfer and capacity building

The *icipe* Capacity Building and Institutional Development Programme is aimed at strengthening capacity in insect science through research training and institutional building; and it has four major components.

- **Higher degree training** for leadership in scientific research and policy formulation. The postgraduate training is held at PhD and MSc levels through the African Regional Postgraduate Programme in Insect Science (ARPPIS) and the Dissertation Research Internship Programme (DRIP).
- **Non-degree training** mainly targeted to practitioners in the national agricultural and health research and extension systems;
- **Professional development programmes**, where postdoctoral fellows, research associates and visiting scientists come to *icipe* to develop and share expertise; and
- **Interactive on-site training**, through collaborative research work carried out with *icipe*'s national partners.

The ARPPIS and DRIP programmes have achieved outstanding results with 74 PhD and 120 MSc degrees conferred to *icipe* students over the years 2002–2007 (Annex 4). More details of the ARPPIS and DRIP programmes are given in the ARPPIS report of 2005–2007. Most of these scientists have remained in the African research community

and the review team met and discussed the programme with several of these previous *icipe* students. The capacity building programme is recognised as one of *icipe*'s strengths contributing to human resource development in insect sciences and understanding of the impact of insects and biodiversity on African livelihoods.

The programme has provided a framework for individual scientists and more than 30 African universities, and other non-African research institutions, are involved in the network on insect science and biodiversity conservation.

Stakeholder feedback from Kenyan institutions to the review team was very positive with regard to ARPPIS and DRIP. MSc and PhD students who have achieved their degrees at *icipe* within ARPPIS and DRIP programmes are considered to be better trained in entomological science compared to those students who did not visit these programmes.

Technology and knowledge development at *icipe* can provide positive impact on tropical arthropod problem solving only if it is disseminated in appropriate ways to the right stakeholders which adopt *icipe*'s systems. Since 2003, *icipe* has successfully transferred technology which was generated in a number of projects (Annex 5). It is evident that figures on number of people trained for a specific technology given in Annex 5 do not necessarily reflect one hundred percent adoption rates since farmers and other local people may be trained without adopting the system. On the other hand, trained farmers and other local people may transfer technology to others in the same region and thus assist unnoticed dissemination. The figures in Annex 5 are but one appropriate measure, among others, to assess *icipe's* impact on arthropod problem solving in SSA.

Training courses organised by *icipe* constitute an integral and important part of the technology and capacity building programmes encompassing a wide range of topics tailored to the needs of different stakeholders. The list in Annex 6 shows that these training courses were held in Kenya and in other SSA countries. The themes cover all aspects of *icipe's* activities, and all kinds of stakeholders were reached by these courses. Thousands of participants were trained over the last years and the trainees range from farmers to scientists.

icipe's scientists have given over 160 presentations at national and international conferences and meetings in Africa and overseas from 2002 to 2007 (see list in Annex 7). At least three *icipe* scientists will present invited talks and five workshops will be organised by *icipe* staff at the International Congress of Entomology in Durban, South Africa, in 2008. The remarkable international presence of *icipe* scientists is witness of an overall high level of scientific work and recognition in the international scientific community. Furthermore, *icipe* staff has served in scientific journal reviews, has evaluated scientific project proposals, is active in editorial boards and scientists were repeatedly consulted as experts by international organisations (Annex 8).

A considerable amount of teaching material was produced by *icipe* staff (Annex 9). These books, brochures, posters and curricula are invaluable materials for disseminating knowledge and information coming out from research and being transferred to all levels of stakeholders, such as farmers, advisors and private business organisations.

Partners and representatives of collaborating institutions have been interviewed by the review team and were asked specifically to comment on *icipe*'s competence in technology transfer and capacity building. Kenyan government institutions, for example the Kenya Agricultural Research Institute (KARI), the Ministry of Agriculture (MOA), Kenya Plant Health Inspectorate Service (KEPHIS), and private organisations like the Fresh Produce Exporters Association of Kenya (FPEAK) have attested to *icipe*'s very high competences and professionalism coupled with science-based, sound information transferred adequately to all levels of stakeholders. *icipe*'s efforts and successes in capacity building were highly recognised and much appreciated by all interviewed partners.

The Professional Development schemes promote research interaction and networking through visits and exchange programmes that provide opportunities for both young as well as established scientists, including university faculty worldwide, to share and contribute to *icipe*'s research agenda. Through these schemes, *icipe* programmes have hosted some 25 scientists since 2003.

The review team was invited to visit and review two of several **Biofarm Consortium** (BC) projects, one located in the Upper Gibe Valley and one near Addis Ababa in Ethiopia. The objectives of the project are to reduce tsetse and mosquito infestation in Ethiopia, Kenya and beyond by closely cooperating with national disease control programmes and local communities under the auspices of the African Union's programme called 'Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC)'. The goal of Biofarm Consortium is to free both humans and animals from the devastating effects of sleeping sickness, nagana and malaria and allow new potential for improved livelihoods, rural

development and poverty alleviation for rural people. Scale-up efforts are undertaken to increase the outreach in a systematic manner to other parts of the two countries and ultimately to transfer the system and technology to the eastern Africa region. *icipe* is one of the six partners engaged in BC, and the Centre's tsetse and mosquito control projects in Kenya and Ethiopia are the major entry points for the Biofarm Consortium platform. The Biofarm Consortium projects are complex agglomerations of activities that go far beyond *icipe*'s mission and competences (e.g. organic vegetable growing, compost technology, biogas production) and it is, therefore, appropriate to collaborate with other partners that take responsibility for agricultural and domestic innovations not related to arthropods. Such complex programmes may bear an inherent risk to fail because they tend to bring about too many innovations at once, and thus leave no time to rural people to adopt new technologies step-by-step. It should not be ignored that such complex systems need strong and lasting training support by the Biofarm Consortium, and it should be recognised that such technology and training-intensive approaches are difficult to replicate and to transfer to other regions. The review team **recommends** that the role of *icipe* in the Biofarm Consortium be carefully reviewed and that the Centre strictly limit its engagement to arthropod-related activities.

5.4 Product and market development

A list of products that were derived from *icipe* projects and reached markets or are still in the pipeline is given in Annex 10. Research programmes of all four divisions have generated and facilitated development of a number of quality products that have reached local markets or are still under development as, for example, desmodium seed production in collaboration with a private seed company in Kenya, fodder silage systems and equipment for desmodium and Napier grass, fruit fly trap and bait technology for mango growers, *Metarhizium anisopliae*-based mycoinsecticide against fruit flies and the adult pheromone constituent PAN to control desert locust hoppers. PAN has now been registered as a plant protection agent for locust control in the Sudan. The Animal Health Division has research-based products such as a synthetic tsetse fly repellent, a cattle collar dispenser for the repellent and a trap for riverine tsetse, in the pipeline for commercialisation. The synthetic tsetse fly repellent has also been registered as a patent. The Human Health Division has at least one product, an efficient repellent against the *Anopheles* malaria vectors that is interesting to commercialise. Commercial Insects Programme has developed products such as wild and mulberry silk fabrics for local markets and exports, honey produced by local beekeepers trained by *icipe* and butterfly farming products for export (see market figures for quantities and market values in Annex 10).

The review team discussed the question repeatedly at what point *icipe*'s engagement for product development and marketing should end and where the technology should be taken over by stakeholders, e.g. private companies. We came to conclude that these questions must be resolved for each case separately and there is no general recommendation to make. Interviews with the CEO of BridgeWorks, a company specialised in product and market development with a close link to *icipe*, has shown that there is a constant communication and exchange of information between *icipe* researchers and the company which should ensure an optimal technology transfer from *icipe*'s R&D to marketable products.

It is recognised by the review team that *icipe*'s projects are in general highly qualified by interdisciplinary research and development, with solid links to international partners, with efficient technology transfer and outreach and finally, with a good sense for product and market development.

5.5 Recommendations

The review team recognises that some of *icipe*'s partners are highly qualified with a world reputation and they add great value to *icipe*'s programmes by synergistic effects. This is of prime importance for *icipe*'s recognition in Africa and elsewhere, and donors may view and apply such criteria increasingly.

The partner universities (Nairobi and Kenyatta) and other stakeholders interviewed recognised the contribution of *icipe* capacity building programme and provided useful insights on possible areas for strengthening the partnership with *icipe*.

The review team recommends *icipe* to:

- Draw a list of quality criteria for choosing partners and collaborations and screen and select partners of future programmes accordingly.
- Continue the process of reviewing the existing MoU, eliminate those MoU which are of no significance and ensure that the agreements are well aligned with the practices on the ground.

- Strengthen jointly developed research proposals with partner universities rather than just inviting research students to work on predetermined research areas. This would ensure institutional development necessary for the university to provide effective supervision of students in the partnership programme. The partners felt that currently capacity building is limited to the student rather than the institution.
- Invite partner universities to jointly develop research proposals that would ensure that research by students addresses key issues and challenges in communities. This would also ensure that training courses are tailor-made to address emerging needs and challenges in the environment.
- Strengthen joint development of research proposals and to give visibility to partner institutional contributions by apportioning credit in publications and publicity material.

6. EMERGING OPPORTUNITIES AND INNOVATIONS FOR FUTURE PROGRAMMES

Advances in science follow often unpredictable patterns with different disciplines growing at different times and rates, depending largely on factors such as critical breakthroughs, expected market potential of emerging products, recognition of problems by the society at large and expected contribution to problem solving. Because science is an international 'business' with totally globalised characteristics, it is important for *icipe* to foresee and recognise future trends and emerging scientific disciplines in which to invest is best for meeting the Centre's mandate in the future. It is impossible, of course, to attempt a complete analysis of all changes going on in the scientific world and to predict with certainty what *icipe*'s strategic choices should be for the coming 5–10 years. Based on our experience we attempt below to identify some of the ongoing trends that have an obvious significance to *icipe*.

6.1 Climate change and consequences on food production, health and the environment

Global climate change is a reality and there is scientific consensus that this will have a major impact on availability of natural resources, land use and distribution of human populations around the world. Related problems such as food production, vector-borne diseases and changes in biodiversity will emerge and strongly influence livelihood of people in Africa, in particular in rural areas. Enormous resources are now being invested in climate change models attempting to predict the consequences on distribution and abundance of plant pests and diseases, vector-borne diseases of humans and animals and on biodiversity. Despite the fact that such models often bear uncertainties in their predictive value, they indicate with some accuracy the most sensible areas under climate change and thus provide useful information on how these problems may evolve under different scenarios. *icipe* has amassed such a wealth of unique expertise and experience in arthropod-borne problems and biodiversity in SSA that it should attempt to feed in this knowledge and help to improve predictions in critical climatic zones. This could be done in collaboration with qualified groups developing models for SSA. One outcome could be the development of scenarios on impact of arthropod pests on food production in different regions, on vector-borne diseases and on change of arthropod diversity (e.g. pollinators) and their consequences.

6.2 Invasive species and spread of pests and diseases

Increased international trade and travel are leading to the dramatic spread of a large number of plant pests and diseases, human and animal diseases and change of biodiversity. Invasive alien species are considered today to be the second most important factor of biodiversity change after landscape degradation. Research in building up information on invasive alien species, understanding of invasions and ability to predict and survey invasions in sensitive environments will probably become even more important than it is today. Building models for prediction of spread of invasive species under climate change scenarios would strengthen collaborative research and provide incentives for international cooperation on invasive species. Since *icipe* has a good record of successful control of invasive arthropod species it should continue to develop innovative strategies against invasive insects and mites (e.g. biocontrol, approaches with semiochemicals), and more attempts should be made to market these services and products to stakeholders such as KEPHIS and FPEAK. Export companies and plant quarantine services of African countries could make use of *icipe*'s international network in plant health and experience in region-wide problem solving.

6.3 Biotechnology and diagnostic tools

DNA sequencing of arthropod genomes has been achieved for important disease vectors like *Anopheles gambiae* and more genome sequencing is in progress for many other arthropods of economic importance. Scientific and technological progress in biotechnology is extremely fast and new applications emerge at a very high pace making it difficult and expensive to keep up with all of them in plant and insect science. With respect to these technologies, *icipe* has to take strategic decisions which are affordable and will give the Centre a leading role in the region. One such application could be the use in diagnostics of arthropods for genotypes, species and populations. These diagnostic tools would play a major role in understanding taxonomy, ecological interactions, population biology and behaviour. Several of the medically important insects are cryptic species for which there are no reliable morphological diagnostic criteria. Thus, there is a very obvious need for *icipe* to keep up with the developments in molecular diagnostics to be able to provide rapid and accurate species determination for research and control in SSA. These diagnostics will play an important role in understanding and surveying invasive alien species and spread of arthropods under climate changes in SSA.

6.4 Biosafety of genetically modified organisms

Genetically modified plants (GMP) are now commercially grown on more than 100 million hectares worldwide and the trend is clearly indicating that GMP cultivation will increase, especially in developing countries. At present, South Africa is the only country on the continent with commercially grown GMP, however, other SSA countries have run field experiments with GMP and it is a matter of time until other SSA countries will follow South Africa. The controversy around GMP requires biosafety research and capacity building which is independent of commercial interests and scientifically sound to provide the much needed credibility to interested farmers and other stakeholders. Herbicide tolerance and insect resistance are the only traits deployed in commercially grown GMP so far. Effects of insect resistant GMP on non-target arthropods is of particular interest for biological control organisms and biodiversity in agricultural landscapes. Despite the fact that GMP cultivation in SSA is not yet of practical relevance except in South Africa, it is a very controversially discussed issue creating a lot of questions and uncertainties in the public, in the scientific communities and regulatory authorities. *icipe* would have to play a key role in generating objective data, independent of commercial and political interests, and the Centre could thus contribute substantially to science-based information and less emotional discussions on GMP in SSA. Even more important would be to analyse the impact of multinational companies, marketing GMP, on the seed markets in SSA and to study the market behaviour of farmers.

6.5 Surveillance of vector-borne diseases and their vectors

Vector-borne infections in humans are prevalent in many African countries, but because of its enormous medical importance, human malaria (and its mosquito vectors) has been and should continue to be the major focus of *icipe*. However, with the recent progress in community-based malaria and vector control, stakeholders may find that several previously neglected diseases are important to include in the research agenda of *icipe*. The mosquito-borne Rift Valley fever, for example, recently caused a large outbreak in humans and domestic animals that spread through East Africa. Vector-borne infections in

domesticated animals are common in many African countries, but because of its enormous veterinary importance the trypanosomes causing nagana and their vectors should continue to be the major focus of *icipe*. The recent progress in community-based control of nagana and its vectors gives hope for further developments. But again there are other vector-borne diseases of cattle, sheep and other domestic animals that previously have not been a priority of researchers in Africa.

We suggest that the researchers at *icipe* look into the possibilities of initiating surveillance of mosquito-borne viruses and sandfly-borne protozoa in suitable areas. Such action is best performed in collaboration with institutions that have the necessary knowledge and capacity in virology and protozoology, and with *icipe* as a strong collaborator in entomology. These research arenas will provide *icipe* a broader scientific base, increase the research skills and knowledge of the staff, and provide possibilities for establishing collaboration with new international partners. A successful widening of the research agenda to include also the vectors of mosquito-borne viruses and sandfly-borne protozoa will further strengthen *icipe*'s position as a leading African entomological research institution, and could thus add in the quest for sustainable funding.

6.6 Landscape mapping by satellite sensors and disease risk assessment

The geographical and temporal occurrence of arthropod vectors and vector-borne diseases are influenced by environmental variables such as temperature, rainfall, geology, soil quality, and vegetation type that varies on a geographic scale. The recent surge in high quality geo-coded data from both active and passive satellite censors has made it possible to address the complex topics of large-scale risk assessment for occurrence of vectors and outbreaks of vector-borne diseases. Such information could be very useful in directing vector control to potentially affected areas prior to a vector-borne disease outbreak, in strategic planning for medical and/or veterinarian actions, etc. However, the sophisticated data from satellites will only be useful if matched with reliable and high quality environmental data from the ground that is suitable for the research questions to be addressed.

We are aware that some GIS-based landscape mapping of *Anopheles* breeding sites have been performed by *icipe* scientists, and suggest that such studies should be developed further as well as expanded to include also other vector groups and species. Examples are the mosquito vectors of viruses and the sandfly vectors of lesihmaniasis as suggested in 6.5.

The changing climate of countries in Africa will probably have a major effect on the distribution and abundance of arthropod vector species and the diseases they transmit. The availability of remotely sensed satellite data makes it possible to map and describe the present vector and vector-borne disease situation, and to develop methods for large-scale prediction of direction and magnitude of change in relation to climate variables.

We suggest that *icipe* should explore this avenue of research possibilities further and establish collaboration with appropriate high quality partners as needed to address the questions of how the threat of vector-borne diseases will be modified by a changing climate in the different climatic regions of SSA.

6.7 Biodiversity conservation and ecosystem services

The urgent need to preserve a high biodiversity in sensitive landscapes and threatened ecosystems in order to sustain ecosystem services such as biological pest and vector control, pollination and soil functions requires more research and convincing key examples that show economical, ecological and social benefits resulting from ecosystem services provided by arthropods. The review team is aware that *icipe* has contributed substantially to these research questions locally and regionally in SSA over the last years and it has amassed a lot of information and knowledge which was transferred successfully to local stakeholders. *icipe* has developed innovative paths in conserving and utilisation of arthropod biodiversity and was able to demonstrate economical and ecological values of such projects. We suggest that *icipe* looks for more opportunities in future programmes to strengthen research in assessing, maintaining and improving biodiversity that contributes to higher ecosystem services and ultimately to higher economical benefits of rural populations.

6.8 Upscaling of integrated pest and vector management

The highly successful development of community-based malaria and mosquito vector control in some areas shows a great promise for further development. Likewise, the highly successful development of community-based control of nagana and the tsetse fly shows great promise for a larger geographic cover of the control operations.

However, it may not be simple to upscale such methods from use in a few distinct areas with highly motivated inhabitants, to the very large areas with more or less motivated population that are in need of such control methods for malaria as well as for nagana.

We suggest that development of methods for integrating community-based control of malaria and mosquito vector control into the communities of very large regions and in several countries should be given the highest priority. Such distinct projects should also be very interesting for both national and international organisations to support, because of the high probability of success to control such important and devastating diseases in humans and in domestic animals.

6.9 Export markets and quality standards

Export markets exist in industrialised regions for a number of SSA products. The example of Kenya's horticultural exports to Europe and adoption of EurepGAP quality standards with support from *icipe* shows that this is a promising way of developing livelihood of rural people. The production of high quality products often lacks the back-up of research, and small-scale producers left alone with their arthropod pest and disease problems are not able to meet export safety and quality requirements.

We suggest that *icipe* expands its experience acquired over the last years in Kenya to other regions and products destined for new export markets, whereby services to government agencies and private organisations should be charged for.

6.10 Social sciences

Introduction of social sciences including economic studies into agricultural research at *icipe* had been recommended by the review team in 2002. *icipe* has since employed two economists who are analysing in ongoing projects economic impact and opportunities of alternative pest control methods and quality standards on farm performance and smallholder farmers' health. Such studies are extremely important for policy making and for *icipe*'s strategic decision-making related to pest control. Development is a complex process wherein technology development is not sufficient to bring about change. Social scientists are needed to make an integral contribution to the design and implementation of research projects and transfer of technology processes.

Behaviour is very hard to change and especially so in humans that for generations have lived in an environment with plenty of blood-sucking arthropods and with malaria infections and other vector-borne diseases being so common that they are just part of the daily life (and death). Upscaling and country-wide implementation of the successful methods and strategies to control both the malaria of humans and the nagana sleeping sickness of domestic animals is dependent on precise knowledge on how to motivate a high proportion of the individuals in the communities to take very specific actions. In addition, the community-based control will only continue to be successful as long as the communities continue their struggle to control the vectors and the diseases.

The present review team thus agrees with the previous review in that there is a need for further strengthening of the competence in social science at *icipe*.

6.11 Other issues

There are a number of emerging opportunities and innovations that future programmes could consolidate, validate and scale-up to achieve more widespread impact in food security, sustainable livelihoods, good health and sustainable use of natural resources for the peoples of tropical Africa.

- Use the current R&D programmes to develop best practices or guidelines in using community-based livelihood approaches and natural resource enterprises to achieve conservation objectives in fragile and threatened ecosystems.
- Develop guidelines and policy insights on the development of high value biodiversity and bioprospecting products and respective community-based enterprises as part of the scaling-up strategy for working models.
- Consolidate the alignment of the programme with key international frameworks like Global Hotspots and carbon trade and develop guidelines for building capacities of communities to understand implications and access opportunities that may flow from these international governance arrangements.

icipe needs to demonstrate alternatives or options that it can offer in terms of human health and environmental sustainability especially to such initiatives as the Alliance for a Green Revolution in Africa (AGRA) funded by the Bill and Melinda Gates Foundation and the Rockefeller Foundation. It has scope to do this in partnerships or by strengthening its lesson learning and capture mechanisms beyond product development and establishment of pilot enterprises.

7. INFRASTRUCTURE AND PHYSICAL FACILITIES

Good infrastructures, i.e. appropriate physical facilities (e.g. climate chambers, greenhouses) and equipment (e.g. computers, DNA sequencers) are prerequisites to perform high quality research. This is not to say that good research can be accomplished with top modern equipment only; however, facilities and equipment need to fulfil the required minimal standard. According to senior scientists we consulted at *icipe* HQ in Nairobi, laboratory equipment is valued very differently. Whereas some scientists judge their equipment in reasonable shape, others complain because theirs is completely outdated and is at the limit of fulfilling the needed standard. Servicing of technical equipment is another critical issue mentioned by some scientists. In some labs the review team has observed also that computer equipment is really outdated. Feedback from some stakeholders (e.g. Nairobi University) that have used *icipe*'s facilities before, indicated that the *icipe* equipment needed upgrading and modernising. Keeping up with the fast technical development of equipment as needed for example, in chemical ecology and molecular biology is very costly and may exceed the funding possibilities in individual projects. Special agreements with partner institutes in the USA and Europe might be a way to get access of used but still modern and up-to-date equipment. Investments in maintaining equipment and adding new items as needs arise, should obviously be given high priority in the near future.

The review team recommends that an inventory of equipment be made in all Centres of *icipe* with assigned technical status of the materials which should then be used to design a technical investment plan for the next five years.

Most of *icipe*'s programmes at the HQ, especially the bioprospecting and commercial insects (apiculture and sericulture), have access to reasonable laboratory and workspace facilities for their research, product development and production.

The visit at the Thomas O. Odhiambo Campus at Mbita Point with the field trips was very informative, and the review team was impressed by the high quality work done, especially in the 'push-pull' programme and in the work on *Anopheles* nectar-feeding behaviour in relation to blood-feeding. Greenhouses and experimental fields offer excellent opportunities for applied research and development studies in the 'push-pull' projects. The projects visited are very interesting and relevant for sustainable food production and for developing future control strategies against important vectors of human and animal diseases in SSA and deserve full support by the HQ. Other Human Health, Animal Health and Plant Health projects could certainly engage in more applied

and experimental work at Mbita Point and the surrounding regions, and use the Centre as a reference point for field studies in west Kenya and the Lake Victoria Basin. The costs of running Mbita Point would not increase proportionally if more projects would execute part of their applied and field work there. It is obvious for the review team that the Centre is under-utilised and hence, running costs proportionally high.

The team was impressed by the quality standards of the services provided, the conditions of the buildings, greenhouses and labs of the Centre as well as by the beauty of the location. Scientists at Mbita Point are now fully satisfied with the improved communication facilities giving access to "the rest of the world". One major problem is still the road connecting the *icipe* at Mbita Point with Kisumu and this may be one of the primary reasons why the Centre is not attractive enough for *icipe* staff to spend more time there and, as a consequence, the under-utilisation of the Mbita Point Centre's facilities. Another reason for under-utilisation could be that the Mbita Point field station, with its unique resources for field and experimental studies in basic and applied entomology, has not been sufficiently marketed and advertised to potential visiting scientists and donor organisations.

8. MAJOR ACHIEVEMENTS SINCE THE STRATEGIC REVIEW 2002

The previous review team drew a number of conclusions and made recommendations emerging from the strategic review process in 2002. The team of the programme review 2007 was asked to take up some relevant recommendations made five years ago, analyse them with respect to their present status and express its opinion on their achievements.

8.1 Geographic mandate and subject matter

The previous review team recommended that *icipe* remains an international centre with a primary focus on Africa and its insect/arthropod related problems and potentials, and recommended the Centre to evaluate strategies for increasing its presence across Africa.

In the present evaluation we have observed that some *icipe* R&D activities are well dispersed over many countries in the continent and that overall *icipe* is active in 25 African countries. However, animal health related R&D activities are focused on three countries in eastern Africa and four countries in western Africa, and human health related R&D activities are only indicated for Kenya and Ethiopia. We can see great potential for improvement in the geographic cover of animal and human health related R&D activities with *icipe* involvement. The team **concludes** that arthropod science related activities are the main entry point in all programmes we have analysed, and insect science is definitely the core subject matter of the Centre. In a few projects we got the impression that, although insect problems were the entry point, other subject matters have become more important. In such cases, we would **recommend** *icipe* to evaluate carefully its role and envisage strong linkages with competent partners.

The previous review team mentions that the external environment is changing rapidly and that the global environmental change is affecting the physical, biological and socio-economic environment. They further suggested that *icipe* should keep abreast with the global trends in research on such issues. We **suggest** that *icipe* should devote more effort into defining the potential effects of a changing climate on the distribution and abundance of pests, vectors and vector-borne diseases.

The review team **concludes** that *icipe* has kept its scientific focus on insects and other arthropods, and has strengthened its activities slightly into new regions across Africa. Plans to establish new partnerships in other African countries with

permanent office presence with *icipe* staff are under evaluation.

8.2 Clients and beneficiaries

The previous review team recommended that *icipe*'s main target beneficiaries should remain the low-income rural communities, with the urban poor becoming increasingly important.

Our programme review demonstrates that major efforts in *icipe*'s projects are clearly devoted to poor communities, be it in rural areas or in urban zones. A few projects which emphasise on production designed for export markets (e.g. vegetables, fruit, ornamentals) may also be beneficial for well-off farmers and may not directly contribute to alleviate poverty in smallholder farming communities; however, such 'entrepreneurs' are income generating and thus contribute to the overall economy of the country.

The review team **concludes** that major programme resources flow into projects aiming at improving livelihood of rural and urban poor communities. This proves that *icipe*'s programme strategy is well aligned with its mandate.

8.3 The R&D continuum

The previous team recommended that strategic research remains *icipe*'s foundation activity.

The present team **concludes** that most ongoing projects fulfil this recommendation perfectly. It can, however, not be denied that some projects could be challenged with respect to finding the right balance in the R&D continuum.

The present team **recommends** that projects with a high proportion of downstream research and training/dissemination should be periodically reviewed and positioned in the R & D continuum to prevent too heavy involvement in activities at local level which could dilute strategic research and the international advantage of the Centre.

The previous team recommended the legal and structural issues of establishing an *icipe*-independent brokering organisation.

The present review team had the opportunity to interview the CEO of Bridgeworks Africa Ltd and **concludes** that the research commercialisation agreement between the brokering organisation and *icipe* is in force since June 2004 and has since offered the development of a number of commercial products issued from *icipe* research. (For more details see this report and Annex 10.)

8.4 Core scientific competences

The previous team recommended a systems approach as a long-term goal and proposes to *icipe* to apply more often a cross-cutting approach with environmental, economic and social aspects.

The present team **concludes** that a number of the present programmes are strongly interdisciplinary and cover the requested cross-cutting aspects. The present team observed, however, that socio-economic sciences are still under-represented in *icipe,* and we **recommend** to strengthen these disciplines.

8.5 Role in education and training

The previous team concluded that capacity building and training is one of *icipe*'s most unique accomplishments on the African continent and sets *icipe* apart from other institutions. The team, however, also feels that capacity building and training may absorb too many resources from research programmes and science capacities and it recommends that *icipe* give high priority to maintaining an appropriate balance between science and capacity building.

The present review team agrees fully with the recommendation made previously and **concludes** that *icipe* has outstanding qualities in capacity building and training in insect science on the African continent. It is our opinion, however, that some of the ongoing projects are not yet well balanced and need careful consideration of the formerly made recommendation.

8.6 Partnerships and networks

Current thinking on research for development underpins the need for research to make its contribution within wider innovation systems which bring together a wide range of partners and stakeholders. These are necessary for commercialisation or institutionalisation of innovations that meet or answer significant problems of communities. It is critical to get the partnerships right in order to bring research science to bear on practical problems of developing communities.

The previous team concluded that a key to *icipe*'s future success lies in its ability to identify and enter into appropriate collaborative arrangements for its research, capacity building and technology transfer.

The present review team **concludes** that there is evidence that *icipe* is working with up- and down-stream partnerships, and that the recommendations from the last strategic review have been largely attended as outlined also in the May 2007 update provided by *icipe*. However, there is scope for *icipe* to strengthen this area by:

- Strengthening relationships with service providers and authorities that determine policies that affect widespread uptake of innovations;
- Encouraging joint monitoring adn evaluation (M&E) and sharing of lessons with key stakeholders;
- Building internal capacities and mechanisms that enhance good practices of working in partnerships; for example, incorporating partnership practices in staff development and appraisal systems.

The review team **recommends** *icipe* to enter into collaborations with partners complementing *icipe*'s core disciplines (arthropod science and application), and to this end, to select partners for collaboration according to a number of quality criteria to be established by *icipe*'s management.

ANNEX 1:
Background, Terms of Reference and Review team CVs

1. Background to the Review

icipe considers the regular monitoring and evaluation of the performance of its research and training programmes as an important activity to regulate both quality and relevance as well as ensure compliance to its mandate and mission. As a result, the Centre undergoes numerous reviews to assess its institutional performance and output. This includes research projects, which have their own mechanisms of review and planning, based on agreements with funding partners, and with close participation of the stakeholders. These periodic monitoring and evaluation exercises are a major assistance to the prioritising of *icipe*'s activities, which will help us to refocus to meet the needs of the beneficiary communities as well as the larger constituency. From an institutional standpoint, both the Governing Council and the Sponsoring Group of *icipe* (SGI) have important roles to play in this vital exercise.

Institutional Reviews

Starting in 1983, the donors constituting the SGI instituted the *icipe* Periodic External Review (IPER), as an instrument to undertake the review of the scientific programmes, administrative and financial management of the Centre. The SGI appoints the review members, generally numbering 6–8, and provides terms of reference for the review team. The team is usually composed of a multidisciplinary group of individuals knowledgeable not only in their respective disciplines, but also in the global research scene in agriculture, health and the environment and are also conversant with general development bottlenecks, management and resource mobilisation.

The reviews involve study of relevant documentation, visit and review of ongoing *icipe*'s work programmes, field sites and stations. The review mission also consults with a broad range of partners and collaborators. The review lasts for a period of two to three weeks and results in a detailed report providing key recommendations. The management team has opportunity to comment prior to submission to the Governing Council and to the SGI. The outcome of these reviews consists of policy guidelines such as vision and strategic documents as well as mid-term plans with clear-cut schedules of implementation.

Previous Reviews

The fourth of *icipe*'s Periodic External Reviews (IPER) was held in May/June 1996. A Mid-term Programme and Management Review was commissioned in 1998 to assess the progress made in implementation of the recommendations of the 1996 IPER. A general consensus was reached between the SGI and *icipe*'s Governing Council that the external review that was due in 2001 would be postponed and instead a strategic review be held in its place. The Strategic Planning Review of *icipe* was held in April 2002 and resulted in the development of *icipe*'s Vision and Strategy 2003–2012 and the currently operative Medium-Term Plans.

External Review, 2007

In consultations held in November and December 2006, both the Governing Council and the SGI agreed to having the next external review of *icipe* held in the first half of 2007. It was further agreed that the review would be research-focused, evaluating the research and capacity building agenda of the Centre.

2. Terms-of-Reference for the Programme Review

Why a Programme Review?

The current vision and strategy outlines steps to be taken to provide the much-needed solutions in food security, sustainable livelihoods, good health and sustainable use of natural resources for the peoples of tropical Africa. The strategy is based on the Centre's '4-Hs' paradigm of human, animal, plant and environmental health, and through the use of a number of scientific tools, approaches and disciplines, in collaboration with R&D partners as well as institutions of higher learning.

Under the subtitle 'Meeting the Needs of a Changing World', the vision and strategy is conscious of the very dynamic global environment that *icipe* operates in. The strategy recognises the tremendous advances being made in natural sciences, increased access to knowledge and information and opening of niche markets based on bio- and industrial products from plants and animals, and spread of insect borne diseases and various invasive species of arthropods, as some of the issues that an institution such as *icipe* must continually reappraise. Climate change and global warming are probably the most important global concerns today. How is *icipe* responding to these environmental challenges in terms of its arthropod vectors of human and animal diseases research activities?

A review of the institution's programmatic agenda becomes handy as a tool for evaluating how icipe is positioning itself to meet the new challenges. Most importantly, the review is able to gauge how the programme agenda is in tune with its institutional mandate and to what extent it meets the development needs of its beneficiary constituency through the creation of knowledge-based solutions, building capacity of individual researchers and institutions in Africa, contributing to policy development and ultimately, reducing the impact of arthropod pests and vectors that have a direct bearing on poverty, food production and well being. Coming at almost midway point of the strategic plan period is timely since the review exercise will provide opportunity to re-evaluate the original assumptions made and assess both indicators and trends that were instrumental in designing the plan. The review also serves the benchmarking function, taking stock of what has been achieved and enabling a more realistic realignment of programme priorities and implementation plans.

The Programme Review will be conducted by an appropriate multidisciplinary team of three members knowledgeable not only in their respective disciplines, but also in the global research scene in agriculture, health and the environment. They will also be conversant with management and resource mobilisation. Much of the Review will be completed as a desk exercise, with essential team meetings for the following: allocation of responsibilities; visits to icipe HQ and selected *icipe* field sites, followed by a visit to one additional country where *icipe* is present through collaborative projects (e.g. Uganda, Tanzania and/or Ethiopia); discussions with *icipe* stakeholders, partners and beneficiaries and writing of the final report.

Strategic Issues to be Considered by the Review

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

The following are other key concerns that the review will address:

i. Success in operationalising the Vision and Strategy (2003–2012)

ii. Impact of *icipe*'s work in meeting national and regional development priorities of its African constituency

iii. Assessment of *icipe*'s research and capacity building results of the last five years and links to future plans of the Centre
iv. Innovative programme design and strengthened research infrastructure to deliver on the institutional mandate
v. Strategic partnering and linkages
vi. Rising to the challenge of emerging opportunities and threats
vii. Sourcing investment for the programmatic agenda.

In summary, we would like the reviewers to: (1) evaluate *icipe*'s performance since the last strategic review in 2002, (2) identify strengths and areas for improvement ('where do we have comparative advantages and where not?') and (3) suggest strategic opportunities and directions for the next five years.

3. Scheduling of the Review

• January 2007:	Internal consultations and sounding of potential review team members
• Early February 2007:	ToR and team nominees provided to GC
• End of February 2007:	ToR and team nominees sent to SGI for endorsement
• Mid March 2007:	Ex-Bo commissions, reviews and endorses ToR and team nominees on behalf of GC
• Mid March 2007	Nominees contacted and terms agreed
• Mid March–May/June 2007	Desk work study by review team (10 days)
• Mid April 2007	Team leader visits *icipe*'s HQ to plan review mission (2–3 days)
• May–June 2007	10–12 days Review Mission to Kenya and Ethiopia (for the latter alternatively Tanzania or Uganda)
• June 2007	Draft Review Report submitted to GC at the end of Review Mission
• End of August 2007	Final Review Report submitted to GC (5 days).

Short CVs of the Review Team

Franz Bigler (Chair of the team)
Switzerland: Since 1980 Principal Research Scientist for IPM/Biological Pest Control and Head of Biosafety Research Unit at Agroscope ART, the Swiss Federal Research Institute for Agriculture, Environment and Economics. *Background:* MSc in Agriculture (1974) and PhD in Entomology and Ecology (1979) from the Swiss Federal Institute of Technology, ETH, Zürich. PhD thesis performed in Greece from 1976–1979 in FAO project on 'Integrated Pest Management of Olive Pests'. One year as research assistant at the Institut National de Recherche Agronomique (INRA) in France in entomology and biological pest control. Since 1980 Teaching of plant protection courses (IPM) at ETH Zürich from 1982–2000. Since 1986 work and consultancy experience in IPM, biological pest control and biosafety in Asia and Latin America. Since 1982 member and convenor of different Commissions, Working Groups and Panels of the International Organisation for Biological Control of Noxious Animals and Plants (IOBC), OECD, FAO, and the European and Mediterranean Plant Protection Organisation (EPPO). Since 1982 permanent expert of the Pesticide Regulatory Authority of Switzerland. From 1992–1996 Secretary General of the International Organisation for Biological Control of Noxious Animals and Plants (IOBC). From 1997–2004 Council member of IOBC/WPRS (West Palaearctic Regional Section). Since 2005 President of IOBC/WPRS. Since 2006 Board member of the International Society for Biosafety Research.

Jan O. Lundström
Sweden: Principal researcher at Uppsala University, Sweden. *Background:* Bachelor of Science in Biology at Umeå University, Umeå (1986) and Doctor of Medical Science in Virology at Karolinska Institute, Stockholm (1990). The thesis work was on the ecology and epidemiology of Sindbis virus—a mosquito-borne and bird-associated virus causing rash and long-lasting arthralgia in humans. Positions include medical entomologist for 4 years at the National Bacteriological Laboratory, Stockholm, research assistant for 1 year at Karolinska Institute, research assistant for 1 year at Swedish Institute for Infectious Disease Control, visiting research virologist for 2 years at University of California – Davis and researcher at Uppsala University for 7 years. Since 2002 part time principal researcher at Uppsala University and part time scientific director for the Swedish Biological Mosquito Control Project. Teaching and lectures on medical entomology, medical ornithology and arbovirology in Sweden at the National Bacteriology Laboratory, Karolinska Institute, Karolinska Hospital, Uppsala University, Umeå University and Danderyd Hospital. Teaching and lectures on parasite infections and sexual selection in birds, insect biodiversity in wetlands, and the balance between biological control and effects on non-target organisms. Supervisor of three PhD students and several exam project students. Chairman of the Society for Zoonotic Ecology and Epidemiology (2003–2006).

Ebbie Dengu
Zimbabwe: Development Innovations Consultant. Studies in agriculture, natural resources management, development management and strategic transformation to BSc and MSc levels at the University of Zimbabwe, University of West Virginia USA, Open University UK and Wits University RSA. Widely experienced development practitioner and consultant in public interventions (land, agriculture, NRM, rural livelihoods, emergency and recovery, state/civil society relationships, research/extension, commodity value chain analysis and agro-BDS) and the management of technical and institutional change. Director of Technology Development Services (TDS) Africa, a consulting trust promoting technical and institutional innovations in smallholder development interventions. He is also on the Board of a number of private corporations as well as development agencies in Zimbabwe. Established the Intermediate Technology Development Group-Southern Africa (ITDG-Southern Africa) programme (1988–2003) and steered a wide range of interventions designed to test different business development services in CBNRM, agro-processing, community-based water and energy management, and small-scale manufacturing and mining in smallholder communities in southern Africa. He has provided consultancy services (programme reviews, impact services and strategic alignment) to major donor, NGO, CGIAR (CIAT, CIMMYT, ICRAF, ICRISAT) and intergovernmental (*icipe*) programmes in South, East and North Africa.

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ENVIRONMENTAL HEALTH

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ANNEX 3:
Research Information
2002–2006 Publications Statistics

Table 1. Publications Peer Reviewed (2002–2006)

Year	Number of Peer Reviewed Publications	Mean Number of Peer Reviewed Articles per Scientist/ Year
2002	55	0.8
2003	70	1.0
2004	54	0.8
2005	59	0.9
2006	103	1.5
TOTAL	**341**	**5.0**

Table 2. Other Publications of Scientific Value (2002–2006)*

Year	Number of Other Publications	Mean Number of Other Publications per Scientist/Year
2002	10	0.6
2003	16	1.0
2004	21	1.3
2005	19	1.2
2006	12	0.8
TOTAL	**78**	**5.0**

**Excluded are PhD and MSc dissertations, annual reports/institutional documents, edited proceedings titles, obituaries of prominent scientists and scholar-only papers.*

Table 3. Proposal Development (2002–May 2007)

icipe Divisions	No. of Proposals	Rejected	Accepted	Under Review	Amount of Funds Granted – US$
Plant Health	60	25	11	24	8,779,095
Human Health	38	12	18	8	5,552,045
Environmental Health	27	3	13	11	2,862,000
Animal Health	22	13	4	5	922,716
Capacity Building and Institutional Development	9	5	3	1	3,625,285

Table 4. MSc and PhD Students Supervised and Resulting Number of Peer Reviewed Publications (2002–2006)

Year	MSc and PhD Scholars Supervised	Number of Peer Reviewed Publications	Number of *icipe* Co-author Scientists
2002	16	22	18
2003	30	28	27
2004	20	20	20
2005	20	25	22
2006	26	35	28
TOTAL	**112**	**130**	**115**

ANNEX 4:
Training and Capacity Building Data from ARPPIS Reports and Extract Data on Students trained

Summary Output of *icipe's* Capacity Building Programmes (2002–2007)

	2002	2003	2004	2005	2006	2007	Total
I. ARPPIS (PhD)							
HH	1	–	1	1	–	–	3
PH	5	4	3	8	4	–	24
AH	1	1	1	2	–	–	5
EH	1	1	3	1	3	–	9
II. ARPPIS (MSc)							
West Africa (Accra)	8	6	5	11	11	–	41
Eastern Africa (Addis)	–	–	–	–	4	–	4
Southern Africa (Harare)	–	–	–	2	4	–	6
III. DRIP (PhD)							
HH	5	1	2	1	2	–	11
PH	3	–	3	4	2	2	14
AH	–	–	–	–	–	–	–
EH	–	–	–	–	6	2	8
IV. DRIP (MSc)							
HH	3	–	3	1	–	–	7
PH	19	11	4	10	11	2	57
AH	4	–	1	1	1	–	7
EH	3	1	4	–	–	–	8
V. Training Courses							
HH	2	–	4	–	–	–	6
PH	–	2	4	2	14	4	26
AH	–	1	–	–	–	2	3
EH	2	3	1	6	3	1	16

*Key: **HH**, Human Health; **PH**, Plant Health; **AH**, Animal Health; **EH,** Environmental Health; **ARPPIS**, African Regional Postgraduate Programme in Insect Science; **DRIP**, Dissertation Research Internship Programme.*

ANNEX 5:
Technology Transfer

Impact (Practical Application of Research Results) and Adoption Rate of ***icipe*** Technologies and Systems

(a) Plant Health:

- During the last 5 years, 9000 farmers in western Kenya and 1000 farmers in central Kenya adopted the push-pull technology resulting in an annual increase of 10,000 tons of maize, 3.5 million litres of milk and 4 tons of desmodium seed. During the next 5 years, 50,000 new farmers are expected to join the push-pull technology.
- Application of fruit fly IPM technologies (based on bait, fungus and orchard sanitation) has resulted in significant reduction of mango fruit rejection by export markets (37% in 2003 to 9% in 2006) among farmers in Eastern Kenya.
- Diamondback moth parasitoid was released in highland cabbage production areas of Kenya, Tanzania and Uganda resulting in complete control of the pest; for Kenya only the economic impact over 25 years was assessed at 24:1.
- Four exotic leafminer parasitoids identified for introduction and release in East Africa.
- The economic benefits over 20 years from the maize stemborer biocontrol programme have been estimated at US$ 183 million for Kenya alone and at US$1.8 billion for the entire African region.
- PAN, a pheromone identified from basic and field research, is now registered for locust control in the Sudan. FAO has plans for further testing and registration in 8 more locust affected countries in sub-Saharan Africa.

(b) Human Health:

- After conducting two regional training workshops on integrated vector management for senior managers of malaria control programmes from 35 countries in Africa, five countries have already adopted the strategy and have established an integrated vector management (IVM) focal point within their ministries, underlining the policy decision in those countries to support IVM.
- After introduction of community based IVM in Nyabondo, Mwea and Malindi (all Kenya), malaria prevalence in the study sites reduced by more than 50% within 2 years.
- 24 PhD and 13 MSc African students trained in medical entomology; the majority of them are presently working in their respective home countries.
- *icipe* played a major role in rejuvenating vector research and control portfolio within the donor community as well as in African Ministries of Health and National Malaria Control Programmes.
- *icipe* played a key role in informing policy against indiscriminate use of pesticides for malaria control, e.g. the debate on re-introduction of DDT.
- 85 peer-reviewed articles published in the last 5 years.

(c) Environmental Health:

- A portfolio of insect-based community enterprises at Arabuko-Sokoke forest currently generates over US$ 100,000 per year in revenues for forest conservation and local livelihoods.
- *icipe*'s Ecosytem Profile for the East African Coastal Forests and Eastern Arc Mountains led to the provision of US$ 7 million from the Critical Ecosystem Partnership Fund for civil society interventions to conserve biodiversity in this global biodiversity hotspot.

- *icipe*'s research on carbon storage baselines in four forests were the first such studies in Kenya and have opened a door for accessing carbon trading funds for forest conservation.
- In 2006, 20.5 tons of silk cocoons were produced in six countries (Kenya, Madagascar, Uganda, Egypt, Ghana and Northern Sudan) and processed into yarn and cloth generating an additional income for participating communities of US$ 192,000.
- In 2006, 100 tons of honey were processed and sold through marketplaces developed by *icipe* in Kenya, Madagascar, Uganda and Southern Sudan with a total value of US$ 2.7 million.
- *icipe*'s bioprospecting programme has developed three new commercially branded products from medicinal plants that are now on sale in Kenyan supermarkets.

(d) Animal Health:

- *icipe*'s odour baited NGU trap technology has been deployed in 500 km^2 in Luke, Ethiopia, reducing tsetse populations by 99% and resulting in reduction in disease incidence by 20%. The number of cattle increased three times and milk yields doubled. More than 1500 farmers have adopted this technology.
- In Mwea, Kenya, *icipe's* NGU traps reduced tsetse numbers from >70 to <10 flies per trap per day, resulting in improved livestock health and productivity and minimising farmers–wildlife conflicts.
- *icipe*'s tsetse trapping technology is being widely used in eastern and southern Africa for monitoring and suppressing of tsetse fly populations by several NGOs.

(e) Capacity Building and Institutional Development:

- *The African Regional Postgraduate Programme in Insect Science (ARPPIS)* provides a 3-year doctoral training to an average of 7–8 PhD research scholars annually who undertake thesis research in various arthropod and insect science-related topics within *icipe*'s 4H research areas. ARPPIS began in 1983 and has to date trained over 190 PhD-level and 130 MSc-level scientists from 30 African countries.
- *The ARPPIS Sub-regional Masters Programme* runs a 2-year MSc training course at sub-regional level, hosted by selected participating universities. Since 2003 a total of 41 MSc scholars have been trained at the universities of Addis Ababa, Ghana and Zimbabwe.
- *The Dissertation Research Internship Programme (DRIP*) enables postgraduate research scholars undertaking studies in tropical insect science from universities in both developed and developing countries to access *icipe*'s state-of-the-art research facilities. During the period 2003–2006, a total of 45 PhD and 106 MSc scholars have been trained.
- *The professional development schemes* promote research interaction and networking through visits and exchange programmes that provide opportunities for both young as well as established scientists, including university faculty worldwide, to share and contribute to *icipe*'s research agenda. Through these schemes, *icipe* programmes have hosted some 25 scientists since 2003.

ANNEX 6:
Training Courses Organised by *icipe* (Within and Between Divisions) and/or Participation of *icipe* Staff in Training Courses Organised by Other Institutions

(a) Plant Health:

(i) Habitat Management Programme: icipe-sponsored Group Training Courses (2002–2006)

Course Title	Duration and Location	Sponsor	No. of Participants
Field training on the establishment and management of push-pull	09/2003 Kenya	Gatsby	8 farmers from Kapchorwa, Uganda, 4 KARI Kitale staff and 9 *icipe* field staff trained at Kiminini, Kitale, Kenya
Training workshop on desmodium bulking	10/2003 Kenya	Gatsby	88 farmers from Trans Nzoia District, and 5 farmers from Bungoma District
Training workshop on socio-economic and biological data collection and management	02/2004 Kenya	Gatsby	5 *icipe* field staff trained at *icipe*, Mbita
Field management of push-pull	06/2004 Kenya	Gatsby	19 new push-pull farmers from Trans Nzoia trained at *icipe* Mbita
Training workshop on striga and stemborer biological data collection and management of push-pull at sites in Bungoma	06/2004 Kenya	Gatsby	7 *icipe* field staff and 5 field assistants trained
Trans Nzoia farmers' study tour of push-pull sites in Bungoma	12/2004 Kenya	Gatsby	21 new push-pull farmers, 4 *icipe* field staff and 2 Ministry of Agriculture extension staff
Push-pull training for new farmers and extension staff in Bondo, Teso and Nyando districts	02/2005 Kenya	Gatsby	18 new push-pull farmers and 3 extension officers from Bondo, Teso and Nyando Districts
NGO workshop on striga and stemborer control and soil fertility improvement technologies	02/2006 Kenya	DFID in collaboration with icipe, KARI, CIMMYT and TSBF	22 NGO and Ministry of Agriculture District Agricultural Officers and extension staff from western Kenya trained in Kisumu, Kenya
NGO Workshop on striga and stemborer control and soil fertility improvement technologies	02/2006 Uganda	DFID in collaboration with icipe, NARO, CIMMYT and TSBF	20 Ugandan NGO and Ministry of Agriculture officials and extension staff trained in Busia, Uganda

Course Title	Duration and Location	Sponsor	No. of Participants
Project proposal development training for push-pull farmer groups (pre-qualification proposal development for KARI ATIRI Programme)	03/2006 Kenya	Kilimo Trust	21 farmers from two farmers groups: KOPUSH Self-Help Group in Rachuonyo District and SIGIRA Women's group in Migori/Uriri
Production of desmodium through vegetative propagation of vines	05/2006 Kenya	Gatsby	22 push-pull and desmodium bulking farmers, and 3 extension staff from Teso, Bungoma and Trans Nzoia were trained in Muran'ga, Kenya
Training on push-pull technologies and study tour of push-pull fields at *icipe* Mbita and 4 districts in Kenya by Ugandan farmers	05/2006 Kenya	Kilimo Trust	33 farmers from Uganda's Kapchorwa, Pallisa, Bugiri, Busia and Tororo districts
Training on push-pull technologies and study tour of push-pull fields in Teso district in Kenya by Ugandan NGO extension staff	06/2006 Kenya	Kilimo Trust	14 Africa2000 Network extension staff and other INSPIRE Consortium partners implementing push-pull in Uganda
Training on push-pull technologies and study tour of push-pull fields in Kuria district by Tanzanian farmers	07/2006 Kenya	Kilimo Trust	19 farmers, 5 nongovernmental organisation representatives and 8 Government extension staff from Inano, Ingwe, Inchugu, Luo-Imbo and Inchage divisions of Tarime district, Tanzania
Workshop on extending push-pull technology through NALEP, KAPP and Ministry of Agriculture in Western, Nyanza and Rift Valley provinces in Kenya	07/2006 Kenya	Kilimo Trust and Biovision	27 district extension, liaison, research and training officers; NALEP coordinators and KAPP coordinators
Identifying economic uses for grass as a means of affording conservation training of farmers/grass weavers in Busia and Suba districts of Kenya	08/2006 Kenya	UNEP /Global Environmental Facility	22 farmers/weavers trained in Busia district and 14 farmers/ weavers trained in Suba district
Push-pull dissemination meeting and training for stakeholders in eastern Uganda	08/2006 Uganda	Kilimo Trust	35 representatives of National Agricultural Research Organization (NARO); Africa2000 Network; Integrated Soil Productivity Initiative through Research and Education (INSPIRE), a consortium of research organisations, Makerere University, NGOs, farmers and local governments in Tororo, Busia, Mbale, Pallisa and neighbouring districts

Continued

Course Title	Duration and Location	Sponsor	No. of Participants
Practical training on the establishment and management of push-pull in new sites in Tarime, Tanzania	09/2006 Tanzania	Kilimo Trust	30 new push-pull farmers; 5 NGO extension staff; and 8 Government extension staff
NALEP stakeholders' training on the establishment and management of push-pull in Suba, Homa Bay, Nyando and Rachuonyo districts	09/2006 Kenya	NALEP and Kilimo Trust	24 NALEP district and division level coordinators, and extension staff from 4 districts; Provincial Director of Agriculture; Provincial Director of Livestock Development; Chief, Animal Production and collaborating NGOs
NGO workshop on push-pull technology in Western, Nyanza and Rift Valley provinces in Kenya	11/2006 Kenya	Kilimo Trust and Biovision	30 NGO project coordinators/ programme managers from Nyanza and Western provinces and Trans Nzoia district
Push-pull and desmodium seed production training workshop for Rift Valley extension officers	12/2006 Kenya	Kilimo Trust	45 divisional level Ministry of Agriculture extension officers and NGOs (MHAC, CCS-ACK, KPMD, KACE, SCC-VI Agroforestry) in Trans Nzoia District
Push-pull training for frontline extension officers in Teso district	12/2006 Kenya	Kilimo Trust	37 divisional level Ministry of Agriculture extension officers from Bungoma and Teso. Bungoma and Teso DAOs also attended
Practical training on push-pull, fodder utilisation and dairy goat production in Vihiga district	02/2007 Kenya	Kilimo Trust	30 push-pull and dairy goat farmers from new sites in Vihiga district; 3 Africa Now field extension staff
Practical training on push-pull, fodder utilisation and dairy goat production in Kisumu district	02/2007 Kenya	Kilimo Trust	60 new push-pull and dairy goat farmers from new sites, Kisumu district; 4 Africa Now field extension staff
Workshop on developing partnerships with the private sector (seed company and stockists) to disseminate 'push-pull' technology	02/2007 Kenya	Kilimo Trust	32 seed stockists from 8 districts in Kenya
Training workshop for Farmer Field School facilitators on push-pull and FFS methodology	04/2007 Kenya	Kilimo Trust	34 push-pull Farmer Field School facilitators from Bungoma, Busia, Suba and Homa Bay; and 15 *icipe* field staff

(ii) Staple Food Crops Training Courses

Country	Course Type	Duration	No. of Participants	Trainees
Eritrea	IPM on stemborer	06/2003	21	Extension workers
	IPM on stemborer	05/2004	27	Farmers
Ethiopia	Management of maize and sorghum borers	03/2005	30	Extension agents and farmers
Uganda	IPM on stemborer	09/2004	3	Diploma students from an agricultural college
	IPM on stemborer	08 and 10/2003 (8 visits)	20–30	Primary and secondary school pupils
	IPM on stemborer	05 and 09/2004 (8 visits)	20–30	Primary and secondary school pupils
	IPM on stemborer	05/2004	15	Farmers
Zanzibar	IPM on stemborer	01/2002	160	Farmers with primary and secondary school pupils
	IPM on stemborer	09/2004	20	MSc and BSc students
	IPM on stemborer	12/2004	40	Extensionists
	IPM on stemborer	02/2005	89	Farmers
Kenya	IPM on stemborer	05/2003	41	Farmers and extensionists
	IPM on stemborer (Kakamega)	01/2005	58	Farmers and extensionists
	IPM on stemborer (Central Kenya)	01/2005	38	Farmers and extensionists
Madagascar	Biology and identification of maize pests	04/2004	14	Farmers
	Biology and identification of maize pests	09/2004	20	Farmers
Tanzania	Group training	08/2003	23	VEO
	Farmers' exhibition	08/2003	2020	VEO, farmers, NGOs
	Awareness building of maize pests and BC	03/2004	74	VEO, farmers, NGOs
	Group training	06/2004	21	VEO
	Group training	09/2004	36	VEO, farmers
	Study tour	09/2004	23	VEO
	MSc training	09–12/2004	1	MSc
	Study tour Zanzibar	08/2004	3	Technicians
	Study tour Malawi	02/2005	1	Technician

Continued

Country	Course Type	Duration	No. of Participants	Trainees
Zanzibar	Awareness building of BC of stemborer	01/2002	160	Farmers
	BC of cereal stemborers	09/2004	40	MSc, BSc, diploma
	BC of cereal stemborers	12/2004	40	Extensionists
	BC of cereal stemborers	02/2005	80	Farmers
Malawi	IPM of cereal stemborers and striga	03–04/2004 (11 courses)	364	Farmers, extensionists, NGOs
	IPM of stemborers, insect mass-rearing	06–07	6	BSc students
Mozambique	Individual short-term training	Various periods	17	BSc students
	BC of stemborers and other pests	07/2002	70	Extensionists and technicians by World Vision, CARE, Govt.
	BC of cereal stemborers	08/2002	30	Extensionists, technicians and farmers by World Vision
Kenya (*icipe*)	Training courses in statistics, taxonomy etc.	10/2002 10/2003 10/2004		NAREs Scientists
	In-country training in statistics	2004		NAREs Scientists

(iii) Horticultural Training Courses

Course Title	Duration and Location	Sponsor	No. of Participants
DANIDA–Taita/Taveta Agricultural Programme vegetable IPM training of frontline horticultural extension workers	06–09/2001 Kenya	DANIDA	20
French bean production IPM training of trainers in collaboration with HCDA, MOA, Sunripe, East African Growers and Winrock International	08–11/2002 Kenya	USAID	15
IPM and hygiene standard practices in okra production for the export market in collaboration with FPEAK members (Sunripe, East African Growers), HCDA, Mboga Tuu, NGOs and MOA	10–11/2003 Kenya	USAID	15
Organic farming for kitchen vegetable gardening in Suba District, Nyanza province in collaboration with the Kenya Institute of Organic Farming	09/2002 to 06/2003 Kenya	Biovision Foundation	10
IPM training of trainers in French bean production for InduFarm Ltd outgrowers in Ndula area Eastern Province	11/2002 Kenya	Indu Farm Limited	15

Continued

Course Title	Duration and Location	Sponsor	No. of Participants
IPM and crop scouting training of trainers in collaboration with Flower Label Program (FLP)-Germany for • Magana Flowers, 8 to 11 October 2002 • Stoni Athi, 4 to 7 November 2002 • Sofia Roses, 22 to 25 October 2002 • Red Land Roses, 18–21 August 2003 • Kiliflora, Arusha, Tanzania, April 2004	(Indicated) Kenya and Tanzania	FLP and the growers	Magana flowers: 13 Stoni Athi: 12 Sofia Roses: 10 Red Land Roses: 10 Kiliflora:10
DBM biocontrol project: Capacity building for national horticulture extension staff in collaboration with Ministries of Agriculture (Kenya, Tanzania and Uganda) • Kenya, August 2002 • Tanzania, January 2003 • Uganda, November 2003 • Kenya (refresher course) September 2004 • Tanzania (refresher course) February 2005 • Uganda (refresher course) November 2005	(Indicated) Kenya, Tanzania and Uganda	BMZ	August 2002: 15 January 2003: 14 November 2003:19 September 2004:16 February 2005: 20 November 2005:17
IPM training of trainers in French bean and snow peas production for Sunripe agronomists in collaboration with COLEACP/PIP and Sunripe Ltd • Serengeti Fresh, Arusha, Tanzania, July 2003 • Laikipia, Kenya, August 2003	(Indicated) Kenya	COLEACP/PIP and Sunripe	Arusha: 15 Laikipia: 12
Integrated pest management training for the smallholder irrigation improvement programme in collaboration with the Ministry of Agriculture and Food Security, Tanzania	06/2003 Tanzania	MOA and Food Security, Tanzania	6
Training of trainers in tomato IPM in Zimbabwe in collaboration with the Plant Protection Research Institute (PPRI), Harare, Zimbabwe	11/2004 Zimbabwe	GTZ/BMZ	30

(b) Technology Transfer Training Courses

Course Title	Duration and Location	Sponsor	No. of Participants
Integrated pest management in mango production training course for farmer-to-farmer trainers, Maragua Ridge Central province, Kenya in collaboration with the Kenya Institute of Organic Farming (KIOF)	04/2005 to 04/2006 Kenya	Biovision Foundation	18
Integrated pest management in mango production training course for farmer-to-farmer trainers, Malindi, Coast province, Kenya in collaboration with Kenya Gatsby Trust (KGT)	06/2003 to 03/2004 Kenya	Biovision Foundation	
Training of farmer-to-farmer trainers in vegetable IPM for smallholder peri-urban vegetable production in Taita Hills (Kenya) and Western Usambara (Tanzania) in collaboration with MOA extension departments	06/2006 (ongoing) Kenya and Tanzania	Biovision Foundation	Kenya: 40 Tanzania: 60

Continued

Course Title	Duration and Location	Sponsor	No. of Participants
Training in coping strategies for the greater grain borer in Mwingi district, Eastern province, Kenya in collaboration with Tanzania Ministry of Agriculture and Food Security	01–02/2003 Kenya	Biovision Foundation	20
NGU trap making, deployment, servicing and tsetse trapping to facilitate community-based tsetse control in collaboration with the Kenya Wildlife Services (KWS) and Mwea National Reserve	04–08/2003 Kenya	Biovision Foundation	NGU trap making: 3; deployment and servicing: 50
Hands-on training in modern beekeeping for farmers in the environs of Mwea National Reserve	07–08/2004 Kenya	Biovision Foundation	12
Hands-on training in wild silk farming for farmers in the environs of Mwea National Reserve	09/2004 to 08/2005 Kenya	Biovision Foundation	10
Development of private sector service providers for the horticulture industry in Kenya in collaboration with MOA, BSMDP, Pact Kenya, NRI-UK, Fresh Produce Exporters (Kenya), FPEAK, outgrowers, farmer groups and Technoserve-Kenya	04/2003 to 12/2005 Kenya	DFID	34
Training course on plant parasitic mites for Dudutech Kenya	12/2004 Kenya	PIP	5
International Group Training Course on Fruit Fly Management, *icipe*, Nairobi, Kenya	10/2005 Kenya	Netherlands SII and IFAD	25
Training of leaders of National Fruit Fly Teams, *icipe*, Nairobi, Kenya	11/2004 Kenya	FAO and IFAD	12
Regional training course on pest risk analysis for national plant protection organisations of Kenya, Tanzania and Uganda, *icipe*, Nairobi, Kenya	07/2005 Kenya	FAO	12
Mobile fruit fly school: Training of Tanzanian extension agents and quarantine specialists on fruit fly surveillance, taxonomy and management, Kibaha, Tanzania	12/2005 Tanzania	IFAD	52
Mobile fruit fly school: Training of Kenyan extension agents and quarantine specialists on fruit fly surveillance, taxonomy and management, Kilifi, Kenya	02/2006 Kenya	IFAD	48
Mobile fruit fly school: Training of Ugandan extension agents and quarantine specialists on fruit fly surveillance, taxonomy and management, Luwero, Uganda	06/2006 Uganda	IFAD	82

(c) Human Health:

Human Health Group Training Courses/Workshops

Course Title	Duration and location	Sponsor	No. of Participants
GIS and remote sensing workshop	05/2002 Kenya	NIH, USA	14 participants
Community workshop on malaria and environment in western highlands of Kisii, Kenya	06/2002 Kenya	Finnish Government	52 ToTs
Vector susceptibility and bioassay training, Tessenei, Eritrea	09/2002 Eritrea	USAID	25 MoH participants
Regional training course on integrated vector management–I	09–10/2002 Kenya	WHO/ AFRO	19 participants from 13 African countries
Bti/ Bs efficacy, application and implementation of pilot vector control surveys: Mapping and monitoring of vector densities, Karen, Eritrea	07/2003 Eritrea	USAID	12 MoH participants in Eritrea
International workshop on bridging laboratory and field research for genetic control of disease vectors	07/2004 Kenya	WHO	32 participants from 16 countries
Regional training workshop on PoPs and alternative approaches to malaria control in Africa	06/2004 Kenya	UNEP Chemicals	14 participants from 7 African countries
Regional training course on integrated vector management–II	10/2004–11/2004 Kenya	WHO/ AFRO	22 participants from 16 African countries
International workshop on spatial analysis for vector borne diseases	06/2005 Kenya	NIH, USA	16 participants from 3 countries in Africa
Community training groups on mosquito control in Malindi, Kenya	08/2005 Kenya	BioVision	19 community groups
Training of trainers (ToTs) in malaria control in Mwea division, Kenya	06/2006 Kenya	NIH	65 ToTs

(d) Environmental Health:

(i) Commercial Insects Programme Training Courses

Course Title	Duration and Location	Sponsor	No. of Participants
Apiculture/sericulture: Training on modern beekeeping and silkworm rearing technologies	10–11/2002 Kenya	GoK	5
Apiculture: Regional training course on modern beekeeping	10–11/2002 Kenya	SIDA-RELMA	27
Apiculture: Training on modern beekeeping technologies for Worldwide Concern staff in Southern Sudan	10/2003 Sudan	Worldwide Concern	4

Continued

Course Title	Duration and Location	Sponsor	No. of Participants
Apiculture/sericulture: Training on modern beekeeping and silkworm rearing technologies	06–07/2003 Kenya	Self	27
Sericulture: Training on modern silkworm rearing technologies for Othoro Women Group, Oyugis	11/2003 Kenya	Embassy of Finland	1
Sericulture: Training on modern silkworm rearing technologies for Othoro Women Group, Oyugis	11/2003 Kenya	American Ambassador's Self Help Fund	6
Apiculture/sericulture: Training on modern beekeeping and silkworm rearing technologies for Prisons Staff	10–11/2003 Kenya	DED	4
Apiculture/sericulture: Training on silkworm rearing technologies for Sisibo Women Group, Eldoret	2004 Kenya	DED	4
Apiculture: Honey production and apiary management for West Pokot farmers	2004 Kenya	DED	4
Apiculture/sericulture: Training on modern beekeeping and silkworm rearing technologies for Kakamega, Mwingi and Arabuko forests communities	11–12/2004 Kenya	UNDP-GEF	38
Apiculture: Honey production and apiary management for Samburu farmers	02/2005 Kenya	African Wildlife Foundation	15
Sericulture: Training on modern silkworm rearing technologies for Rusinga Farmers	04/2005 Kenya	UNDP-GEF Small Grants	4
Sericulture: Training on modern silkworm rearing technologies for West Pokot farmers	04/2005 Kenya	BioVision	4
Apiculture: Honey production and apiary management, Samburu	05/2005 Kenya	AWF	13
Apiculture: Honey production and apiary management, Samburu	05/2005 Kenya	AWF	2
Apiculture: Honey production and apiary management for farmers from Tanga, Tanzania	09/2005 Tanzania	CEPF	20
Apiculture: Honey production and apiary management for Kitui Beekeeping Group	09/2005 Kenya	CIDA	4
Apiculture/sericulture: 1st UNDP-GEF training on modern beekeeping and silkworm rearing technologies for Kakamega, Mwingi and Arabuko forests communities	10–11/2005 Kenya	UNDP-GEF	43
Apiculture: 1st UNDP-GEF training on modern beekeeping technologies for Arabuko Forest communities	10–11/2005 Kenya	NK	4

Continued

Course Title	Duration and Location	Sponsor	No. of Participants
Apiculture/sericulture: Training on modern beekeeping and silkworm rearing technologies	10–11/2005 Kenya	RNE	24
Leadership training, Mwingi	11/2006 Kenya	RNE	14
Apiculture/sericulture: 2nd UNDP-GEF training on silkworm rearing technologies for Kakamega Forest communities	10–11/2005 Kenya	UNDP-GEF	5
Apiculture: Honey production and apiary management for farmers from Taita/Taveta	11/2005 Kenya	CEPF	20
Apiculture: Honey production and apiary management for Samburu farmers	11/2005 Kenya	AWF	7
Apiculture: Honey processing and packaging for Samburu farmers	11/2005 Kenya	AWF	4
Apiculture/sericulture: 2nd UNDP-GEF training on silkworm rearing technologies for Arabuko Forest communities	12/2005 Kenya	UNDP-GEF	2
Apiculture: Honey production, apiary management, processing and packaging for Tana River and Mwingi farmers	04/2006 Kenya	World Vision	15
Apiculture: Honey production and apiary management for Kitui Beekeeping Group	06/2006 Kenya	CIDA	6
IV International Trainers Course in Apiculture and Sericulture for 24 African countries	11–12/2006 Kenya	IIS, IFAD, Embassy of Netherlands	30
Apiculture/sericulture: Training on modern beekeeping and silkworm rearing technologies for Mwingi wild silk and beekeeping farmers	12/2006 Kenya	Embassy of Netherlands Small Grants	36
Apiculture: Honey production and apiary management for Kwale beekeepers	02/2007 Kenya	Ford Foundation	8
Sericulture: Training course in silk postharvest technology for ASF farmers	03–04/2007 Kenya	UNDP-GEF	5
Apiculture: Honey production and apiary management for Samburu farmers	05/2007 Kenya	AWF	14
Sericulture: Training course in wild silk farming for Mwingi farmers	05/2007 Kenya	RNE	12
Training course in ICS for organic certification, Mwingi	06/2007 Kenya	Toyota Foundation	25
Training course in ICS for organic certification, Mwingi	07/2007 Kenya	Toyota Foundation	45

(ii) Applied Bioprospecting Training

Course Title	Duration and Location	Sponsor	No. of Participants
Training in the distillation of *Ocimum kilimandscharicum* medicinal plant	08/2002 Uganda	UNDP/GEF-SGP Uganda	3
Training in the distillation of lemon grass medicinal plant	08/2002 Uganda	UNDP/GEF-SGP Uganda	3
Training in the distillation of *Ocimum kilimandscharicum* medicinal plant	04/2003 Kenya	UNDP/GEF-SGP Kenya, MacArthur Foundation	9
Training in group dynamics, leadership skills and constitution making	11/2003 Kenya	MacArthur Foundation	350
Training in methods for active participation	12/2003 Kenya	MacArthur Foundation	321
Training in record keeping	12/2003 Kenya	MacArthur Foundation	288
Training in gender issues	02/2004 Kenya	MacArthur Foundation	289
Training in fuel wood energy-saving technologies	05/2004 Kenya	MacArthur Foundation	993
Training in environmental health and hygiene	07/2004 Kenya	MacArthur Foundation	951
Training in skills enhancement and team building	12/2004 Kenya	DED, Kenya	32
Training in bamboo cultivation, management and utilisation	03/2005 Kenya	MacArthur Foundation	361
Training in on-farm agroforestry	03/2005 Kenya	MacArthur Foundation	377
Training of the community in beekeeping technologies	05/2005 Kenya	MacArthur Foundation	774
Knowledge exchange visit in industrial processes and manufacturing	07/2005 Kenya	Ford Foundation	30
Community-to-community exchange visit for beekeeping learning experience	08/2005 Kenya	MacArthur Foundation	20
Knowledge exchange visit in eco-tourism	10/2005 Kenya	Ford Foundation	8
Knowledge exchange visit in herbal products enterprises	11/2005 Kenya	Ford Foundation	5
Training in harvesting and post-harvest handling, and processing of *Mondia whytei* medicinal plant	04/2006 Kenya	Ford Foundation	9
Training in on-farm plant cultivation of *Ocimum kilimandscharicum* medicinal plant	03/2006 Kenya	CEPF	12

Continued

Course Title	Duration and Location	Sponsor	No. of Participants
Training in the oil processing of neem medicinal plant	04/2006 Kenya	CEPF	**No. ?**
Training in *Aloe barbandensis* nurseries establishment	06/2006 Kenya	WWF-EARPO	12
Training in cultivation, harvest and postharvest handling of neem, on documentation, monitoring and evaluation	08/2006 Kenya	CEPF	9
Knowledge exchange visit in cultivation and processing of *Ocimum kilimandscharicum* medicinal plant	11/2006 Kenya	CEPF	12
Training in cultivation, harvest and postharvest handling of neem and documentation	03/2007 Kenya	WWF-EARPO	15
Training in *Aloe secundiflora* nurseries establishment	04/2007 Kenya	WWF-EARPO	14

(e) Animal Health:

Course Title	Duration and Location	Sponsor	No. of Participants
Tsetse trap making, deployment and servicing (Mwea Project)	08/2003 Kenya	Biovision	54
Tsetse trapping technology, deployment, servicing and community management in Luke, Ethiopia	12/2003 Ethiopia	SDC	75
Tsetse trapping technology and community mobilisation in Ethiopia	07/2006 Ethiopia	Biovision	700
Training of pastoralist livestock keepers in tsetse trapping and repellent technologies in Narok	10/2003 Kenya	IFAD	32
Human African trypanosomosis—Capacity strengthening introductory course (jointly organised by KARI-TRC and *icipe*)	01–02/2006 Kenya	UNICEF/UNDP/ World Bank/ WHO-TDR	27 (from 15 African countries)
Principles of baseline data collection for integrated area-wide tsetse and trypanosomosis intervention projects with a sterile insect technique component	03–04/2006 Kenya	FAO/IAEA	26 (from 23 African countries)
Bioinformatics of African pathogens and disease vectors	05–06/2007 Kenya	CNRS France	85

(f) Arthropod Pathology Unit Training Courses:

Course Title	Duration and Location	Sponsor	No. of Participants
Molecular characterisation of germplasm isolates	08/2004 (3-week in-house training) Kenya	USAID-Bureau	8 *icipe* staff, 1 PhD-Kenyatta University, 5 managers from biopesticide industries
Techniques and bioassays in insect pathology using entomopathogenic fungi	05/2005 to 07/2005 Kenya	ARPPIS Scholars	3
Efficacy tests and humoral studies on *Rhipicephalus appendiculatus* and *Amblyomma variegatum*	06–07/2005 The Sudan	PhD scholar Ministry of Livestock	1
Techniques and bioassays in insect pathology using entomopathogenic hyphomycetes fungi	09/2006–07/2007 Kenya	ARPPIS (PhD scholars) Egerton University	2
Techniques and bioassays in insect pathology using *Bacillus thuringiensis*	05/2006–07/2007 Kenya	DRIP (PhD Scholar) KARI	1
Techniques in insect pathology	07/2007 Kenya	JKUAT (MSc Horticulture)	1
Isolataton, identification and efficacy techniques in toxin production, in *Bt*.-protein purification techniques	01/2007 to date Kenya	JKUAT (MSc Biotechnology)	2

ANNEX 7:
Presentations at National and International Conferences/Meetings

(a) PLANT HEALTH

2007

Knapp M. Exploration and evaluation of natural enemies for the invasive spider mite *Tetranychus evansi*. 1st Meeting, IOBC/WPRS Study Group on Plant Feeding Mites, Jerusalem, March 2007.

Mithöfer D. Economic impact of EurepGAP standard on small to large scale producers and farm worker welfare in Kenya. Regional GAP Workshop organised by FAO, UNCTAD and the Kenyan National Task Force on Horticulture, held at KEPHIS, Nairobi, Kenya, March 2007.

2006

Ekesi S. Development and improvement of mass rearing procedure for *Bactrocera invadens* and *Ceratitis* species in Africa. 2nd Research Coordination Meeting of the IAEA Coordinated Research Programme on "Development of Mass Rearing for the New World (*Anastrapha*) and Asian (*Bactrocera*) Fruit Fly Pests in Support of SIT", Salvador, Brazil, September 2006.

Ekesi S., Hanna R. The African Fruit Fly Initiative (AFFI): Overview of research activities, accomplishments and future plans. 7th International Symposium on Fruit Flies of Economic Importance and 6th Meeting of the Working Group on Fruit Flies of the Western Hemisphere, Salvador, Brazil, September 2006.

Kahuthia-Gathu R., Löhr B., Poehling H.-M., Mbugua P. K. Diversity and role of wild crucifers in the major cabbage and kale growing areas of Kenya. 5th International Workshop on Diamondback Moth and Other Crucifer Insect Pests, Beijing, China, October 2006.

Knapp M. Growing vegetables in eastern Africa—Pest control in organic/integrated agricultural production, biodiversity, farmer economy and export markets. Organic Agriculture in Development—The Need for Integrated Production for Food Security, University of Copenhagen, Denmark November 2006.

Knapp M., de Moraes G. J., Fiaboe K. K. M., Furtado I. P. Biological control of *Tetranychus evansi* in Africa. 12th International Congress of Acarology, Amsterdam, The Netherlands, August 2006.

Löhr B., Gichini G., Rossbach A., Nyambo B. After release dispersal of *Diadegma semiclausum* and its effect on diamondback moth population, damage and indigenous parasitoids. International Workshop on Diamondback Moth and Other Crucifer Insect Pests, Beijing, China, October 2006.

Macharia I., Mithoefer D., Löhr B. Update of the ex-ante impact assessment of the biological control of *Plutella xylostella (*diamondback moth) in Kenya. 5th International Workshop on Diamondback Moth and Other Crucifer Insect Pests, Beijing, China, October 2006.

Nyambo B., Seif A. A., Varela A. M., Löhr B. Coping with international food standards: Kenya's experience in export horticulture to EU (poster). Volkswagen Foundation International Workshop on Resources, Livelihood Management, Reforms, and Processes of Structural Change, Gobabeb, Namibia, September 2006.

Rossbach S. A., Löhr B., Vidal S. Host range expansion of diamondback moth, *Plutella xylostella* L. to peas: Effects on its parasitoids in Kenya. 5th International Workshop on Diamondback Moth and Other Crucifer Insect Pests, Beijing, China, October 2006.

Srinivasan S., Löhr B. Is diamondback moth a polyphagous pest? Some thoughts about its host range expansion to pea. 5th International Workshop on Diamondback Moth and Other Crucifer Insect Pests, Beijing, China, October 2006.

Tonnang H. E. Z., Nedorezov L. V., Ochanda H., Owino J., Löhr B. Application of differential equation models to the population dynamics of diamondback moth and its parasitoid—

Diadegma semiclausum. 5th International Workshop on Diamondback Moth and Other Crucifer Insect Pests, Beijing, China, October 24–27, 2006.

Wagener B., Reineke A., Zebitz C. P. W., Löhr B. Molecular phylogeny of *Diadegma* species important in biological control of *Plutella xylostella* (L.). 5th International Workshop on Diamondback Moth and Other Crucifer Insect Pests, Beijing, China, October 2006.

2005

Borgemeister C. *icipe*'s 4H Paradigm: Approaches to environmental, plant, animal and human health research in tropical Africa (Keynote address). Tropentag 2005, Stuttgart-Hohenheim, Germany, October 2005.

Borgemeister C., Chabi-Olaye A., Nolte C., Schulthess F., Ndemah R., Sétamou M. Role of habitat management technologies in the management of cereal stem and cob borers in sub-Saharan Africa (Invited speaker). 2nd ISBCA, Davos, Switzerland, September 2005.

Britto E. P. J., da Silva F. R., Fiaboe K. K. M., Gondim M. G. C. Jr., de Moraes G. J., Delalibera I., Knapp M. Population dynamics of predators associated with *Tetranychus evansi* Baker & Pritchard (Acari: Tetranychidae) in solanaceous plants in Recife (poster). 9º Simpósio de Controle Biológico (SICONBIOL), Recife, Brazil, maio 2005.

Ekesi S., Lux S. A. Effect of various synthetic food bait combinations on African fruit flies. 4th Research Coordination Meeting on "Development of Improved Attractants and Their Integration into Fruit Fly SIT Management Programmes" and International Conference on Area-wide Control of Insect Pests: Integrating Sterile Insect and Related Nuclear and Other Techniques, Vienna, Austria, May 2005.

Knapp M., Löhr B., Schulthess F., Sithanantham S., Baya J. Biological control of important pests in eastern Africa (oral presentation). 9º Simpósio de Controle Biológico (SICONBIOL), Recife, maio 2005.

Nyambo B. Coping with the EurepGAP standard in East Africa: Kenya's experience and lessons learned. PAN Africa's Stakeholder Workshop on Food and Fairness: Changing Supply Chains for African Livelihoods and Environment, Dakar, Senegal, November 2005.

Nyambo B., Löhr B. The role and significance of farmer participation in biocontrol-based IPM for brassica crops in East Africa. International Symposium of Biological Control of Arthropods, Davos, Switzerland, September 2005.

Saunyama I. G. M., Kwaramba J. R., Knapp M. Toxicity of Amitraz, Dimethoate and Malathion to the spider mite *Tetranychus evansi* Baker & Pritchard and the beneficial arthropods *Phytoseiulus persimilis* Athias-Henriot, *Hippodamia variegata* (Goeze) and *Diaeretiella rapae* (McIntosh) (poster). 9º Simpósio de Controle Biológico (SICONBIOL), Recife, Brazil, maio 2005.

Wosula E. N., Agong S. G., Knapp M. Development of tomato hybrids (*Lycopersicon esculentum* x *Lycopersicon hirsutum*) resistant to tobacco spider mite (*Tetranychus evansi*) [Won the award for best oral presentation.] Fifth Workshop on Sustainable Horticultural Production in the Tropics, Agricultural Resources Centre, Egerton University, Njoro, Kenya. November 2005.

2004

Ekesi S., Lux S. A., Maniania N. K. Prospects for soil inoculation with the entomopathogenic fungus, *Metarhizium anisopliae* as an IPM component for fruit fly management in African orchards. 5th Meeting of the Working Group on Fruit Flies in the Western Hemisphere, Bonaventure Resort and Spa, Fort Lauderdale, Florida, USA, May 2004.

Fiaboe K. K. M., Gondim Jr. M. G. C., de Moraes G. J., Knapp M., Ogol C. K. P. O., Britto E. P. J. Artrópodes predadores associdos a *Tetranychus evansi* Baker & Pritchard (Acari: Tetranychidae) em Solanáceas nativas em Minas Gerais, Espírito Santo e Rio de Janeiro (poster). XX Congresso Brasileiro de Entomologia, Gramado, Brazil, Setembro 2004.

Fiaboe K. K. M., Gondim Jr. M. G. C., de Moraes G. J., Knapp M., Ogol C. K. P. O., da Silva F. R. Avaliação de *Tetranychus evansi* e *Aculops lycopersici* como presas para quatro Ácaros predatores frequentemente associados a Solanáceas nativas no Brasil (poster). XX Congresso Brasileiro de Entomologia, Gramado, 05-10 Setembro 2004, p. 172.

Furtado I. P., Kreiter S., de Moraes G. J., Tixier M.-S., Flechtmann C. H. W., Knapp M. (2004) Ácaros plantícolas do Nordeste do Brazil (poster). XX Congresso Brasileiro de Entomologia, Gramado, Brazil, Setembro 2004.

Kithusi G. G., Knapp M. Effects of four biopesticides on the spider mite *Tetranychus evansi* Baker & Pritchard in the laboratory (oral presentation). 5th Symposium of the European Association of Acarologists, Berlin, Germany, July 2004.

Knapp M., Sarr I., Baumgärtner J., Ogol C. P. K. O. Spatial and temporal dynamics of *T. urticae* in small scale tomato fields (oral presentation). 3rd African Acarology Symposium, Cairo, Egypt, January 2004.

Löhr B., Gathu R., Momanyi C. Biological impact of the exotic diamondback moth parasitoid, *Diadegma semiclausum* (Hellen), in Kenya. XXII International Conference of Entomology, Brisbane, Australia, August 2004.

Löhr B., Macharia I., deGroote H. Ex-ante impact assessment of the introduction of the diamondback moth parasitoid, *Diadegma semiclausum*, in Kenya. XV International Plant Protection Congress, Beijing, China, May 2004.

Löhr B., Rossbach A. Diamondback moth, *Plutella xylostella* L. on peas in Kenya: Impact of the host shift on the pest and its parasitoid. 4th International Workshop on the Management of DBM and Other Crucifer Pests, The University of Melbourne, Victoria, Australia, November 2001.

Murungi L. K., Knapp M., Hassanali A., Agong S. G., Masinde P. W. The activity of leaf-emitted volatile compounds and essential oils in tomato accessions against the tobacco spider mite *Tetranychus evansi* Baker & Pritchard. 4th Workshop on Sustainable Horticulture in the Tropics. Moi University, Eldoret, Kenya, November 2004.

Nyambo B. Development of private sector extension services for the horticultural industry in Kenya. UK Food Standards, London, UK, December 2004.

Nyambo B. Development of private service providers for the horticultural industry in Kenya: A pilot study. AAB Centennial Conference on "Advances in Applied Biology: Providing New Opportunities for Consumers and Producers in the 21st Century", St Catherine's College Oxford, UK, December 2004.

Nyambo B. Private service providers for the horticultural industry in Kenya: Lessons in the use of mass media communication, Workshop on "Effective Communication Between Agricultural Research, Extension and Farmer", Bolzano, Italy, October 2004.

2003

Löhr B., Gathu R. Biocontrol-based IPM for the diamondback moth in eastern and southern Africa. Conference on IPM Development and Implementation in Africa, Kampala, Uganda, September 2003.

2002

Knapp M. Important mite crop pests in Africa. 11th International Congress of Acarology, Merida, Mexico, September 2002.

Nyambo B. Challenges to effective farmer participatory IPM technology development and dissemination in sub-Saharan Africa. 1st IPM Research and Extension Symposium, Kampala, Uganda, September 2002.

(b) ANIMAL HEALTH

2007

Saini R. K. Comprehensive Training and Capacity Building in Support of PATTEC Projects. 1st Meeting of the Sub-Regional Steering Committee for West Africa and 2nd Meeting of PATTEC Coordinators, Bobo Dioulasso, Burkina Faso, June 2007.

Saini R. K. 11th Meeting of the PAAT Programme Committee, WHO Headquarters, Geneva, Switzerland, April 2007.

Saini R. K. Special Donors Conference on PATTEC, Addis Ababa, Ethiopia, February 2007.

2006

Saini R. K. Capacity building needs and assessment for tsetse and trypanosomiasis control in six 1st phase African countries (Burkina Faso, Mali, Ghana, Ethiopia, Kenya and Uganda) for the Pan African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) (Invited paper). 31st Meeting of the International Scientific Council for

Trypanosomosiasis Research and Control (ISCTRC) and National PATTEC Coordinators Meeting, Addis Ababa, Ethiopia, September 2006.

Saini R. K. Tsetse and trypanosomaisis research, development and training opportunities at *icipe*. 10th Meeting of the FAO Programme Against African Trypanosomaisis (PAAT) Programme Committee, Florence, Italy, April 2006.

2005

Saini R. K. 7th Conference of Ministers Responsible for Animal Resources, Kigali, Rwanda, October–November 2005.

Saini R. K. Evaluation of repellents and baits in 'push-pull' tactic for tsetse and trypanosomosis suppression. 28th Meeting of the International Scientific Council for Trypanosomosiasis Research and Control (ISCTRC), Addis Ababa, Ethiopia, September 2005.

Saini R. K. Toxicological assessment of a tsetse repellent developed for smallholder indigenous communities of sub-Saharan Africa, on the health of exposed animals. 28th Meeting of the International Scientific Council for Trypanosomosiasis Research and Control (ISCTRC), Addis Ababa, Ethiopia, September 2005.

Saini R. K. UNICEF/UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR) Meeting on Capacity Strengthening for Research on Human African Trypanosomiasis, Geneva, Switzerland, June 2005.

Saini R. K. What *icipe* Can Offer to Forum for Agricultural Research in Africa (FARA). SADC FANR Pilot Learning Workshop, Lilongwe, Malawi, April 2005.

Saini R. K. Baits for behavioural manipulation of vectors of trypanosomiasis: Can this be improved by genomic approaches? (Invited paper) International workshop on "A Time to Heal, Cracking Africa's Killer Disease," organised by the Bill and Melinda Gates Foundation, Ford Foundation, Biovision Foundation, *icipe*, ILRI and DAAD, Nairobi, Kenya, March 2005.

2004

Saini R. K. Repellents for integrated tsetse management—Where we are and where we are heading. Seminar, *icipe*, Nairobi, Kenya, November 2004.

Saini R. K. Role and contribution of *icipe* in supporting T&T interventions (Invited paper). 8th Meeting of the PAAT Programme Committee, Rome, Italy, April 2004.

Saini R. K. The role of repellents in integrated control of tsetse and trypanosomiasis, (Invited paper). USDA/ARS, Centre for Medical, Agricultural and Veterinary Entomology (CMAVE), Gainesville, Fl. USA, May 2004.

Saini R. K. Repellents for integrated tsetse management (Invited paper). Symposium on "New Developments in Global Arthropod Repellent Research", XXII International Congress of Entomology, Brisbane, Australia, August 2004.

2003

Saini R. K. Repellents: A harmonious approach—Invited presentation on the repellent technology, one of the three technologies for evaluation at the DFID sponsored workshop on "Recent Advances in Livestock Keeper-based Tsetse Control: The Way Forward", Nairobi, Kenya, October 2003 (http://www.agfax.net/-).

Saini R. K. Repellents for protection of pastoralists' cattle from tsetse and trypanosomiasis. 27th Meeting of the International Scientific Council for Trypanosomiasis Research and Control (AU/ISCTRC), Pretoria, South Africa, September–October 2003.

Saini R. K. Avoidance of refactory 'hosts' by tsetse and identification of the mediating semiochemicals. 27th Meeting of the International Scientific Council for Trypanosomiasis Research and Control (AU/ISCTRC), Pretoria, South Africa, September–October 2003.

Saini R. K. Practical research to increase efficiency of tsetse and trypanosomiaisis intervention operations (Invited paper). FAO/PAAT Coordinators Meeting, Pretoria, South Africa, September 2003.

Saini R. K. Repellents as tools for integrated tsetse management (Invited paper). 14th European Conference of the Society of Vector Ecology (SOVE), Bellinzona, Switzerland, September 2003.

2002

Saini R. K. Attractants and repellents for tsetse—Where do we go from here? (Invited paper). EU-sponsored Workshop on Integrated Vector Control Including Synergistic Use of Drugs and Bait Technologies for Control of Trypanosomiasis and Tick Borne Diseases, Institute of Tropical Medicine, Antwerp, Belgium, April 2002.

Saini R. K. Integrated control of tsetse and trypanosomiasis. AU Conference of Ministers Responsible for Animal Resources, Addis Ababa, Ethiopia, March 2002.

(c) HUMAN HEALTH

2007

Shililu J., Novak R. Malaria control in sub-Saharan Africa: Challenges and opportunities for integrated vector management. Symposium on Vector Biology, Ecology and Control, Celebrating Prof. Mir Mulla's 50 Years of Research and Teaching, University of California, Riverside, USA, June 2007.

2006

Gichia S., Nyarangi E., Howard A., Omlin F. X. Empowering the communities in malaria control and prevention: 4 years' experience in western Kenya. 3rd Kenya NGO Alliance Against Malaria (KeNAAM) National 'Fresh Air Conference', Nairobi, Kenya, July 2006.

Githure J. Integrated vector management for malaria control in Africa (Keynote address). Virginia Polytechnic Institute and State University, Blacksburg, Virginia, USA, May 2006.

Howard A., Vulule J., Omlin F. X. Aqueous neem extract shows *Anopheles gambiae* s.s. larval growth retardation and larval and pupal mortality in laboratory tests. Royal Society of Tropical Medicine and Hygiene "Research in Progress" Meeting, Liverpool, UK, December 2006.

Mbogo C. M., Shililu J. I., Nzovu J. G., Githure J., Novak R. J. Origin of blood meals in indoor resting malaria vectors in a rice irrigation scheme in eastern Kenya. 55th Annual Meeting of the American Society of Tropical Medicine and Hygiene, Atlanta, USA, November 2006.

2005

Lugalia R., Anjili C., Langat B., Mwanyumba P., Ngumbi P., Mbati P., Githure J., Tonui W. Estimation of minimum number of *Leishmania major* amastigotes required to infect *Phlebotomus duboscqi*. 26th African Health Sciences Congress, Ain Soukhna, Egypt, December 2005.

Manda H., Gouagna L. C., Kabiru E. W., Hassanali A., Yan G., Beier J., Githure J. *Plasmodium falciparum* development in the midgut of *Anopheles gambiae* s.s. feeding on some predominant plants in western Kenya. Fourth Pan-African Malaria Conference, MIM, Cameroon, November 2005.

Menge D. M., Guda T., Zhong D., Pai A., Zhou G., Beier J. C., Gouagna L., Yan G. Fitness consequences of *Anopheles gambiae* hybridization. Fourth Pan-African Malaria Conference, MIM, Cameroon, November 2005.

Mwangangi J., Shililu J., Mbogo C., Kabiru E., Githure J., Novak R. Anopheline larval productivity in relation to rice growth cycle at three different ecological villages in Mwea, Kenya. 26th African Health Sciences Congress, Ain Soukhna, Egypt, November 2005.

Shililu J., Githure J., Mutero C. Impact of integrated anti-malarial interventions on malaria vector populations and prevalence of malaria parasites. System-wide Initiative on Malaria and Agriculture Workshop, Dar-es-Salaam, November 2005.

2004

Githure J. I. (Keynote address) Eastern and South Africa Centre of International Control (ESACIPAC) Symposium on Parasite Control in Eastern and Southern Africa, Nairobi, April 2004.

Kibe L. W., Mbogo C. M., Keating J., Molyneux S., Githure J. I., Beier J. C. Community participation in vector control activities in Malindi, Kenya, 25th African Health Sciences Congress, Ain Soukhna, Egypt, December 2004.

Mbogo C. M., Beier J. C., Keating J. Relationships between the entomological force of malaria parasite transmission by mosquitoes and the public health burden of malaria in African communities: 53rd Annual Meeting of the American Society of Tropical Medicine and Hygiene, Miami, Florida, USA, November 2004.

Omlin F. X. Combating malaria in the highlands of western Kenya through a sustainable ecosystem approach. African Health Sciences Congress, Nairobi, Kenya, October 2004.

2003

Githure J. I. Presidential Invited Keynote Speaker at the Royal Entomological Society of London, UK "Taking Integrated Vector Management to African Communities", June 2003.

Mbogo C. M., Githeko A. K., Regens J. L., Githure J. I., Beier J. C. Environmental determinants of *Anopheles* (Diptera: Culicidae) aquatic larval habitats in urban Kisumu and urban Malindi, Kenya. 52nd Annual Meeting of the American Society of Tropical Medicine and Hygiene, Philadelphia, USA, December 2003.

Mbogo C. M., Ohaga S. O., Muiruri S. K., Novak R. J., Beier J. C. Larval control for African malaria vectors in rural settings: Opportunities and challenges. 52nd Annual Meeting of the American Society of Tropical Medicine and Hygiene, Philadelphia, USA, December 2003.

Midega T. J., Mbogo C. M., Mwambi H., Wilson M. D., Yan G., Githure J. I., Beier J. C. Estimating population density and survival for *Anopheles gambiae* and *Anopheles funestus* along the Kenyan coast using mark–release–recapture experiments. 52nd Annual Meeting of the American Society of Tropical Medicine and Hygiene, Philadelphia, USA, December 2003.

Nyanjom S., Chen H., Gebre-Michael T., Bekele E., Shililu J., Githure J. I., Beier J. C., Yan G. Population genetics structure of *Anopheles arabiensis* mosquitoes in Ethiopia and Eritrea. 24th African Health Sciences Congress, Addis Ababa, Ethiopia, October 2003.

Shililu J., Ghebremeskel T., Mbogo C. M., Githure J. I., Novak R. Larval ecology and control: Implications for mosquito control in a semi-arid context. Vector Control Symposium, American Society of Tropical Medicine and Hygiene, Washington, November 2003.

2002

Braginets O. P., Minakawa N., Mbogo C. M., Githeko A. K., Yan G. Population genetic structure of *Anopheles funestus*: Comparison of mitochondrial genes, microsatellites and chromosomal inversions. 51st Annual Meeting of the American Society of Tropical Medicine and Hygiene, Denver, Colorado, USA, November 2002.

Githure J. I. Keynote speaker (integrated vector management). Parasitological Society Meeting of Southern Africa (PARSA), South Africa, October 2002.

Gouagna L. C., Okech B., Killeen G., Obare P., Ferguson H., Beier J. C., Githure J. I., Yan G. Is *Plasmodium falciparum* transmission to mosquito influenced by disease severity in mosquitoes? Third Pan-African MIM Meeting, Arusha, Tanzania, November 2002.

Jacob B. G., Regens J. L., Mbogo C. M., Githeko A. K., Keating J., Swalm C. M., Gunter J. T., Githure J. I., Beier J. C. Occurrence and distribution of *Anopheles* (Diptera: Culicidae) larval habitats on land cover change in urban Kisumu and Malindi, Kenya. 51st Annual Meeting of the American Society of Tropical Medicine and Hygiene, Denver, Colorado, USA, November 2002.

Mbogo C. M., Kahindi S., Keating J., Githeko A. K., Ndega B., Kibe L. W., Karanja D. M., Atieli F. K., Githure J. I., Beier J. C. Ecology of malaria vectors in urban Malindi and Kisumu, Kenya. 51st Annual Meeting of the American Society of Tropical Medicine and Hygiene, Denver, Colorado, USA, November 2002.

Mbogo C. M., Mwangangi J. M., Nzovu J. G., Mushinzimana E., Ojwang G., Githure J. I., Beier J. C. Environmental determinants of *Anopheles* larval distributions along the Kenyan Coast. 51st Annual Meeting of the American Society of Tropical Medicine and Hygiene, Denver, Colorado, USA, November 2002.

Shililu J., Ghebremeskel T., Mbogo C. M., Githure J. I., Brantley E., Novak R. Larval ecology and control of malaria vectors in Eritrea. Symposium on Malaria Control in Africa organised by EHP-USAID at the African Health Sciences Congress, Kampala Uganda, April 2002.

Zhou G., Yan G., Minakawa N., Beier J. C., Githure J. I., Mbogo C. M. Modelling the effects of climate change on malaria vector species distribution in East Africa. 51st Annual Meeting of the American Society of Tropical Medicine and Hygiene, Denver, Colorado, USA, November 2002.

(d) ENVIRONMENTAL HEALTH

2007

Adolkar V. Sericulture Stakeholders Workshop, KARI, Thika, Kenya, May 2007.

Kioko E. N. Cocoon characteristics of the African silkmoth, *Gonometa postica* (Lepidoptera: Lasiocampidae) from farmers' fields in Mwingi, Kenya. The 17th Conference of the African Association of Insect Scientists and the Entomological Society of Ghana, Dakar, Senegal, June 2007.

Macharia J. Stingless Bees Keeping as an Incentive to the Community for Rainforest-Conservation (poster). The Sixth International Science and the Management of Protected Areas (SAMPAA) Conference, Acadia University, Wolfville, Nova Scotia, Canada, May 2007.

Muli E. Organization of beekeepers for production of high quality bee products and value-addition. The Honey Seminar and Workshop on "Developing Business to Bee Products", Addis Ababa, Ethiopia, January 2007.

Raina S. Value chain and innovation in the global food system. Agribusiness Forum 2007, FAO, Rome, June 2007.

Raina S. Development of sericulture and apiculture enterprises for the poor in fragile ecosystems using the value chain approach, ICARDA, Aleppo Syria, April 2007.

2006

Adolkar V. The Trainers Course and Fourth International Workshop on the Conservation and Utilisation of Commercial Insects, in Kenya and Uganda, November 2006.

2006 BOZONET Regional Inception Workshop, Nairobi, August 2006.

Gordon I. Commercial Insects in a Buffer Zone Context. Fourth International Conference on Commercial Insects, Nairobi, December 2006.

Gordon I. On *icipe's* CEPF Livelihoods Project. Forest Department CEPF Sensitisation WorkshoIDB/IFAD International Workshop on Promotion of Income Generating Activities in the NENA Region Based on Sericulture and Apiculture Technologies, Cairo, Egypt, July 2006.

Macharia J. The Trainers Course and Fourth International Workshop on the Conservation and Utilisation of Commercial Insects, in Kenya and Uganda, November 2006.

Macharia J. Institutional Workshop on Agrobiodiversity Conservation, African Institution for Capacity Building (AICAD), Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya, November 2006.

Muli E. IDB/IFAD International Workshop on Promotion of Income Generating Activities in the NENA Region Based on Sericulture and Apiculture Technologies, Cairo, Egypt, July 2006.

Muli E. The Trainers Course and Fourth International Workshop on the Conservation and Utilisation of Commercial Insects, in Kenya and Uganda, November 2006.

Ngoka B. The Trainers Course and Fourth International Workshop on the Conservation and Utilisation of Commercial Insects, in Kenya and Uganda, November 2006.

Nguku E. 3rd International Textile Clothing & Design Conference, October 2006.

Nguku E. The Trainers Course and Fourth International Workshop on the Conservation and Utilisation of Commercial Insects, in Kenya and Uganda, November 2006.

Raina S. IDB/IFAD International Workshop on Promotion of Income Generating Activities in the NENA Region Based on Sericulture and Apiculture Technologies, Cairo, Egypt, July 2006.

Raina S. Promoting Equitable Access and Contribution to Global Knowledge, Hotel Intercontinental, Nairobi, Kenya, May 2006.
Raina S. The Trainers' Course and Fourth International Workshop on the Conservation and Utilisation of Commercial Insects, in Kenya and Uganda, November 2006.

2005

Kioko E. N. Population trends of the African silkmoth, *Gonometa postica* (Lepidoptera: Lasiocampidae) in Mwingi, Kenya. The 16th Conference of the African Association of Insect Scientists and the Entomological Society of Ghana, Legon, Accra, Ghana, June 2005.
Nguku E. Food Sovereignty Workshop, Silver Springs Hotel, Nairobi, Kenya, October 2005.
Raina S. Project Development Workshop on Agricultural Development in Southern Sudan.

2004

Adolkar V. Conference on Assuring Food and Nutrition Security in Africa by 2020, Kampala, Uganda, April 2004.
Adolkar V. Organic and Natural Products of Kenya Workshop, *icipe*, Nairobi, Kenya, March 2004.
Kioko E. N. The 5th International Symposium on Tropical Biology, Alexander Koenig Zoological Research Institute and Museum, Bonn, Germany, May 2004.
Macharia J. Organic and Natural Products in Kenya Workshop, Kasarani, Nairobi, Kenya, 2004.
Macharia J. Organic and Natural Products in Kenya Workshop, Kasarani, Nairobi, Kenya, 2004.
Muli E. Conference on Assuring Food and Nutrition Security in Africa by 2020, Kampala, Uganda, April 2004.
Muli E. Organic and Natural Products in Kenya Workshop, Kasarani, Nairobi, Kenya, 2004.
Muli E. Royal jelly production using East African honey bee races. 8th IBRA Conference on Tropical Bees and VI Encontro sobre Abelhas, Ribero Preto, Brazil, September 2004.
Muli E. Participatory Forest Management (PFM) Awareness and Information Sharing Workshop, Machakos, Kenya, May 2004.

2003

Adolkar V. Strategic Action Planning in Forest Sector Stakeholder Workshop Forest User Group and Environmental NGOs, Nakuru, Kenya, July 2003.
Adolkar V. The 15th Conference of the African Association of Insect Scientists and Entomological Society of Kenya, *icipe*, Nairobi, Kenya, June 2003.
Adolkar V. Trees On-Farm Network (TOFNET) Stakeholders Workshop and Steering Committee Meeting, *icipe*, Nairobi, Kenya, November 2003.
Gordon I. A synopsis of threats and opportunities for the hotspot. CEPF Workshop on Eastern Arc and Coastal Forests of Tanzania and Kenya: Dar-es-Salaam, Tanzania, March 2003.
Kioko E. N. The 15th Conference of the African Association of Insect Scientists and Entomological Society of Kenya, *icipe*, Nairobi, Kenya, June 2003.
Raina S. The CGIAR Challenge Program on Water and Food, Nairobi, November 2003.

2002

Adolkar V. African Pollinators Initiatives Workshop, *icipe*, Nairobi, Kenya, February 2002.
Kioko E. African Pollinators Initiatives Workshop, *icipe*, Nairobi, Kenya, February 2002.

(e) CAPACITY BUILDING AND INSTITUTIONAL DEVELOPMENT

2006

Ochieng-Odero J. P. R. Commission of Higher Education, Nakuru, Kenya, September 2006.

Ochieng-Odero J. P. R. Innovative Africa Symposium, Kampala, Uganda, November 2006.

Ochieng-Odero J. P. R. Meeting of the Technical Working Group (TWG) on Developing a Postgraduate Programme in Agricultural Information and Communication Management in the ASARECA Region, Entebbe, Uganda, October 2006.

Ochieng-Odero J. P. R. Meeting on Capacity Strengthening for Research on Human African Trypanosomiasis Geneva, Switzerland, June 2006.

Ochieng-Odero J. P. R. Postgraduate Education and Management Workshop, Egerton University, Njoro, Kenya.

Ochieng-Odero J. P. R. The International Council for Science (ICSU) Regional Office for Africa, 2nd Regional Consultative Forum, Johannesburg, South Africa, September 2006.

2005

Ochieng-Odero J. P. R. The First African Conference of Vice-Chancellors, Provosts and Deans of Science, Engineering and Technology (COVIDSET 2005), Accra, Ghana November 2005.

Ochieng-Odero J. P. R. The African Programme for Health Innovation (APHI) Workshop, The National Institute of Medical Research, Dar-es-Salaam, Tanzania, May 2005.

Ochieng-Odero J. P. R. Launching and Planning Workshop of the Lake Kivu Pilot Learning Site, Kigali, Rwanda, April 2005.

2004

Herren H. R., ole-MoiYoi O., Ochieng-Odero J. P. R. 28th Meeting of the Committee of Directors of ASARECA, Nairobi, Kenya, February 2004.

Ochieng-Odero J. P. R. African Technology Policy Studies Network (ATPS) Policy Dialogue, Hilton Hotel, Nairobi, Kenya, January 2004.

ole-MoiYoi O., Ochieng-Odero J. P. R. Nairobi Workshop on Canada–Africa Collaboration in Higher Education. February 2004.

Ochieng-Odero J. P. R. Workshop on National Science and Technology Policy, February 2004.

2003

Ochieng-Odero J. P. R. Capability building and capacity enhancement for R&D within an increasingly globalised economy: Reflections from an African Perspective. Global Dialogue on Intellectual Property (IP), Public Health and Collective Management of IP on the theme "A New Framework for Health Research and Development," sponsored by the Rockefeller Foundation, Bellagio Study and Conference Centre, Villa Serbelloni, Italy, September 2003.

Ochieng-Odero J. P. R. International Conference on Higher Education Management on "Quality Assurance through Curriculum Design—A Case Study of Higher Education Management in East Africa". DAAD-sponsored *icipe* scholars presented their work in poster sessions, October 2003.

Ochieng-Odero J. P. R. Symposium on University Education in Kenya on the theme "Re-engineering University for National Development", Nairobi, Kenya, October 2003.

(f) MOLECULAR BIOLOGY AND BIOTECHNOLOGY DEPARTMENT

2007

Masiga D. [Co-chair of organising committee]. Bioinformatics of African Pathogens and Disease Vectors, *icipe*/ILRI, May–June 2007.

2006

Masiga D. [Member of organising group and training facilitator] European Molecular Biology Organization (EMBO)/UNICEF/UNDP/World Bank Special Programme for Research and Training in Tropical Diseases (TDR) training course on RNA interference (RNAi) and reverse genetics in trypanosomes, Noguchi Memorial Institute for Medical Research, Accra, Ghana, January 2005; Nairobi, Kenya, November–December 2006.

Masiga D. Training Course on Bioinformatics and Functional Genomics Applied to Tsetse Fly Vectors of Human African Trypanosomiasis, South African National Bioinformatics Institute (SANBI), Cape Town, RSA, July 2006.

2004

Osir E. Consultative Meeting of GMO Guidelines Project, *icipe*, Nairobi, Kenya, June 2004.

Osir E. Expert Workshop on Understanding the Gender Dimensions of Biotechnology Research and Application in Africa, Pretoria, South Africa, November 2004.

Masiga D. [Course Coordinator] 3rd Biochemical Society of Kenya (BSK) Computational Biology Training, Computer Science Department, Egerton University, September 2004.

2003

Masiga D. [Course Coordinator] 2nd Biochemical Society of Kenya (BSK) Computational Biology Training, Computer Science Department, Kenyatta University, August 2003.

2002

Masiga D. [Course Coordinator] 1st Biochemical Society of Kenya (BSK) Computational Biology Training Workshop, Institute of Computer Science, University of Nairobi, September 2002 (http://www.icipe.org/bionet/events.htm).

Osir E. Development of international scientific biosafety testing guidelines for transgenic plants (GMO Guidelines Project) of the International Organization for Biological Control, *icipe*, Nairobi, Kenya, November 2002.

ANNEX 8:
icipe Staff Participation in Journal Reviews, Editorial Boards and Expert Consultations and Reviews

(i) Journal Reviews

Journal Title	No. of *icipe* Staff	Division/ Department
Acta Tropica	3	MBBD/BCED
African Journal of Biotechnology	1	MBBD
Agricultural and Forest Entomology	1	PHD
Annals of the Entomological Society of America	1	PHD
BioControl	1	PHD
Biocontrol, Science & Technology	1	PHD
Biological Control	3	PHD
Bio-organic and Medicinal Chemistry	3	BCED
Bulletin of Entomological Research	6	PHD/BCED
Crop Protection	4	PHD/BCED
Discovery and Innovation	1	MBBD
East African Journal of Life Sciences	1	MBBD
Entomologia Experimentalis et Applicata	2	PHD
Environmental Entomology	1	PHD
International Journal of Tropical Insect Science	6	MBBD/PHD/BCED
International Journal of Tropical Microbiology	1	MBBD
International Journal of Tropical Pest Management	2	PHD
Journal of Agricultural and Food Chemistry	3	BCED
Journal of Applied Entomology	2	PHD
Journal of Chemical Ecology	3	BCED
Journal of Economic Entomology	1	PHD
Journal of Invertebrate Pathology	1	PHD
Kinetoplastid Biology and Disease	1	MBBD
Molecular and Biochemical Parasitology	1	MBBD
Molecular Ecology	1	MBBD
Parasitology	1	MBBD
Phytoparasitica	1	PHD
Plant and Soil	1	PHD
PNAS	3	BCED
Scientia Horticulturae	1	PHD
Tropical Insect Science	1	PHD
Weed Research	1	PHD

*Key: **HHD**, Human Health Division; **PHD**, Plant Health Division; **AHD**, Animal Health Division; **EHD,** Environmental Health Division; **MBBD**, Molecular Biology and Biotechnology Department; **BCED**, Behavioural and Chemical Ecology Department.*

(ii) Scientific Proposal Reviews

Organisation/Body	No. of *icipe* Staff	Division/ Department
BBSRC, UK	3	BCED
6th Framework Programme for Life Sciences for Health, Belgium	1	AHD
European Developing Countries Clinical Trial Partnership (EDCTP), the Netherlands	1	AHD
International Foundation for Science (IFS), Sweden.	5	PHD/MBBD/BCED
Bill and Melinda Gates Foundation, USA	1	AHD
National Geographic Society	3	BCED
NOW-ALW X Geo & Biosphere	3	BCED
Swiss National Science Foundation	3	BCED
The Rockefeller Foundation	3	BCED
WOTRO	1	PHD

*Key: **HHD**, Human Health Division; **PHD**, Plant Health Division; **AHD**, Animal Health Division; **EHD,** Environmental Health Division; **MBBD**, Molecular Biology and Biotechnology Department; **BCED**, Behavioural and Chemical Ecology Department.*

(iii) Editorial Board Members

Journal Title	No. of *icipe* Staff	Division/ Department
Acta Tropica	3	BCED
African Journal of Biotechnology	1	MBBD
BioControl	1	PHD
Biocontrol News and Information	1	PHD
Biological Control	1	PHD
Bulletin of Entomological Research	1	PHD
Discovery and Innovation	3	BCED
East African Journal of Life Sciences	1	MBBD
East African Medical Journal	1	AHD
Entomologia Experimentalis et Applicata	1	PHD
Forest and Agricultural Entomology	1	PHD
International Journal of Health Geographics	1	AHD
International Journal of Tropical Insect Science	5	PHD/BCED
Journal of African Health Sciences	1	AHD
Journal of Applied Entomology	3	PHD
Journal of Chemical Ecology	3	BCED
Journal of Economic Entomology	1	PHD
Journal of Insect Science	3	BCED
Phytoparasitica	1	PHD

*Key: **HHD**, Human Health Division; **PHD**, Plant Health Division; **AHD**, Animal Health Division; **EHD,** Environmental Health Division; **MBBD**, Molecular Biology and Biotechnology Department; **BCED**, Behavioural and Chemical Ecology Department.*

(iv) Expert Consultations

Organisation/Body	No. of *icipe* Staff	Division/ Department
AGPP-FAO Rome: Review of the UNA Somalia IPM project: April–May 2007	1	PHD
Advisory Coordinator, FAO Programme Against African Trypanosomiasis (PAAT), March 1998 to 31 July 2010	1	AHD
AGPP-FAO Rome/FAO-Tanzania/Ministry of Agriculture and Food Security Tanzania: Assessment of the status of the elegant grasshopper, *Zonocerus elegans* in Kondoa district, Tanzania, 30 August to 17 September 2003	1	PHD
Business Services Market Development Project (BSMDP) /Promotion of Private Sector Development in Agriculture (PSDA)-GTZ, Kenya/Agricultural Trade Project GTZ: Pilot Project for production of generic QMS smallholder manual under EurepGAP option 2 regulations, 1 October 2005 to 30 November 2006	1	PHD
Business Services Market Development Project (BSMDP): Awareness campaign for the export horticulture producers and outgrowers groups to comply with EU/EurepGAP protocol, July–November 2004	1	PHD
Business Services Market Development Project (BSMDP): Monitoring and evaluation of awareness campaign for the export horticulture producers and outgrowers groups to comply with EU/EurepGAP protocol, September 2004	1	PHD
Clinton Foundation (Rural Initiative): Advisor on agriculture and rural development in Rwanda	1	PHD
COLEACP-PIP: IPM Training of trainers in French bean production	1	PHD
Consultant for PATTEC for their Steering Committee Meetings in Addis Ababa, Ethiopia (2006) and in Burkina Faso (2007)	1	AHD
Consultative meeting on development of insecticides for mosquito control, Virginia Tech, USA, May 2006	1	HHD
Course Director of the FAO/IAEA sponsored course on baseline data collection for the FAO/IAEA Regional Training Course on "Principles of Baseline Data Collection for Integrated Area-Wide Tsetse and Trypanosomosis Intervention Projects with a Sterile Insect Technique Component", 13 March to 7 April 2006	1	AHD
EU/UNA Somalia IPM Project: Development of training modules for tomato production in Somalia, February 2003	1	PHD
FAO-Kenya: Technical support for farmer field school trainers in Kiambu, Muranga, Maragua and Nyeri districts, Central Province Kenya, 12 to 16 August 2002	1	PHD
Flower Label Programme (FLP) Germany: Crop scouting training of trainers for Red Land roses, 18 to 21 August 2003	1	PHD
International Trade Center (ITC), Geneva, Switzerland: Sericulture development in Uganda and development of organic certification for honey in Kenya	1	EHD

Organisation/Body	No. of *icipe* Staff	Division/ Department
Lead Consultant for Ecosystem Profile for East African Coastal Forests and Eastern Arc Mountains Global Biodiversity Hotspot	1	EHD
Lecturer for the International Courses on African Trypanosomes (ICAT), sponsored by World Health Organisation (WHO), International Atomic Energy Agency (IAEA), Medicines Sans Frontieres (MSF) and Association Against Trypanosomiasis in Africa (ATA), 2001 to date	1	AHD
Member of panel of experts, Commission for Higher Education: Evaluation of competitive grants to Kenyan universities	1	PHD
Member of the Scientific Steering Committee of the System-wide Initiative on Malaria and Agriculture (SIMA) 2005	1	HHD
NIH: Fundamentals of International Clinical Research, Cape Town, South Africa, March 2007	1	HHD
NIH: Meeting on Malaria in Urban Areas—interdisciplinary Approach, Miami, USA, May 2005	1	HHD
Panelist on capacity building in Africa at the Grand Challenges in Global Health, Washington DC, October 2006	1	HHD
Lead consultant for Pesticide Action Network-UK/Africa Stockpiles Programme IPM Research project, October/ December 2006	1	PHD
Review and editing the 'BIO-EARN' Biosafety Resource Manual. Consultancy offered by the National Foundation for Research and Development (NFRD), Uganda	1	MBBD
UNEP 1st Conference of Parties of the Stockholm Convention on Persistent Organic Pollutants, Uruguay, May 2005	1	HHD
Wageningen University and Research Center, the Netherlands: Needs Assessment for WSSD and Horticulture Partnerships in East Africa on Improving Market Access, 29 June to 5 July 2005	1	PHD
WHO Consultation on Integrated Vector Management: Critical Review and Analysis of Needs to Support National Vector Control Programmes Implementation, Geneva, May 2007	1	HHD
WHO Second Meeting of the Partnership for Integrated Vector Management in Africa, Doula, Cameroon, April 2004	1	HHD
WHO Temporary Advisor on malaria vector control and personal protection, Geneva, Switzerland, March 2004	1	HHD
WHO Temporary Advisor on the implementation of new vector research strategy, Geneva, Switzerland, April 2007	1	HHD
WWF Eastern Africa Regional Programme Office/ African Stockpiles Programme: IPM awareness creation for journalists (2006)	1	PHD

Key: ***HHD****, Human Health Division;* ***PHD****, Plant Health Division;* ***AHD****, Animal Health Division;* ***EHD,*** *Environmental Health Division;* ***MBBD****, Molecular Biology and Biotechnology Department;* ***BCED****, Behavioural and Chemical Ecology Department.*

ANNEX 9:
List of Teaching Materials Produced by *icipe* Staff for Training and Capacity Building

(a) PLANT HEALTH DIVISION

IPM Manuals

Anon (2007) Generic Manual on Quality Management System for Smallholder Horticultural Farmer Groups in Kenya for Certification to EurepGAP Option 2. http://www.icipe.org/research_areas/plant_health/horticultural_crop_pests/index.html.

Barrion A. T. and Khan Z. R. (2004) *How to Handle Grass Stemborer Larvae.* Development Communication Ltd., Nairobi. ISBN 9966-9856-1-1.

Khan Z. R., Amudavi D. M, Midega C., Pittchar J., Nyagol D., Genga G., Ndiege A., Akelo P., Pickett J. A., Wadhams L. J., Muyekho F. N., and Nyateng B. (Eds) (2007) *Push-pull Curriculum for Farmer Field Schools*. *icipe* science Press, Nairobi. ISBN 92 9064 188 6.

Khan Z. R., Muyekho F. N., Njuguna E., Pickett J. A., Wadhams L. J., Dibogo N., Ndiege A., Genga G. and Lusweti C. (2005) *A Primer on Planting and Managing 'Push-pull' Fields for Stemborer and Striga Control in Maize—A Step-by-Step Guide for Farmers*. *icipe* Science Press, Nairobi. ISBN 92 9064 170 3.

Muyekho F. N., Barrion A. T. and Khan Z. R. (2004*) A Primer on Grass Identification and Their Uses in Kenya.* Development Communication Ltd., Nairobi. ISBN 9966-9856-0-3.

Pittchar J., Kidiavai E., Khan Z. R. and Copeland R. S. (2006*) Grass Rows Technology: Using Native Grasses to Increase Yield of Maize, Sorghum and Millet—A Step-by-Step Guide for Farmers*. *icipe* Science Press, Nairobi. ISBN 92 9064 178 9.

Seif A., Varela A. M., Michalik S. and Löhr B. (2001*) A Guide to IPM in French Beans Production with Emphasis on Kenya*. *icipe* Science Press. ISBN 92 9064 142 8.

Seif A., Varela A. M. and Nyambo B. (2003*) Tomato Pests and Diseases in Somalia and their Control*. UNA IPM Project in Somalia, UNA-Nairobi Regional Office.

Varela A. M., Seif A. and Löhr B. (2003) *Integrated Pest Management for Brassicas (With Emphasis on Eastern and Southern Africa)*. *icipe* Science Press. ISBN 92 9064 148 7.

Varela A. M., Seif A. and Löhr B. (2003*) A Guide to IPM in Tomato Production in Eastern and Southern Africa*. *icipe* Science Press. ISBN 92 9064 149 5.

Varela A. M. and Seif A. (2006) *A Guide to IPM in Mango Production in Kenya*. *icipe* Science Press. ISBN 92 9064 176 2.

Varela A. M., Seif A., Nyambo B. and Lohr B (2005*) A Guide to IPM in Cut Flower Production in Kenya*. *icipe* Science Press, Nairobi. ISBN 92 9064 172 X.

Varela A. M. and Seif A. (2004*) A Guide to IPM and Hygiene Standards in Okra Production in Kenya*. *icipe* Science Press. ISBN 92 9064 161 5.

Training Manuals:

Nyambo B. (2005*) Training Format for IPM in Mango Production in East Africa*. *icipe* Science Press, Nairobi. ISBN 92 9064 171 6.

Nyambo B., Varela A. M. and Seif A. (2003) Training Formats for Course on Integrated Pest Management for Tomato Production in Somalia, No. 4. UNA/*icipe* IPM Training Formats on Tomato Pests and Diseases in Somalia; UNA IPM Project in Somalia, UNA-Nairobi Regional Office.

Leaflets:

EurepGAP standard for small-scale farmers of fresh fruit and vegetables to the European market.

Promoting integrated pest management (IPM) for cabbage and related vegetables in East Africa.

Brochures:

Farmers' guide on planting a push-pull field.

Grow desmodium and stop striga: Plant desmodium as an intercrop and stop striga weed growing in your maize.

Grow desmodium for seed and make money.
Kuza desmodium na uzuie kwekwe ya striga: Panda desmodium pamoja na mahindi ili izuie kwekwe ya striga kukuwa ndani ya shamba lako la mahindi (in Swahili).
Panda mahindi na napia zaidi upate pesa nyingi (in Swahili).
Use "push-pull" strategy and produce more maize by controlling stemborers and striga weed.

Posters:
Components of fruit fly management.
EurepGAP—What smallholder producers of fruits and vegetables must do to access markets in European Union.
Major insect pests and diseases of brassicas in East Africa.
Major insect pests and diseases of mango in Kenya.
Mango-infesting fruit flies destroy crop quality and yield.

Miscellaneous:
The Gatsby Charitable Foundation (2005) The Quiet Revolution: Push-pull Technology and the African Farmer. Gatsby Occasional Paper. The Gatsby Charitable Foundation, London.

(b) HUMAN HEALTH DIVISION

Developed IVM training modules in English and French for senior level disease control managers in collaboration with WHO.
Entomology and vector control training manual for Ministry of Health technicians.
Training Manual on Malaria and Environment for Community Members and Public Health Officers.

(c) ENVIRONMENTAL HEALTH DIVISION

Raina S. K. (2004) Commercial Insects: A Practical Guide for Raising and Utilizing Silkmoths and Honey Bees in Africa (Three books published in 7 languages: English, French, Kiswahili, Spanish, Luganda, Arabic and Amharic). *icipe* Science Press, Nairobi. ISBN 086098 246 7, ISBN 086098 241 6, ISBN 086098 247 5.

(d) ANIMAL HEALTH DIVISION

Contribution—Three chapters for WHO training manual (in preparation).

(e) CAPACITY BUILDING AND INSTITUTIONAL DEVELOPMENT PROGRAMME

Ekesi S. and Billah M. K. (Eds) (2006) *A Field Guide to the Management of Economically Important Tephritid Fruit Flies in Africa*. *icipe* Science Press, Nairobi. ISBN 92 9064 179 7.

ANNEX 10:
Product and Market Development

A. Products that were derived from *icipe* projects

– Two product lines, Naturub® and Mondia Tonic® were developed and commercialised from the two indigenous medicinal plants, *Ocimum kilimandscharicum* and *Mondia whytei,* respectively. The products are sold mainly through six corporate supermarket chains in Kenya that consist of a total of 36 stores. The stores are distributed in three cities and nine towns in Kenya. Approximately 150,000 customers visit these stores a day.
– A project initiated by the Applied Bioprospecting Programme has built the capacity of the community living adjacent to Kakamega forest in Kenya to undertake commercial cultivation and processing of the two medicinal plants, *O. kilimandscharicum* and *M. whytei,* on their farms.
– The Commercial Insects Programme has also developed a number of products.

1. Naturub® Balm
- Used for alleviation of flu, colds, chest congestion, aches, pains and insect bites;
- Registered as a medicine with the Pharmacy and Poisons Board of Kenya in 2002;
- Naturub® has been registered as a trademark with the Kenya Industrial Property Institute;
- More than 110,000 units have been sold.

2. Naturub® Ointment
- Used for relief of muscular aches and pains;
- Registered as a medicine with the Pharmacy and Poisons Board of Kenya in 2007;
- Naturub® has been registered as a trademark with the Kenya Industrial Property Institute of Kenya;
- More than 2000 units have been sold.

3. Mondia Tonic®
- Used as an antidepressant, antioxidant, appetiser, a revitaliser and for clearing hangovers;
- Registered as a food supplement with the Kenya Bureau of Standards;
- Registered with the Kenya Industrial Property Institute.
- More than 1000 units have been sold.

4. Wild Silk Fabric
- Savanna Silk (blend of *Gonometa postica* and *Bombyx mori* bivoltine silk)
- Sea Breeze Silk (Blend of *Argema mimosae* and *Bombyx mori* bivoltine silk)
- Rain Forest Silk (Blend of *Anaphe panda* and *Bombyx mori* bivoltine silk)

5. *Bombyx mori* Bivoltine Silk Fabric
- Plain white silk fabric
- Dyed fabric
- Tie and dye fabric
- Screen printed and patterned fabric
- Natural dyed fabric
- Silk scarves
- Silk shirts

6. Eco Honey
- Acacia honey
- Polyflora honey
- Wattle honey
- Ocimum honey
- Neem honey
- Royal jelly honey

7. Stingless Bee Honey
8. Royal Jelly
9. Propolis
10. Candles/Beeswax
11. Mozigone Insect Repellent

12. Other Products
- In 2005, following confirmation of locust control effects of PAN, the Sudanese National Pesticides Council registered PAN for use alone or in combination with bio- or chemo-pesticides in the control of desert locust hopper bands.
- Desmodium seed produced through public–private partnership. Western Seed Company produces 3 tons of desmodium seed per year
- *icipe* odour-baited NGU traps are being widely used to monitor and suppress savanna tsetse in many eastern and southern African countries. NGOs like the Intermediate Technology Group (ITDG) (UK) and Practical Action Eastern Africa also advocate use of NGU traps in tsetse infested areas.
- Repellent collars to protect cattle from tsetse bites are under development and are being validated in large-scale field trials.

B. Products in the pipeline

- AfriLure (food attractant for fruit fly control)
- Bioteph (fungus for fruit fly control)
- Mosquito bait
- Mosquito repellent
- Mycoinsecticide for thrips
- Mycoinsecticide for termites
- Mycoinsecticides for leafminers
- Trap for riverine tsetse (vectors of human African trypanosomiasis)

ANNEX 11:
Acronyms and Abbreviations

AFFI	The African Fruit Fly Initiative
AGPP-FAO	Plant Protection Service of FAO
APU	Arthropod Pathology Unit
ARPPIS	African Regional Postgraduate Programme in Insect Science
ATA	Association Against Trypanosomiasis in Africa
AWF	African Wildlife Fund
BBSRC	Biotechnology and Biological Sciences Research Council (UK)
BC	Biological control
BDS	Biodiversity
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (Germany) [Federal Ministry of Economic Cooperation and Development]
BSMDP	Business Services Market Development Project
CBNRM	Community-Based Natural Resource Management
CCS-ACK	Christian Community Services - Anglican Church of Kenya
CEPF	Critical Ecosystem Partnership Fund (of Conservation International)
CIAT	Centro Internacional de Agricultura Tropical (Colombia)
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo (Mexico)
CIP	International Potato Centre (Peru)
CNRS	Centre National de la Recherche Scientifique (France)
COLEACP/PIP	Europe/Africa-Caribbean-Pacific Liaison Committee/Pesticide Initiative Programme
DANIDA	Danish International Development Agency
DAO	District Agricultural Officer
DBM	Diamondback moth
DED	German Development Service
DFID	Department for International Development (UK)
DRIP	Dissertation Research Internship Programme
EU	European Union
EurepGAP	Euro-Retailer Produce Working Group for Good Agricultural Practice
FAO	Food and Agriculture Organisation of the United Nations
FFS	Farmers' field schools
FLP	Flower Label Program (Germany)
FNIH	Foundation of the National Institute of Health (USA)
FPEAK	Fresh Produce Exporters Association of Kenya
GC	Governing Council
GEF-SGP	Global Environment Facility-Small Grants Programme (Uganda)
GIS	Geographical information systems
GTZ	Gesellschaft für Technische Zusammenarbeit (Germany)
4H	The 4 'healths'—human, plant, animal and environmental
HCDA	Horticultural Crops Development Authority (Kenya)
IAEA	International Atomic Energy Agency
ICRAF	World Agroforestry Centre (Kenya)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics (India)
IDRC	International Development Research Centre (Canada)
IFAD	International Fund for Agricultural Development (Italy)
IFS	International Foundation for Science (Sweden)
ILRI	International Livestock Research Institute (Kenya)
INSPIRE	Integrated Soil Productivity Initiative through Research and Education
IPM	Integrated pest management
ITDG	Intermediate Technology Group (UK)
IVM	Integrated vector management

JKUAT	Jomo Kenyatta University of Agriculture & Technology (Kenya)
KACE	Kenya Agricultural Commodity Exchange Limited
KAPP	Kenya Agricultural Productivity Project
KARI	Kenya Agricultural Research Institute
KEPHIS	Kenya Plant Health Inspectorate Service
KGT	Kenya Gatsby Trust
KIOF	Kenya Institute of Organic Farming
KPMD	Kenya Programme on Maize Development
KWS	Kenya Wildlife Service
LGB	Larger grain borer
M&E	Monitoring and evaluation
MDG	Millennium Development Goals
MHAC	Manor House Agricultural Centre, Kitale (Kenya)
MOA	Ministry of Agriculture
MSF	Médicines Sans Frontières
NALEP	National Agriculture and Livestock Extension Programme
NARES	National agricultural research and extension systems
NARO	National Agricultural Research Organisation (Uganda)
Netherlands SII	The Dutch Ministry of Foreign Affair's Program for Cooperation with International Institutions
NGO	Non-governmental organisation
NIH	National Institutes of Health (USA)
NK	Nature Kenya
NOW-ALW X	Geo & Biosphere
NRI	Natural Resources Institute (UK)
NRM	Natural Resource Management
OECD	Organisation of Economic Co-operation and Development
PAAT	Programme Against African Trypanosomiasis
PAN	Phenylacetonitrile
PATTEC	Pan African Tsetse and Trypanosomosis Eradication Campaign (approved by the African Union under the NEPAD Initiative)
PNAS	Proceedings of the National Academy of Sciences (USA)
PPRI	Plant Protection Research Institute (Zimbabwe)
R&D	Research and development
RELMA	Regional Land Management Unit (SIDA)
RNE	Royal Netherlands Embassy
RSM	Red spider mite
SCC-VI	Swedish Cooperative Centre, VI - Agroforestry
SDC	Swiss Agency for Development and Cooperation (Switzerland)
SGI	Sponsoring Group of *icipe*
SIDA	Swedish International Development Agency
SIMA	System-wide Initiative on Malaria and Agriculture
SSA	Sub-Saharan Africa
ToTs	Training of trainers
TRC	Trypanosomiasis Research Centre
TSBF	Tropical Soil Biology and Fertility Programme (CIAT)
UNA	United Nations Association
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VEO	Village Extension Officer
WHO/AFRO	World Health Organisation/Regional Office for Africa
WHO/TDR	World Health Organisation/Special Programme for Research and Training in Tropical Diseases Research
WOTRO	Netherlands Foundation for Tropical Science
WSSD	World Summit on Sustainable Development (August 2002)
WWF	World Wide Fund for Nature

icipe is a unique and advanced research and training organisation working to improve the lives and livelihoods of people in Africa. Because insects and other arthropods have a major impact in almost every area of their physical well-being and prosperity, ***icipe*** is making its contribution by continuing to improve the plant, animal, human and environmental health of, primarily, smallholder farmers and disadvantaged urban dwellers in Africa.

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