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COMMITTEE ON COMMODITY PROBLEMS

JOINT MEETING OF THE FOURTH SESSION OF THE SUB-GROUP ON BANANAS AND THE FIFTH SESSION OF THE SUB-GROUP ON TROPICAL FRUITS

Rome, 9 – 11 December 2009

PROJECT PROPOSAL FOR SUBMISSION TO THE COMMON FUND FOR COMMODITIES: PARTICIPATORY VALIDATION AND DISSEMINATION OF MANAGEMENT TECHNOLOGIES FOR *BACTROCERA INVADENS* AND OTHER MAJOR PESTS THAT CONSTRAIN PRODUCTION AND EXPORT OF FRUITS AND VEGETABLES IN EAST AND SOUTHERN AFRICA

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Participatory Validation and Dissemination of Management Technologies for *Bactrocera invadens* and other Major Pests that Constrain Production and Export of Fruits and Vegetables in East and Southern Africa

A project proposal submitted to the

COMMON FUND FOR COMMODITIES (CFC)
By
Ministry of Agriculture Food Security (MAFSC) of the Republic of Tanzania

On behalf of:

Kenya Plant Health Inspectorate Service (KEPHIS), Nairobi; Kenya Agricultural Research Institute (KARI), Nairobi; Ministry of Agriculture & Food Security, Plant Health Service (MAFSC), Dar es Salaam; Mikocheni Agricultural Research Institute (MARI), Dar es Salaam; Ministry of Agriculture, Animal Industries & Fisheries (MAAIF), Kampala; National Crops Resources Research Institute (NaCRRI), Kampala; Ministry of Agriculture (MoA), Maputo; Eduardo Mondale University (EMU), Maputo; International Centre of Insect Physiology and Ecology (*icipe*), Food and Agriculture Organization (FAO) of the UN and other partners.

Date: November 11, 2009

ACRONYMS AND ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
AFFP	African Fruit Fly Programme (of *icipe*)
ARI	agricultural research institutions
ARPPIS	African Regional Postgraduate Programme in Insect Science
BC	biological control
BMZ	German Ministry for Economic Cooperation and Development
CABI	CAB International
CFC	Common Fund for Commodities
DRIP	Dissertation Research Internship Programme
EF	entomopathogenic fungi
EU	European Union
FAO	Food and Agriculture Organization of the UN
FAO-IGSGTF	Intergovernmental Sub-Group on Tropical Fruits (of FAO)
FAO-TCP	Technical Cooperation Programme (of FAO)
FFS	Farmers Field School
FINTRAC-HDC	The Financial Transactions and Reports Analysis Centre of Canada-Horticultural Development Cooperation
GTZ	Gesellschaft für Technische Zusammenarbeit
HCDA	Horticultural Crops Development Authority (Kenya)
HDC	Horticultural Development Corporation
IAEA	International Atomic Energy Agency
IARC	international agricultural research centre
icipe	International Centre of Insect Physiology and Ecology
IFAD	International Fund for Agricultural Development (Italy)
IITA	International Institute of Tropical Agriculture
IPM	integrated pest management
IPPC	International Plant Protection Convention
ITFSP	Tree Crops into Farming Systems Project (of GTZ)
MAT	male annihilation technique
MDG	millennium development goal
MoA	Ministry of Agriculture (Kenya)
MRL	maximum residue levels
MSW	mango seed weevil
NARS	national agricultural research systems
NPPO	National Plant Protection Organisation
PCC	Programme Coordination Committee
PEA	project-executing agency
POP	persistent organic pollutant
PRA	pest risk analysis
PSB	Project Supervisory Body
PSC	Project Steering Committee
PSDA	Promotion of Private Sector Development in Agriculture (of GTZ)
R&D	research and development
SADDC	Currently SADC [Southern Africa Development Community countries]
SAAGA	South African Avocado Growers Association
SIT	sterile insect technique
TAC	Technical Advisory Committee
TCDC	Technical Cooperation Between Developing Countries (FAO unit)
UNEP	United Nations Environment Programme

PART I: Project logical framework

PART 1: OVERALL PROJECT GOAL, PURPOSE AND OUTPUTS

Narrative Summary	Verifiable Indicators	Means of Verification	Assumptions and Risks
Goal: To enhance food security, improve income generation capacity and livelihood of fruit and vegetable growers in East Africa and neighbouring countries.	Increase in food production and income generation capacity of smallholder farmers in targeted countries.	National fruit sale statistics, publications.	Political commitment to horticulture improvement remains the same.
Purpose: To validate, adapt, implement and disseminate, in collaboration with international and national partners, effective approaches (that are based on baiting technology, biopesticides, parasitoids, trapping, orchard sanitation and post harvest treatments) that lead to reduction of fruit and vegetable losses due to fruit flies and mango seed weevil (MSW) infestation leading to quality production to meet the needs of both the domestic and export markets.	(1) Reduced fruit infestation in project benchmark sites by at least 30% ; (2) increased knowledge of NARS and NPPOs in partner countries on fruit flies and MSW IPM technologies; (3) availability of new baits and biological control agents for management of fruit flies and MSW; (4) reduced incidence of rejection in export markets and increased access to markets by growers; (5) parasitoids of fruit flies established and significantly contribute to suppression of fruit flies; (6) post harvest management tools validated and adapted by growers and commercial companies; (7) availability of phytosanitary management tools; and (8) availability and uptake in knowledge on PRA, pest diagnosis and phytosanitary information management.	(1) Production and survey records, number of NARS and NPPOs trained, publications and reports; (2) request for releases of parasitoids, establishment and publication records; (3) post harvest treatment data, publication records and report; and (4) survey records from participating countries, databases and availability of pest diagnostic tools.	Demand for quality fruit and vegetables continue; continued demand for monitoring, management and identification tools for target pests.
Outputs (1) Suitable IPM package based on baits, mass trapping, biopesticides, parasitoids and orchard sanitation for management of fruit flies and MSW validated, adapted, disseminated and made available to growers; (2) fruit and vegetable infestation by target pests significantly reduced; (3) fruit fly parasitoids established in target countries and contribute to fruit fly suppression; (4) availability of effective post harvest treatment protocols for fruit flies; (5) fruit fly monitoring, detection and diagnostic information tools available for NARS and NPPOs; (6) NARS and NPPOs capacity in fruit fly monitoring, detection and management significantly improved; and (7) fruit fly management products locally produced and taken up by entrepreneurs.	(1) Existing and new management tools validated, adapted and disseminated to at least 100 growers per site by mid 2013; 30% reduction in damage translating to US$200 additional income/family (2) facility for mass production of parasitoid in place by mid 2011; parasitoid mass reared, released and established in at least 20 localities by mid 2011; (3) post harvest treatment regimes validated in large-scale trial by end of 2013 and parameters made available to commercial companies; (4) quarantine detection materials in place in target countries; (5) at least 200 NARS and NPPOs trained in fruit fly monitoring, detection and management; (6) CD-based information tools for improved quarantine setting produced and disseminated by mid 2013; and (7) fruit fly management products are locally available and production taken over by local entrepreneurs.	(1) Reports and publication records, direct opinion of end users; (2) rearing facility, (3) request for control agents, user opinion; (4) post harvest treatment parameters; (5) survey records and databases; (6) number of experts and entrepreneurs trained and (7) availability of control agents.	Existing and new management tools are adaptable for control of target pests; parasitoids establish, access to sampling locations; respective governments, NARS, NPPOs and growers cooperate; markets for a commercial product are sufficiently large and lucrative to attract local entrepreneurs.

PART II: ACTIVITIES AND INPUTS RELATED TO THE OUTPUTS, MEANS AND COSTS

Component 1 - Pre-Harvest Management Measures: New technologies, exotic natural enemies and other existing management tools for controlling *B. invadens* and other target pests assembled, validated in large-scale trials and disseminated.

ACTIVITIES	MEANS/PROCEDURES	COST TO CFC & DURATION	RISK AND ASSUMPTIONS
(1) Assembling and large-scale validation, adaptation and dissemination of IPM package for fruit flies based on baiting, male annihilation, use of fungal pathogens, parasitoid releases, ant technology, orchard sanitation, and assessing impact at selected benchmark sites in each participating country. (2) Field-testing of solid bait station as alternative to liquid bait spray for field suppression of target fruit flies. (3) Conducting on-farm validation, adaptation and dissemination of trunk application of *soft* pesticides and fungal pathogens against MSW at selected sites in each country. (4) Establishment of a pilot facility for production of: (i) locally developed baits from waste brewer's yeast, (ii) the fungus, *Metarhizium anisopliae* and (iii) fruit fly monitoring traps.	(1) Selection, procurement and distribution of appropriate materials (baits, traps, fungus, etc.); (2) development of criteria (with inputs from local collaborators) for site and grower selection and participation; (3) identification of sites/farms, meeting with growers, interviews, developing collaborative agreements; (4) establishment of a mass rearing facility for parasitoids; (5) preparing experimental design for package validation, adaptation, demonstration and dissemination jointly with growers, NARS and NPPOs; (6) training farmers on application and implementation; (7) on-farm assessment of pests infestation, identification and yield losses; and (8) data analysis, report writing and conclusions on technical viability and post experiment meeting with growers for feedback.	Total project costs for all activities (in Kenya, Tanzania and Uganda) for 3 years: US$670,000.	Financial disbursement is timely; collaborators provide effective contribution; NARS, NPPOs and growers are cooperative; access to farms granted by growers.

Component 2 - Post-Harvest Treatments: Cold and hot water post-harvest disinfestations trials completed and validated for *B. invadens* on mango and avocado.

(1) Maintain colonies of *B. invadens* for heat and/or cold tolerance testing. (2) Determination of the coldest tolerant stage of *B. invadens* on avocado. (3) Determination of the hottest tolerant stage of *B. invadens* on mango. (4) Large-scale validation trials on avocado (cold treatment). (5) Large-scale validation trials on mango (heat treatment).	(1) Procurement of appropriate materials (water bath, thermocouples, data loggers, walk-in refrigerators etc.); (2) fruit infestation, data collection; and (3) sharing data with public–private.	Total project costs for all activities for 3 years: US$180,000.	Financial disbursement is timely; insect colonies are stable; all parameters are taken regularly.

Component 3 – Surveillance and preventative measures: Surveillance, identification and mitigation measures to avert the threats of other exotic fruit flies that may impact on the management strategy			
(1) Conduct systematic trapping, monitoring and detection for exotic fruit flies in fruit and vegetable growing regions and other strategic locations in target countries to guide the application of phytosanitary management. (2) Establish in each participating country a database for target pests for the management of surveillance data and information sharing among partner countries. (3) Identify faunistic relationships and pathways for possible introduction and spread of other economically damaging fruit flies from the subcontinent. (4) Conduct relevant import pest risk analysis (PRA) using current and possible pathways as identified in (1) above. (5) Develop a regional standard based on the PRA for regulating fresh fruits and vegetables (or other commodity pathways) on which participating countries can agree. (6) Prepare working instructions or standard operating procedures (SOPs) for border inspectors regarding enforcement of the provision of the regional standard.	(1) Procurement and distribution of materials (baits, traps, computers for databasing etc.); (2) development of a protocol for trapping, monitoring and detection; (3) identification of strategic locations for traps installations (airports, border posts, fruit dumping sites etc.); (4) setting up fruit fly monitoring systems and continuous servicing; (5) inputting data into the databases and information sharing; (6) recruit Pest Risk Analyst; (7) conduct workshop for PRA development; (8) identify key exotic fruit fly species and commodities that may come along the pathways; (9) prepare SOPs for border inspectors.	Total project costs for all activities for 3 years: US$250,000.	Financial disbursement is timely, NARS and NPPO commitment remains favourable; access to sampling locations is granted.
Component 4 – Training and technology dissemination - Enhanced technical capacity at various levels of competency to support and sustain the project			
(1) Activity 1: Train NARS and NPPOs (training of trainers [ToT]) on surveillance and pre-harvest management packages—baiting; male annihilation; use of fungal pathogens; parasitoid mass rearing techniques, quality control, release and evaluation of parasitism; and orchard sanitation. (2) Activity 2: Conduct farmers' field school (FFS) hands-on training approaches on surveillance and all management packages and awareness campaigns on technology availability. (3) Activity 3: Facilitate training of local entrepreneurs and representatives of industries in participating countries on bait production at the pilot facility and operation and use of post harvest treatment. (4) Activity 4: Carry out public awareness to facilitate large-scale adoption and application of the recommended management tools by preparing and disseminating guidelines for implementation of control tools with due regard to market requirements through leaflets, posters, manuals and radio and TV programmes. (5) Activity 5: Advanced level training at PhD and MSc for young Africans.	(1) Development of criteria for selecting NARS, NPPOs and growers from participating countries for training; (2) designing FFS training curriculum and preparation of training materials; (3) participatory on-farm demonstration and dissemination of surveillance and management packages to NARS, NPPOs, and growers; (4) organise and conduct hands-on training on parasitoid rearing and impact evaluation in the field.	Total project costs for all activities for 3 years: US$ 400,000.	Financial disbursement is timely, NARS and NPPO commitment remains favourable; access to media is granted, political situation in the countries is stable.

Project Summary

Title: Participatory Validation and Dissemination of Management Technologies for *Bactrocera invadens* and other Major Pests that Constrain Production and Export of Fruits and Vegetables in East and Southern Africa

Duration: Three years

Location: Eastern Africa: Kenya, Tanzania, Uganda; Southern Africa: Mozambique

Objective and Nature: In Africa, improvement of fruit and vegetable productivity and quality enhances food security, employment opportunities and the economy in pursuit of the UN millennium development goals (MDGs). Horticultural crops such as mango, avocado and cucurbits in particular are an invaluable instrument for agricultural development because of their high economic returns and nutritive value, and their latent ability to serve as an engine for agricultural and economic diversification especially for smallholders who can gear production to specific local, regional or export markets. While the horticultural sector presents many opportunities for rural economies and improving livelihood of smallholders, several factors constrain production and limit the potential for trade. Insect pests are generally regarded to be the most important. Tephritid fruit flies (e.g. *Bactrocera invadens* and *Ceratitis cosyra,* and the mango seed weevil [MSW]) cause direct damage to important export crops such as mango, avocado and cucurbits, leading to 40–80% losses depending on locality, variety and season. Quarantine restrictions on fruit fly- and MSW-infested fruits limit export to large lucrative markets in South Africa, Europe, the Middle East, Japan and USA, where the insects are quarantine pests. Pest infestations reduce revenues and profits of smallholder growers and traders, and cause increasingly high production costs to local and export markets. The project, therefore, aims to improve the productivity and quality of mango, avocado and cucurbits in eastern and southern Africa (Kenya, Tanzania, Uganda and Mozambique) thereby improving incomes of smallholders and traders engaged in production and trade of the target crops. This objective is to be achieved through participatory validation, adaptation, dissemination and training of NARS, NPPOs and growers on environmentally sustainable and affordable technologies for the management of fruit flies and MSW. This will include implementation of IPM programmes that are based on application of food baits, biopesticides, ant technology, parasitoid releases and orchard sanitation to minimise the use of pesticides that lead to unwanted pesticide residues in fruits which would then facilitate compliance with standards required for both domestic and export markets. To access the quarantine sensitive market, post harvest treatment parameter will be developed for uptake by local entrepreneurs. The project will also train NARS, NPPOs and growers on fruit fly systematic trapping, monitoring and detection to prevent entry of exotic fruit flies into the countries.

The proposed project will contribute to several millennium development goals (MDGs) and specifically the reduction of poverty and hunger (MDG 1), using environmentally sustainable technologies (MDG 7), and contribute to global partnerships for development (MDG 8).

Recipient of Grant:	FAO-Intergovernmental Sub-Group on Tropical Fruits (FAO-IGSGTF)	
Recipient of Loan:	To be determined	
Total project cost:	US$ 2,181,696	
CFC-financing:	US$ 1,500,000	
Mode of Financing:	**Grant:**	US$ 1,500,000
	Loan:	US$ 0
Co-financier:	**FAO**	US$ 298,000
	BMZ	US$ 194,700
	SAAGA	US$ 38,996
Counterpart contribution:		US$ 175,000
Project Executing Agency:	*icipe* – African Insect Science for Food and Health	
Supervisory body:	FAO-IGSGTF	
Starting date:	July 2010	

BACKGROUND

The Region

In Africa, agriculture remains the foundation of the society and food security forms the base for economic development and stability. A large proportion of the population is engaged in farming, and production of fresh fruits and vegetables plays an important role in achieving food security both at the household and national levels, offering increased opportunity for trade and employment. Horticultural crops are especially an invaluable instrument for agricultural development, and trade in fruit and vegetable provides an important opportunity for economic growth in pursuit of the UN millennium development goals (MDGs) (GHI, 2006). Economically, horticulture is one of the most attractive sectors owing to the relatively high value of the products involved. For example, in Kenya, fruit and vegetable exports alone were estimated to be worth US$ 380 million in 2007 increasing to US$ 460 million in 2008 (KRA, 2008) serving as a main source of foreign exchange. Locally-grown fruit (such as mango and avocado) and vegetables (such as cucurbits) are, therefore, an important source of income and foreign exchange in Africa (Dolan et al., 1999), in addition to gaining recognition as major sources of vitamins and other important nutrients. Promotion of consumption of fruits and vegetables has been included in national nutrition programmes of many countries because of the increasing awareness of the nutritive value of the crops (http://www.fao.org/ag/magazine/FAO-WHO-FV). The increasing purchasing power of local populations has also resulted in increased domestic demand for these produce. Additionally, the demand for quality tropical fruit in Europe, the Middle East, America and Japan is on the increase. The above factors, combined with increasing globalisation of trade have created new and lucrative production and trade opportunities in SSA.

THE ROLE OF HORTICULTURE IN ACHIEVING THE MILLENNIUM DEVELOPMENT GOALS (MDGS)

Horticultural crops have an important role to play in achieving the millennium development goals (MDGs) (GHI, 2006). A strengthened horticultural sector can have a positive impact on all of the eight MDGs because the sector can directly contribute to poverty reduction and food security issues (**MDG1**) in rural economies of Africa where the highest production of fruits and vegetables takes place. Horticultural crops are known to generate more jobs per hectare, on-farm and off-farm, than staple based agricultural enterprises (Ali et al., 2002) and they can generate higher profits than staple-based crops especially when land is relatively scarce and labour is abundant. This greatly benefits farmers and landless labourers in rural settings by providing income that is used to alleviate hunger and reduce poverty (**MDG1**). Fruits and vegetables are the most important sources of micronutrients. Improvement in diet can increase the productivity of the rural farmers (**MDG1**) and their children to achieve universal primary education (**MDG2**), reduce health care related costs and increase incomes. Women are the major producers of horticultural crops in Africa and they are also involved in value-addition activities from production to marketing and their involvement in horticulture promotes gender equality and empowerment (**MDG3**). The absence of essential micronutrients exacerbates poor children's vulnerability to disease. Improving access to fruits and vegetables reduces mortality and morbidity of infants and children under the age of five (**MDG4**), particularly in rural areas as well as improving maternal health (von Braun et al., 2004) (**MDG5**). A healthy diet rich in fruit and vegetables bolsters the body's immune system, helping it to resist HIV/AIDS, malaria and other infectious diseases that are rampant in Africa (FAO/ILSI, 1997) (**MDG6**). Fruits and vegetables are also recognised by FAO and WHO as the primary nutritional tools to prevent non-communicable and micronutrient related diseases (WHO-FAO, 2005). These two major UN organisations recently launched the campaign that every individual should consume 400 g of fruits and vegetables a day (excluding starchy tubers such as potatoes) to combat micronutrient deficiencies (http://www.fao.org/ag/magazine/FAO-WHO-FV). Perennial fruit trees such as mango can conserve and protect the soil in hilly and in high rainfall regions ensuring environmental sustainability (**MDG7**). The collaborative effort across many national and international agricultural centres and the private sector across Africa, Asia, Europe and the US in this project represents a global partnership for development to help the rural economies of Africa (**MDG8**).

THE TARGET COMMODITIES – MANGO, AVOCADO AND CUCURBITS

Mango is one of the four major commodities of concern to the FAO-Intergovernmental Sub-Group on Tropical Fruits and is the second most internationally traded tropical fruit after pineapple (http://www.fao.org/). World production of mango was at 32 million tons in 2006 and showed a slight increase to 33 million tons in 2007 (http://www.fao.org/). Mango production in Africa has been relatively stable at 2 million tons since 2003 (http://www.fao.org/). The total area under production in the 4 project target countries in Africa stands at 52,000 ha (FAOSTAT, 2007) and it represents an important export crop for all the countries. According to data presented at the FAO Inter-Governmental Sub-Group on Tropical Fruits held in Australia in 1999 and Costa Rica in 2001, mango exports from Africa were estimated at 35–40,000 tons annually and were worth over US$ 42 million (Lux et al., 2003). This value has gradually eroded as a result of import bans by several countries due to the invasion of *B. invadens* (www.irrinnews.org; W. Otieno [KEPHIS], personal communication).

Avocado production globally was estimated at 3 million tons in 2007 with America producing 80% of the world avocados, and the rest of the world accounting for the remaining 20%. In Africa, total production in 2007 was at 364,000 tons. Only 10% (200,000 tons) of avocado production is traded internationally. With the huge expansion in production areas of the Hass cultivar in many countries including Africa, the volume that is being traded internationally is likely to increase (Toerien, 1999).

Cucurbits (mainly watermelon, cucumbers and zucchini) production in the world was estimated at 137 million tons in 2007 (FAOSTAT, 2007). Among the 3 cucurbits, watermelon is the most cultivated (93 million tons). In Africa production was estimated at 5 million tons in 2007 (FAOSTAT, 2007).

For all the 3 target crops above and as with all other horticultural produce, the European Union (EU) is the largest destination market for African countries. Huge volumes are traded among African nationals although the exact figures are unknown. In the 4 target project countries, the export of fruits and vegetables is increasing at an annual rate of 15–20% and this trend is likely to continue with horticulture employing over 4 million people, mostly women and the youth in the production, transport, processing and trade sectors. Over 80% of the produce comes from smallholders who produce for the local and export markets to obtain the much-needed cash income for improving household food security. However, despite substantial increases in exports in recent years, the share of all African suppliers of mango, avocado and cucurbits to lucrative markets abroad remains below 25%. With the current liberalisation in trade, increasing growth in consumption patterns and addressing of factors that afflict production such as fruit flies, opportunities exist for increasing the export of these commodities.

Constraints

To maximise the benefits from production of fruits and vegetables, the constraints impeding increased production must be addressed. Two of the major obstacles to increased fruit and vegetable production in East and southern Africa are infestation by fruit flies (mainly the exotic *Bactrocera invadens* and native *Ceratitis* species) and the mango seed weevil (*Sternochetus mangiferae*) (Mwangi, 1985; Lux et al., 2003; Ekesi et al., 2009).

Female fruit flies that lay eggs under the skin of fruits and vegetables cause direct losses. The eggs hatch into larvae that feed in the decaying flesh of the crop. Infested fruits and vegetables quickly rot and become inedible or drop to the ground. In addition to this direct loss, major indirect losses result from quarantine restrictions that are imposed by importing countries to prevent entry and establishment of unwanted fruit flies. For example, export of potential host species of *B. invadens* such as mango and avocado from Kenya is already banned or limited to Seychelles, Mauritius and South Africa. Sales of non-traditional hosts have also been compromised in trade to South Africa (avocado) and United States (beans). Ugandan exports of banana have been severely affected due to quarantine restrictions on *B. invadens* despite it not normally being associated with this crop. This restricts free trade and export of fresh fruits and vegetables to important lucrative markets abroad.

Although Africa is known to be the origin of several fruit fly introductions and establishments worldwide, (the most notorious species being the Mediterranean fruit fly, *C. capitata*) with the intensification of fruit trade, the continent has also become highly vulnerable to introduction of alien fruit fly species. Most recently *B. invadens* and *B. latifrons* were translocated to Africa from Asia (Drew et al., 2005; www.tephritid.org). In 1997, *Bactrocera zonata* was introduced into Egypt. *Bactrocera cucurbitae* has also been in Africa for years without a clear date of introduction. The invasion of alien species can cause extensive economic and ecological damage, with unpredictable negative effects on native populations. Alien species impact on environment is believed to be second only to habitat destruction (Naeem *et al*., 1995; Lyon and Miller, 2000). Invasive species can alter successional patterns, mutualistic relationships, community dynamics, ecosystem functions and resource distributions. Invasive species that cause extinction of native species will ultimately reduce local and global species diversity (Vitousek et al., 1996; Collins et al., 2002). Currently, there is clear evidence that the indigenous *C. cosyra* is being displaced by the invasive *B. invadens* in various parts of Africa where the pest has been reported (Ekesi et al., 2006a; S. Ekesi, unpublished data; R. Hanna, unpublished data).

The Target Exotic Tephritid Fruit Flies

(1) Bactrocera invadens: This new invasive fruit fly pest is believed to have invaded Africa from the Asian subcontinent and was discovered in Sri Lanka soon after it was reported from Africa (Drew et al., 2005). Since first detection in March 2003 in Kenya, the insect has rapidly spread across tropical Africa and is now known from 28 countries and the Comoros Islands (Drew et al., 2005; French, 2005; S. Ekesi, unpublished data; R. Hanna, unpublished data). The Inter-African Phytosanitary Council has described it as a "devastating quarantine pest" (Drew et al., 2005; French, 2005). Damage to mango (its primary host plant) has increased to between 40–80% especially in lowland areas where it is now the dominant fruit fly pest (Ekesi et al., 2006b; R. Hanna et al., unpublished data). Ongoing host range studies across Africa have shown that the pest attacks other cultivated crops such as cucurbits, tomatoes, citrus, avocado and banana but the primary host plant is clearly mango compounding the existing problem on the crop. With grants from IFAD, BMZ and core support from *icipe*, studies on the bioecology of the exotic fruit fly, its response to improved attractants, bait sprays, male annihilation, fungal pathogens, efficacy of the indigenous weaver ant (*Oecophylla longinoda*) (Van Mele et al., 2007), and efficacy of two introduced natural enemies (*Fopius arisanus* and *Diachasmimorpha longicaudata*) from Hawaii have been completed.

(2) Bactrocera cucurbitae: The melon fly *B. cucurbitae* is possibly the world's most damaging fruit fly species on vegetable crops, particularly cucurbits (White and Elson-Harris, 1992). It is widely distributed in Asia (where it is indigenous) and in East Africa (Kenya and Tanzania). As in mango, trapping and bait sprays have been developed for the management of *B. cucurbitae* infesting cucurbit crops. Additionally, studies have been completed with regard to efficacy of the natural enemy *Psyttalia fletcheri*.

Indigenous Tephritid Fruit Flies

A varying combination of five indigenous species including *Ceratitis cosyra, C. fasciventris, C. rosa, C. anonae* and *C. capitata* attack mango. Out of the five species the most damaging is *C. cosyra.* On cucurbits, *Dacus* species are prevalent while no native fruit flies are known to attack avocado. Traditionally, yield loss on these crops due to native fruit flies can range between 30–70% depending on the locality, season and variety (Lux et al., 2003). Baseline ecological data relevant to the application of management strategies is currently available for these indigenous fruit fly species and their response to food attractants and susceptibility to fungal pathogens has been quantified (Manrakhan, 2005; Ekesi et al., 2005; Ekesi et al., 2006a, b).

Mango Seed Weevil (MSW)

Like fruit flies, mango seed weevils cause direct losses to the mango fruit. MSW is responsible for premature fruit drop, direct damage to fruit pulp, and reduced seed germination (Hansen; 1993; Peña et al., 1998; Verghese et al., 2005). It is also a major quarantine pest in many countries (CABI, 2000). Adult weevils insert their eggs into mango fruitlets and initially cause small, dark marks on the skin. The larvae develop inside the seed and the emerging adults cause substantial internal damage to the fruit pulp, while their exit holes provide entry to pathogens that accelerate the deterioration of the infested fruit (Joubert, 1998). Infestation by MSW in East Africa can vary between 25–68% depending on the variety, locality and season (Mwangi, 1985; Z. Seguni, unpublished data). Like fruit flies, indirect loss is associated with quarantine restrictions. As in the case of fruit flies, some smallholders practice cover-spray application at fruit set while a large majority does nothing and consequently suffer heavy losses especially for exports targeting the Middle East. Those that apply cover sprays apply insecticides that are not MRL compliant. Potent isolates of the entomopathogenic fungi and *soft* pesticides have been identified in the laboratory by *icipe* and there is an urgent need for large-scale on-farm validation and dissemination of these control approaches jointly with farmers.

Proposed Management Strategies for Project Target Pests

Previous experience with exotic and native fruit fly species in Africa and with other species in similar ecologies in Latin America and the South Pacific has shown that management of a complex of fruit fly species is unlikely to be successful if based on a single management technique (Aluja et al., 1996; Allwood and Drew, 1997; Lux et al., 2003). An integrated pest management (IPM) approach offers the best method to improve the economies of the production system by reducing yield losses and enabling growers to comply with stringent quality on the export market (Aluja et al., 1996; Allwood and Drew, 1997; Lux et al., 2003).

icipe, and various partner institutions through several research project grants from donors such as IFAD, FAO, and IAEA, has identified and developed a number of fruit fly management options against the target exotic and native fruit flies (*Bactrocera invadens, B. cucurbitae*, *Ceratitis cosyra, C. fasciventris, C. rosa, C. anonae*, *C. capitata* and *Dacus* spp.). These include several management products that are based on baiting techniques, male annihilation technique (MAT), mass trapping, use of the entomopathogenic fungus (*Metarhizium anisopliae)*, conservation of natural enemies and orchard sanitation using the Augmentorium (Lux et al., 2003; Ekesi et al., 2005; Ekesi and Billah, 2006; Ekesi et al., 2006ab., Ekesi et al., 2007; Van Mele et al, 2007; Vayssières et al, 2009b; Hanna et al., unpublished). On-farm trial results obtained with the native species have been very encouraging and the management toolbox is ready for large-scale validation, adaptation, dissemination and promotion. In addition to the various management packages above, the efficacy of two introduced natural enemies (*Fopius arisanus* and *Diachasmimorpha longicaudata*) from Hawaii has been completed against *B. invadens* (Mohamed et al., 2008; 2009). With regard to *F. arisanus*, limited field releases of the parasitoid have begun in Kenya and Tanzania in 2008 following issuance of permits from the various government authorities and large-scale releases are anticipated if approval is granted for this project. Similarly, studies on the impact of *P. fletcheri* on *B. cucurbitae* have been completed in Reunion and this parasitoid is ready for shipment to Africa for release against this important cucurbit pest.

The importance of field sanitation as an effective tool for reducing infestation by MSW has been stressed and is strongly advocated in South Africa (Joubert, 1998). This technique will be promoted in this project. Recent important findings have shown that mango seed weevils hibernate in huge numbers on the trunk of the mango tree. Unknowingly, growers apply control agents on the mango canopy rather than the trunk. Several *soft* pesticides such as spinosad, imidacloprid and thiamethoxam have been identified as valuable tools for trunk application against the MSW. MSW are also highly susceptible to fungal pathogens and because adult weevils spend a substantial part of their time in the soil at the base of the mango trees in addition to the trunk, the potent fungus that has been identified will become a valuable tool for management of the insect. Any management approach for MSW that is based on a single tactic is less likely to provide a sustainable solution (Hansen, 1993) and an IPM strategy based on the use of orchard sanitation, entomopathogens and *soft* pesticides will be promoted and disseminated.

Regulatory measures such as post-harvest quarantine treatments usually applied before export of fruits and vegetables will be very important in the current project particularly for the devastating *B. invadens*. Currently, outside of the Republic of South Africa, there is no facility available for post-harvest treatment in sub-Saharan Africa and parameters for treatment must be established which will be given high priority in the project. Without such post-harvest treatments to provide quarantine security, quarantine restrictions will limit available markets for fruits and vegetables from East and southern Africa. Available quarantine treatment options include using irradiation, chemicals, physical treatments and controlled atmospheres. Prohibition on the use of chemicals such as ethylene dibromide and methyl bromide as post-harvest quarantine fumigants, the expensive nature of irradiation and the fact that controlled atmosphere are mainly directed at dried fruits means that the use of cold and heat treatments may be an appropriate option for the target crops in the proposed project. There is, therefore, the need to identify effective cold and hot treatment regimes that are not harmful to the fruits, yet cost effective and suitable to the smallholder farmer. That will be pursued in the project. In this regard, the project will target mango for hot water treatment and avocado for cold disinfestations. Effective parameters will be established in close collaboration with industry partners, NARS and NPPOs for both fruits against *B. invadens*.

A sound quarantine system to reduce the risk of entry, establishment, spread and in general survival of a pest that is not already endemic to a country is very important as it can minimise the severity of the pest problem. In many African countries, however, the concept of a sound quarantine system is far from ideal and is often viewed as difficult. Indeed, quarantine problems are often compounded not only by rapid expansion of international trade in fruit and vegetables but also by international passenger traffic, uncontrolled movement of fruits and poor surveillance practices. According to Armstrong and Jang (1997) there may actually be more risk for introduction of exotic pest species from contraband fruits smuggled by airline passengers than commercial shipments of fruits. Adequate training of inspectors to respond to unknown fruit flies is an important activity and the need to train quarantine specialists at quarantine barriers on detection, monitoring and taxonomy of fruit flies and MSW is therefore crucial and will be vigorously pursued in this project. Indeed an efficient quarantine system in Africa may also limit the spread of these devastating pests from Africa to other parts of the world. For example, in Australia, the implementation of an effective IPM programme for fruit flies and better regional control efforts in Southeast Asia have led to fewer fruit flies being 'exported' to other countries. Additionally, correct identification of a wide range of fruit species was found to reduce the probability of misidentification of an incursion into Australia and saved unnecessary expenditure of further surveillance, containments and eradication (www.aciar.gov.au).

Although our target pests and particularly the fruit fly species attack numerous tropical fruits and vegetables, the project shall focus on mango, avocado and cucurbits (cucumber, watermelon, and zucchini). All these target crops represent important smallholder products for both domestic and export markets.

PROJECT JUSTIFICATION

In East and southern Africa, production of fruits and vegetables is recognised as a major source of income generation and has been accorded high priority in the national development plans of most of the countries in the region. This is also reflected in the region's agricultural sector priorities in which enhancement of horticultural production for income generation figures prominently (HCDA, 2004; Mugenyi, 2004; E. Niyibigira et al., unpublished data). In Kenya, horticulture including flower production overtook tourism in 2007 contributing up to US$ 1 billion in foreign exchange (KRA, 2008). Out of this, fruit and vegetable exports alone was estimated to be worth US$ 380 million in 2007 increasing to US$ 460 million in 2008 (KRA, 2008). In Tanzania, horticulture earned the country US$ 9.2 million in 2003 (Mugenyi, 2004). In Uganda, in 2003 alone, export of fruits and vegetables contributed US$ 12.5 million to the national economy, which was equivalent to 4% of the country's total export value (E. Niyibigira et al., unpublished data). Exports of mango and banana fruits alone from Mozambique to neighbouring South Africa, the largest destination market for horticultural produce from the country, are estimated to be worth around US$ 20 million annually. Recent studies estimate that the horticulture sector in Maputo (South) and Manica (Central) provinces alone could generate revenues of more than US$ 25 million per year through both commercial and smallholder (family) production. The export of fruits and vegetables in the four African countries—Kenya, Tanzania, Uganda and Mozambique—is increasing at an annual rate of 15–20% and this trend is likely to continue with horticulture employing over 4 million people, mostly women and the youth in the production, transport, processing and trade sectors. Over 80% of the produce comes from smallholders who produce for the local and export markets to obtain the much-needed cash income for improving household food security and livelihood.

In this region, however, one of the major problems afflicting production of quality fruits and vegetables is infestation by fruit flies, especially the invasive species, *B. invadens*. Assessment made by *icipe*-led African Fruit Fly Programme in 1999 showed that, out of 90,000 tons of mango produced annually in Kenya about 40% is lost to native fruit fly infestation (Lux et al., 2003). With the arrival of *B. invadens*, from the Asian sub-continent, damage to mango in Kenya, Tanzania and Uganda has risen to between 40 to 80% (Seguni and Mwaiko, 2005; Ekesi et al., 2006b; Ekesi et al., 2009). On cucurbits (such as cucumber, squash, bitter melon and watermelon), the fruit fly problem is severe ranging between 30–60% and is largely due to two species—*B. cucurbitae* and native *Dacus* spp. (Ekesi and Billah, 2006a; S. Mohamed, unpublished data). Besides causing these extensive direct losses in the field, fruit flies greatly restrict the trade and export of fruits and vegetables to large and lucrative markets abroad where they are regarded as major quarantine pests (Barnes, 2004). For example, exports of potential host species of *B. invadens* such as mango, avocado and cucurbits from Kenya are already banned in Seychelles, Mauritius and South Africa. Trade of several horticultural produce between Africa and the US has been severely hampered by recently issued Federal

Order by US banning importation of several cultivated fruits and vegetables from African countries where *B. invadens* has been reported (USDA-APHIS, 2008). In the case of avocado, Kenya lost US$ 1.9 billion in 2008 due to *B. invadens* quarantine restriction imposed by South Africa. Ugandan exports of banana have been severely affected due to quarantine restrictions on *B. invadens* despite it not normally being associated with this crop. Production and export of fresh fruit and vegetables in Mozambique are now seriously affected by *B. invadens*. South Africa, its major trading partner has closed its markets to fresh fruits including bananas and mangoes, which are among the most important products exported from Mozambique. The current export volume for banana is 35,000 tons per year with a foreign exchange value of US$ 17.5 million. At Vanduzi Company in the Central province of Manica about US$ 1.5 million has been lost due to the presence of *B. invadens* and quarantine restrictions on the export of various fresh fruits and vegetables. These restrictions threaten the income of more than 500 families that produce and sell fresh fruit and vegetables to the company. The Ministry of Agriculture reported several fresh fruit businesses closed and workers sent home because of market reaction to this new situation in Mozambique. For instance, in the Maputo Province, five banana producing companies exporting to South Africa, with a total of 900 ha are at a risk of bankruptcy and some of the 1500 people directly employed are being laid off.

The mango seed weevil (MSW) on the other hand causes direct damage to mango fruit pulp and up to 68% infestation has been recorded in coastal Kenya and Tanzania (Mwangi, 1985; Z. Seguni, unpublished data). Aside from direct losses, MSW is also a serious quarantine pest like fruit flies and indirect losses result from quarantine restrictions imposed by importing countries to prevent entry and establishment of the pest (CABI, 2000).

Considerable losses due to fruit flies and MSW reduce the profits of smallholder growers and traders and contribute to high production costs. Some farmers frequently control these pests by spray application of broad-spectrum pesticides like malathion and diazinon, most of which are listed as candidate persistent organic pollutants (POPs) by UNEP (www.unep.org/thematic/chemicals). These pesticides often contribute to high pesticide residues on fruits and vegetables and rejection by export markets. Other growers who cannot afford available pesticides suffer considerable losses due to high levels of fruit fly and MSW infestations. When available to rural farmers, pesticides are often applied too ineffectively to significantly affect pest incidence (MoA, 2003). Furthermore, there is often scant regard for human and environmental safety when these pesticides are applied. Because of lack of basic knowledge about the biology and ecology of fruit flies, some smallholders practice early harvest as a strategy to evade infestations. This often does not help as some fruit fly species like *B. invadens, C. cosyra* and *C. rosa* attack green immature and mature mango and banana fruits (S. Ekesi *et al*., unpublished data). Additionally, the quality of early harvested fruits is inferior to tree-matured fruits. This control action is, therefore, ineffective. The recently introduced uniform and strict quarantine regulations and maximum residue levels (MRLs) by the EU compound the problem and jeopardise the lucrative export and trade in fruits and vegetables from Africa to Europe. Consequently, the success of fruit and vegetable production in Kenya, Tanzania, Uganda, and Mozambique whether it is for the rapidly expanding domestic market or for export will largely depend on sound management of fruit flies and MSW. So, there is a critical need to validate, adapt and disseminate IPM programmes based on baiting technique, male annihilation, use of biopesticides, parasitoids and orchard sanitation that promote alternatives to broad-spectrum insecticides. Proposed strategy in the technology transfer to the growers is to involve them directly in the validation, adaptation and dissemination through Farmer Field School (FFS) in several benchmark sites in the participating countries. Experience in the development of the various management options to date shows that several farmers are interested in the technological package and rapid uptake is anticipated especially given the ever-increasing loss at the export market. If losses caused by fruit flies and MSW can be reduced, food self-sufficiency will be increased and the livelihood of the farming community will be enhanced and the economy will improve.

Equally important for the transfer of appropriate pre-harvest technologies for combating the native and invasive fruit flies is the need for regulatory measures such as post-harvest quarantine treatments (usually applied before export of fruits and vegetables). There is no facility available for post-harvest treatment in the four target countries. Parameters for treatment must be established. Without treatments to provide quarantine security, quarantine restriction will limit available markets for fruits and vegetables from the region. There is, therefore, the need to identify effective post-harvest treatments that are not harmful to either the fruit or humans coming in contact with or consuming the fruit. In this regard, parameters for hot water treatment for mango and cold treatment for avocado will be developed jointly with industry partners/growers, NARS and

NPPOs and aptly transferred to relevant authority. It is believed that investment in post-harvest treatment plant in the region could improve export of fruits and vegetables from East Africa by up to 50% (R. Ntoyai, Kenya Plant Heath Inspectorate Service, pers. commun.). Phytosanitary measures that reduce the risk of entry, establishment, spread and general survival of a pest that is not already endemic to a country are imperative to prevention and exclusion of the invasive species. Adequate training of inspectors to respond to unknown insects through surveillance is an important activity. The above will also be pursued in the project.

The project shall build on the vast experience of *icipe* and FAO on IPM and previous knowledge with dealing with invasive pests and particularly *B. invadens* with the aim of enabling effective management of all target fruit flies and MSW in East and southern Africa.

CONSULTATION WITH STAKEHOLDERS

In the development of this project document several consultations were held with stakeholders. The resources provided by IFAD, FAO, IAEA and BMZ to the *icipe*-led African Fruit Fly Programme (AFFP) has allowed for consultative meetings with stakeholders in East and southern Africa that included fruit and vegetable growers, NARS and NPPOs and governments of participating countries on the problems related to fruit flies and MSW in the region and to design a project document for long-term management of these insects. The AFFP through its various regional stakeholders' meetings since November 2005 to date has had an extensive consultation with regional partners on the tactics for dealing with fruit flies in Africa. The GTZ with participation of *icipe* also held a stakeholder workshop in March 2006 on mango value chain and identified fruit flies and MSW as the major obstacles limiting increased fruit and vegetable production in Kenya. Following these various stakeholder meetings, the FAO in August 2006 and April 2009 sponsored a task force meeting with broad participation of government officials of Kenya, Tanzania (mainland and Zanzibar) and Uganda to develop a long-term strategy for management of both fruit flies and MSW in the region. The current proposal provides a comprehensive view of the outcome of the task force meeting and if approved would go a long way in ameliorating the fruit fly and MSW related problems in the region thereby increasing food security, income generation capacity and livelihood of the East and southern African countries.

PROJECT DESCRIPTION

Project Vision: The proposed project is a collaborative joint initiative of FAO with *icipe* and national institutions in eastern and southern Africa with the broad objective of improving the income and nutrition of smallholder families and increase the export earnings of the target countries by improving yield and quality of fruits and vegetables through the introduction of sustainable IPM programmes and post harvest treatment tools for fruit flies and MSW.

Project Mission Statement: The project shall build on existing experience of the collaborating institutions and provide management tools to growers by validating and adapting new and existing technologies combining them into an IPM package and disseminating the management tools to smallholder farming communities in the targeted countries. The project also plans to provide post-harvest management tools to allow for export of fruits to quarantine sensitive markets. Training at various levels of competence will be a fundamental component of the project, and capacity of NARS and NPPOs in surveillance, pest risk analysis (PRA), pest diagnostics and phytosanitary information management will be improved. The proposed project builds on several consultations with stakeholders in the fruit and vegetable industries, local authorities of the target countries, international fruit fly experts and donor agencies following completion of a FAO-TCP project on surveillance of *B. invadens* in East Africa that revealed serious economic problems associated with the invasion of the insect.

Goal: To enhance food security, improve income generation capacity and livelihood of fruit and vegetable growers in eastern and southern African countries.

Purpose: To validate, adapt, implement and disseminate in collaboration with international and national partners effective approaches (that are based on baiting technology, biopesticides, parasitoids, trapping, orchard sanitation and post harvest treatments) that lead to reduction of fruit and vegetable losses due to fruit flies and mango seed weevil (MSW) infestation leading to quality production to meet the needs of both the domestic and export markets.

Collaborating Institutions, NARS and ARO: ***Kenya:*** (1) Ministry of Agric., Nairobi (MoA-N) – Dr. W. Songa & Mr. M. Mbinga; (2) Kenya Plant Health Inspectorate Service (KEPHIS) - Dr. W. Otieno & Mr. S. Muchemi; (1) Kenya Agricultural Research Institute (KARI) – Drs. L. Wasilwa & M. Waiganjo; (4) International Centre of Insect Physiology and Ecology (*icipe*) – Drs. S. Ekesi & S. Mohamed. ***Tanzania:*** (1) Mikocheni Agricultural Research Institute (MARI) – Dr. Z. Seguni; (2) Ministry of Agriculture & Food Security, Plant Health Service (MAFS) – Mr. W. Mwaiko, Dr. G. Kirenga & Ms. B. Pallangyo. ***Uganda*** – (1) National Crops Resources Research Institute (NaCRRI) & Ministry of Agric. Animal Industries & Fisheries, Kampala (MoA-U)– Dr. I. Rwomushana & F. Okullowany. ***Mozambique*** – Ministry of Agric., (MoA-M) - Dr. S. Mangana; Eduardo Mondale University (EMU) – Dr. D. Cugala. ***FAO*** – Dr. J. Jones. Responsibilities of all project partners are as listed in Annex 1. At project inception meeting, partners will identify relevant farmer groups at project benchmark sites and key private sectors for project implementation and operations.

PROJECT COMPONENTS

Four project components are proposed. These are listed below with the respective envisaged activities per component.

Component 1—Pre-Harvest Management Measures: New Technologies, Exotic Natural Enemies and Other Existing Management Tools for Controlling *B. Invadens* and Other Target Pests Assembled, Validated in Large-Scale Trials and Disseminated.

Specific activities

(1) Assembling and large-scale validation, adaptation and dissemination of IPM package for fruit flies based on baiting, male annihilation, use of fungal pathogens, parasitoids releases, ant technology, orchard sanitation and assessing impact at selected benchmark sites in each participating country (***CFC funded for Kenya, Tanzania, Uganda, Mozambique. FAO co-financing for Mozambique***).
(2) Field-testing of solid bait station as alternative to liquid bait spray for field suppression of target fruit flies (***BMZ co-financing activity***).
(3) Conduct on-farm validation, adaptation and dissemination of trunk application of *soft* pesticides and fungal pathogens against MSW at selected sites in each country (***BMZ co-financing activity***).
(4) Establishment of a pilot facility for production of (i) locally developed baits from waste brewer's yeast, (ii) fungus pathogen, *M. anisopliae* and (iii) fruit fly monitoring traps (***Exclusively CFC funded***).

Component 2 - Post-Harvest Treatments: Cold and hot water post-harvest disinfestations trials completed and validated for *B. invadens* on avocado and mango, respectively

Specific activities

(1) Maintain colonies of *B. invadens* for heat and/or cold tolerance testing (***BMZ and FAO co-financing***)
(2) Determination of the most cold tolerant stage of *B. invadens* on avocado (***SAAGA funded***)
(3) Determination of the most hot tolerant stage of *B. invadens* on mango (***CFC funded***)
(4) Large-scale validation trials on avocado (cold treatment) (***SAAGA funded***)
(5) Large-scale validation trials on mango (heat treatment) (***CFC funded***)

Component 3 – Surveillance and Preventative Measures: Surveillance, identification and mitigation measures to avert the threats of other exotic fruit flies that may impact on the management strategy and the industry

Specific activities

(1) Conduct systematic trapping, monitoring and detection for exotic fruit flies in fruit and vegetable growing regions and other strategic locations in target countries to guide the application of phytosanitary management. (***CFC funded for Kenya, Tanzania, Uganda. FAO co-financing for Mozambique***)

(2) Establish in each participating country a database for target pests for the management of surveillance data and information sharing among partner countries. (***CFC funded for Kenya, Tanzania, Uganda. FAO co-financing for Mozambique***)
(3) Identify faunistic relationships and pathways for possible introduction and spread of other economically damaging fruit flies from the subcontinent (***CFC funded for Kenya, Tanzania Uganda. FAO co-financing for Mozambique***)
(4) Conduct relevant import pest risk analysis (PRA) using current and possible pathways as identified in (1) above. (***CFC funded***)
(5) Develop a regional standard based on the PRA for regulating fresh fruits and vegetables (or other commodity pathways) on which participating countries can agree. (***CFC funded***)
(6) Prepare working instructions or standard operating procedures (SOPs) for border inspectors regarding enforcement of the provision of the regional standard. (***CFC funded***)

Component 4 – Training and Technology Dissemination: Enhanced technical capacity at various levels of competency to support and sustain the project

Specific activities

(1) Train NARS and NPPOs (training of trainers) on surveillance and pre-harvest management packages—baiting; male annihilation; use of fungal pathogens; parasitoid mass rearing techniques, quality control, release and evaluation of parasitism; and orchard sanitation. (***CFC funded for Kenya, Tanzania, Uganda. FAO co-financing for Mozambique***)
(2) Conduct Farmers' Field School (FFS) hands-on training approaches on surveillance and all management packages and awareness campaigns on technology availability. (***CFC funded for Kenya, Tanzania, Uganda. FAO co-financing for Mozambique***)
(3) Facilitate training of local entrepreneurs and representatives of industries in participating countries on bait, fungus and trap production at the pilot facility and operation and use of post harvest treatment. (***CFC funded***)
(4) Carry out public awareness to facilitate large-scale adoption and application of the recommended management tools by preparing and disseminating guidelines for implementation of control tools with due regard to market requirements through leaflets, posters, manuals, and radio and TV programmes. (***CFC funded***)
(5) Advanced level training at PhD and MSc for young Africans. (***CFC funded***)

COMPONENT 1

PRE-HARVEST MANAGEMENT MEASURES:
New technologies, exotic natural enemies and other existing management tools for controlling B. invadens and other target pests assembled, validated in large-scale trials and disseminated

Background

Under this component, the project intends to achieve the objectives through participatory on-farm validation, adaptation and dissemination of technologies based on baiting technology, use of male annihilation, entomopathogenic fungus (*M. anisopliae*), releases of parasitoids (*F. arisanus* and *P. fletcheri*), promotion and conservation of the weaver ant (*O. longinoda*), and orchard sanitation through the use of the Augmentorium (Ekesi et al., 2005; Ekesi and Billah, 2006; Ekesi et al., 2006ab, Ekesi et al., 2007; Van Mele et al., 2007; Vayssières et al., 2009b; Hanna et al., unpublished). This package of IPM will therefore consist of a 'menu' of management options suitable for different species and ecologies and also depending on pests' severity/levels of damage in the various localities. The effectiveness and feasibility of the packages will be tested with full participation of growers, NARS and NPPOs in all the target countries. A pilot production facility for locally developed bait, fungus and traps will be established for demonstration to potential entrepreneurs that may take up production while at the same time producing materials for field suppression activities in all the 4 target countries. The specific activities and methodological approach envisaged under this component are briefly described below.

Activity 1: Assembling and large-scale validation, adaptation and dissemination of IPM package for fruit flies based on baiting, male annihilation, use of fungal pathogens, parasitoids releases, ant technology, orchard sanitation and assessing impact at selected benchmark sites in each participating country.

Traditionally, the use of food attractants consisting of hydrolysed protein or ammonia-based mimics such as NuLure combined with relatively small amounts of insecticides has been the major control method for fruit flies (Roessler, 1989). The food baits containing pesticidal toxicant are applied locally to 1-m^2 spots of tree canopy or trunk, avoiding contact with fruits. Adult fruit flies are attracted to the spot from a distance where they ingest the toxicant and are killed. *icipe* has identified powerful commercial attractants such as GF-120, Mazoferm, methyl eugenol and terpenyl acetate that could be utilised both as liquid baits, solid bait stations and killer blocks for management of *B. invadens, B. cucurbitae* and native *Ceratitis* and *Dacus* species. Concurrently, local baits that are cheaper than the imported baits listed above have been developed from industrial raw materials such as waste brewer's yeast (DuduLure) that are effective against all the target fruit species above.

The entomopathogenic fungus *M. anisopliae* has been developed for both adults and pupariating larvae of the different fruit flies. Candidate isolates will be employed both for soil inoculation against all target pests and whenever possible as killing agents in baiting stations/biodegradable spheres.

The efficacy of two introduced natural enemies (*F. arisanus* and *D. longicaudata*) from Hawaii has been completed and ready for field releases. Limited field releases of *F. arisanus* have been carried out in Kenya and Tanzania in 2008 following issuance of permits from the various government authorities. Additionally, discussions have been completed with CIRAD Reunion to import *P. fletcheri,* which has shown tremendous potential for classical biocontrol programme against *B. cucurbitae.* This parasitoid will be released in the target countries for the management of this pest in cucurbit crops.

The weaver ant *O. longinoda* has been shown to effectively suppress fruit flies on mango in Benin, West Africa (Van Mele et al., 2007). The efficacy of this technology is yet to be tested in eastern and southern Africa and this technology will be integrated into the IPM package being proposed for the region.

Sound crop sanitation that involves the collection and destruction of all fallen fruits will be strongly advocated. A new technique that involves the use of the Augmentorium® (Klungness et al., 2005) developed by Hawaiian entomologists will be employed. The Augmentorium serves the double purpose of field sanitation and conservation of natural enemies of fruit flies. It is a tent-like structure that sequesters fruit flies that emerge from fallen rotten fruits that are collected from the field and deposited in the structure while at the same time conserving their natural enemies by allowing parasitoids to escape from the structure through a fine mesh at the top of the tent.

The components of the IPM package will therefore include the following elements: (1) fruit fly monitoring using simple trapping system; (2) fruit fly suppression using baiting technology either as canopy bait spray or solid bait station combined with appropriate toxicant (insecticides or the identified fungal pathogen); (3) male annihilation with methyl eugenol as perimeter trapping; (4) soil inoculation with candidate entomopathogenic fungus to kill pupariating fruit fly larvae; (5) mass rearing and release of parasitoids (6) ant technology through promotion and conservation in the orchard; and (6) orchard sanitation (by collecting and deposition of fruits in an Augmentorium). Packages will therefore include a 'menu' containing several complementary techniques. NARS and NPPO collaborators in consultation with growers and *icipe* will choose a combination of elements from the packages, which are locally feasible and applicable. Such 'custom tailored' variants of the package will be demonstrated and promoted in each of the participating countries. Depending on the consultation with the growers, packages suitable for different species and ecologies and pests' severity/levels of damage in the various localities will be chosen and applied. Treatments proposed for field-testing must consist of: (i) custom tailored IPM package, (ii) farmers' methods of control and (iii) untreated control whenever possible. Efficiency of treatments shall be monitored by number of fruit flies caught on each plot using appropriate food bait during the season and by the actual fruit infestation by fruit fly larvae at harvest time.

Parasitoids will be released: (1) at project target and non-target crops (mango, citrus, zucchini, cucumber, bitter gourd and watermelon) at project benchmark sites; (2) at selected farm sites and urban settings containing garden and ornamental trees that are host to target fruit flies (e.g. *Terminalia catappa* for *B. invadens*); (3) in wholesale and retail fruit dumping sites with a variety of host fruits; and (4) in managed and unmanaged refugia consisting of unsprayed annuals or perennial plant hosts suitable for development of the fruit flies and parasitoids. Adult parasitoids will mostly be targeted for releases. However, whenever possible, the parasitoid preferred host fruits (*Sclerocarya birrea; T. catappa* and *Cucurbita pepo*; *Momordica charantia* for *F. arisanus* and *P. fletcheri* respectively) will be field collected, exposed to fruit fly adults and then parasitoids in the laboratory and later released back to the field in an Augmentorium.

The international partners and participating NARS that were trained in mass rearing, handling and release of the parasitoids will evaluate parasitoid dispersal and impact after releases in the countries. To document the establishment, dispersal and impact of the introduced parasitoids in the ecosystem and to monitor for evidence of non-target impacts on beneficial fruit flies, surveys will be conducted along pre-determined distance in the target countries. Different host fruit species for target pests as well as fruits, flowers and galls that might be hosting beneficial fruit flies will be examined for fruit fly infestation. Various urban and farm site ornamental fruits will also be collected and processed to assess for establishment. At all localities, samples will be collected at various times throughout the year rather than strict specificity to a particular period. Radius from the nearest location of release point will also be measured. Post-release evaluations will be conducted at intervals appropriate for each host/parasitoid system at release sites and at distances with intervals depending on the spread potential of the parasitoids. Fruits will be collected at various locations where releases have been conducted, incubated in the laboratory until fruit flies and parasitoid emergence and parasitism index and impact on target as well as the non target hosts will be assessed. One Augmentorium shall also be installed in each of the project demonstration plots to preserve parasitoids in the orchards while contributing to orchard sanitation.

Implementation of this activity will be closely linked with training and technology dissemination operations of the project (*see component 4 below*).

Activity 2: Field testing of solid bait station as alternative to liquid bait spray for field suppression of target fruit flies

Although liquid bait sprays can provide effective control of fruit flies, recent advances in baiting technology are moving towards the development of solid bait stations that will limit the cost of application. Such solid stations have all the advantages of standard liquid bait spray but additional benefits of lure and kill solid stations include minimal risk of fruit contamination and environmental non-target effects, lower cost option and less labour inputs on the part of the producer (IAEA, 2008). Such a solid bait station is composed of (1) a bait to attract the flies, (2) a killing agent (approved insecticides or entomopathogen to kill the attracted flies and (3) an optional housing or protective device. Several liquid baits identified by *icipe* including Mazoferm and the locally developed DuduLure will have to be converted into solid station using appropriate matrix, housed in protective devices followed by determination of application regimes through field testing and possible impact on non-target beneficial insects. Once on-farm testing is completed and its safety to non-target is confirmed, the solid stations will be included in the technology package recommended for on-farm validation and adaptation in participating countries. This activity will be funded exclusively by BMZ grant to the AFFP and will be conducted only by *icipe* in Kenya.

Activity 3: Conduct on-farm testing and validation of trunk application of soft pesticides and fungal pathogens against MSW at selected sites in each country (BMZ co-financing activity in year 1 only)

Several *soft* pesticides such as spinosad, imidacloprid, and thiametoxam were recently identified by *icipe* for management of the MSW. Similarly, the entomopathogenic fungus, *M. anisopliae* has also been found to be a useful tool in the IPM package for MSW. Different formulations of the fungus have been tested and an oil-based formulation has been found suitable for field application based on long persistence in the field and amenability to mass production. Orchard sanitation, which has proven to be an effective tool for managing

MSW in Hawaii, will also form an important component of the management package. In this activity we, therefore, propose to conduct a large-scale field testing and validation of the technologies based on soft pesticide application, trunk application of fungal pathogen and orchard sanitation as a means of managing MSW on mango. For both technical and economic reasons parallel replications of such activity in all the countries will be too expensive and not feasible and will be done solely by *icipe* under the umbrella of the ongoing BMZ project with participation of local fruit growers in on-farm testing and validation. Once efficacy is confirmed in Kenya, the technologies will gradually be rolled out into the other participating countries possibly from the second year of project operation. Proposed package for field-testing will therefore include the following elements: (1) suppression with *soft* pesticides alone (2) suppression with the fungus (*M. anisopliae*) alone, (3) orchard sanitation and (4) combined application of the 3 methods. Efficiency of treatments shall be monitored by number of MSW caught in light traps on each plot during the season and by the actual fruit infestation by MSW at harvest time.

Activity 4: Establishment of a pilot facility for production of (1) locally developed baits from waste brewer's yeast, (2) the fungus*, Metarhizium anisopliae *and (3) fruit fly monitoring traps

In Australia and several of the Pacific Islands, locally developed protein baits from waste brewer's yeast are now widely used for fruit fly control. Commercial products such as Tongalure® and Promar® are available at much lower prices than other imported commercial lures such as NuLure and GF-120. Following well-established standard procedures, *icipe* has also tested various yeast products from different countries and developed DuduLure, which has proven to be as effective as imported commercial lures and can be produced at 20% of the cost of the imported products. For large-scale experimental use by the project in target project countries, a laboratory pilot production unit will be established at *icipe*. Similarly, since the efficacy of the fungus *M. anisopliae* (also developed by *icipe*) and traps (locally adapted from the imported Lynfield trap) have been confirmed, there is the need to establish a demonstration plant that will assist both in production of these materials for field use in all the 4 countries during the project cycle and for demonstration to potential entrepreneurs that might be interested in commercialisation of the products. Indeed private sector interest in the IPM toolbox that is being proposed is of key importance and there are already encouraging signs from development partners such as RealIPM, DuduTech and BridgeWorks. All these companies are concerned with production, marketing and commercialisation of eco-friendly and socially acceptable techniques.

COMPONENT 2

POST-HARVEST TREATMENTS MEASURES:
Cold and hot water post-harvest disinfestations trials completed and validated for *B. invadens* on avocado and mango, respectively

Background

In today's global horticultural economy, the application of IPM tools and classical biological control methods alone may not be an acceptable option for assessing quarantine sensitive markets. Post-harvest treatments are therefore needed to maintain the flow of export commodities through lucrative marketing channels from Africa. The need to research and develop efficacious quarantine treatments to move fruits and vegetables through quarantine barriers becomes crucial. Post-harvest quarantine treatments include fumigation with toxic compounds, irradiation, non-host status and regulatory inspection protocols. Not all of these measures are applicable under the African setting. For example, fumigation is currently banned, irradiation may be too expensive, non-host status is applicable to commodities that are not host to fruit flies while systems approach will probably require years of intensive biological and host/plants studies. Research efforts in the current project will, therefore, be directed at physical disinfestation treatments such as heat or cold treatment. We propose to conduct these activities exclusively on *B. invadens* on mango (heat treatment) and avocado (cold treatment) for sole reason that these two crops have significantly been affected by quarantine restrictions due to *B. invadens* across the target countries. There are 4 phases in the development of heat and cold treatment: (1) establishment and maintenance of the insect colony, (2) investigation of the larval development in the target crop (3) determination of the most heat or cold tolerant stage and (4) large scale trial using the most heat or cold tolerant stage. Colonies of *B. invadens* already exist at *icipe* and only require maintenance for continuous supply of the insect for the activity. Studies on the development of *B. invadens* on avocado and mango have been completed through *icipe* core research support. In this component, the project has set realistic objectives of availing data, information and whenever possible materials after completion of the above trials that can facilitate development of post harvest treatment facility rather than establishing a facility itself. Establishment of a facility cannot be met within the proposed project resources. However, once appropriate data have been generated and the data are disseminated to the industry, rapid uptake is anticipated from the industries that are willing to recoup lost export market. The activities required to accomplish this component are therefore determination of the most cold tolerant stages and large scale validation trials that will contribute towards lifting of major trade barriers. In this regard, the following actions are envisaged:

Activity 1: Maintain colonies of* B. invadens *for heat and or cold tolerance testing (BMZ* and FAO *co-financing activity)

To conduct experiments of post harvest treatment for the target fruit flies, a regular supply of good quality insects of pre-determined reproductive stages and age is crucial. *icipe* has developed standard rearing methodologies for all the target fruit fly species (Ekesi et al., 2007). This activity will be conducted mainly at *icipe* with funds from BMZ and FAO and will also benefit mass rearing of parasitoids for field releases since the host insects are necessary for the rearing of the natural enemies.

Activity 2: Determination of the coldest tolerant stage of* B. invadens *on avocado

This test will be conducted using the most internationally accepted methodology of Jessup (1994). *Bactrocera invadens* eggs (not more than 24 h old) will be inoculated into 1050 avocadoes. This will be done by inoculating avocado fruit with eggs at a constant temperature and waiting for the appropriate time to obtain the different life stages (as earlier defined from the already completed phase (1). Fruit containing the different life stages will be placed in a cold room at 1 ºC delivery air temperature (DAT) (2 ºC pulp temperature) and their survival determined after different exposure times to cold (e.g. 3, 5, 7, 9, 11, 13, 15 and 17 days). After exposure, the fruit will be stored at 25 ºC for 24 hours and then dissected to determine the numbers of larvae, both dead and alive, recorded in each fruit. The untreated control fruit will be dissected after seven days at 25 ºC to determine the natural mortality level. A sufficient number of fruit will be inoculated with a number of eggs that will provide at least 100 viable individuals per life stage per cold treatment exposure. The experiment will be replicated three to five times.

Activity 3: Determination of the most heat tolerant stage of* B. invadens *on mango

This test will be conducted using the most internationally accepted methodology of Sharp et al. (1989ab) and Armstrong et al. (1995). For heat treatment, this will be done by inoculating mango fruit with eggs at a constant temperature and waiting for the appropriate time to obtain the different life stages (as earlier defined from the already completed phase (1). Fruit containing the different life stages will be immersed in water maintained at 45 ºC in metal containers and propane gas operated burners and their survival determined after different exposure times to heat treatment (e.g. 20, 25, 30, 35, 40, 45, 50 and 55 min). After exposure, the fruit will be processed as described above. The effect of treatment on fruit quality will also be assessed using the methods of Sharp et al. (1989ab). Mangoes will be not be accepted if they display any shriveling, different colour, scalding and flavour and unusual aroma compared with untreated control.

Activity 4: Large-scale validation trials on avocado

In this trial, fruit inoculated with eggs and allowed to develop to the most heat or cold tolerant life stage identified in Activity 2 will be used. The fruit will be placed in cold storage and then inspected according to the procedures in Activity 2, except that 3000–5000 individuals of the most tolerant life stage will be tested for survival. Appropriate dose response curves (e.g. Probit analysis with Abbott's correction) will be used to determine the lethal time of exposure needed to achieve >99% mortality with 95% confidence.

Activity 5: Large-scale validation trials on mango

In this trial, fruit inoculated with eggs and allowed to develop to the most heat tolerant life stage identified in Activity 3 will be used. The fruit will be immersed in hot water and then inspected according to the procedures in Activity 3, except that 3000–5000 individuals of the most tolerant life stage will be tested for survival. Appropriate dose response curves (e.g. Probit analysis with Abbott's correction) will be used to determine the lethal time of exposure needed to achieve >99% mortality with 95% confidence.

COMPONENT 3

SURVEILLANCE AND PREVENTATIVE MEASURES:
Surveillance, identification and mitigation measures to avert the threats of other exotic fruit flies that may impact on the management strategy and the industry

Background

As part of globalisation in trade in fruits and vegetables, trade between the targeted eastern and southern African countries, their neighbouring countries and importing countries will be gradually liberalised thus increasing the chances of inadvertently translocating fruit flies that constrain horticulture among these countries. Generally, in addition to increases in trade, the cultural ties and customs of bearing gifts (such as host fruits) by visitors and travelers among African countries will obviously lead to exchange of fruit flies. Mechanisms must be found to minimise this problem and pest surveillance activities and training of NPPOs in all countries will be essential. Knowledge of existence of certain species of fruit flies in neighbouring countries will ensure that NPPOs of eastern and southern African countries and their trading partner countries respond quickly to emergencies arising from pest invasions and develop appropriate measures to manage and minimise incursions. In this regard, the following activities are proposed for this project component:

Activity 1: Conduct systematic trapping, monitoring and detection for exotic fruit flies in fruit and vegetable growing regions and other strategic locations in target countries to guide the application of phytosanitary management.

To prevent entry of other exotic fruit flies into the countries, NPPOs of the participating countries must enforce a systematic trapping and monitoring system. This can be achieved by establishing an extensive grid of attractants such as methyl eugenol (ME), Cuelure (CUE) and Trimedlure traps round the countries including all the major ports of call for immigration, trade and fruit dumping sites. This should provide early warning against entry of a range of exotic fruit fly species and incursions of indigenous flies into current or previously uninfested areas and this activity will be vigorously pursued in the current project. Survey methodology will follow the guidelines developed by IAEA (2003) and Ekesi and Billah (2006).

Activity 2: Establish in each participating country a database for fruit fly species for the management of surveillance data and information sharing among partner countries.

To ensure management of surveillance data and identification of possible pathways for introductions, a database for all fruit fly species will be established in each participating country. It is anticipated that information gathered on fruit fly fauna, their pathways for introduction and effective management option to prevent further spread will be shared among participating countries and other interested fruits and vegetable importing countries.

Activity 3: Identify faunistic relationships and pathways for possible introduction and spread of other economically damaging fruit flies from the subcontinent

ISPM Nos. 2 and 11, the primary international standards for pest risk analysis (www.ippc.int), offer guidance on how pathways can be identified and how analysis should be conducted, with emphasis on imported commodities where the pathway is known. The processes that determine the introduction and establishment of an organism are: (1) human-assisted, e.g. truck transport, passenger baggage; (2) biological, e.g. flight; or (3) abiotic, e.g. wind dispersal. Among these, human-mediated introduction is by far the most important and has been growing at an exponential rate due to global trade (Pimentel et al., 2000). In each of the participating countries, key trading partners, commodities, routes and means of transport will be defined and all possible pathways, for example, routes (source and destination); commodities (plants, garbage) or conveyances that harbour contaminating pests (hitchhikers); transport purpose (smugglers, passengers or travelers, mail, overland transit); transport technology (airliners, road freight, ships); and packing material will be characterised to facilitate development of pest risk analysis. Whenever possible, pathway analysis will be carried out which may be qualitative, quantitative or a combination of the two depending on the nature of the analysis and the data available (Morgan and Henrion, 1990; Hennessey, 2004). For most risk mapping applications, simple pathway models are employed. Many possible outcomes may be presented by the model depending on several key factors such as: the pest infestation rate, the number and frequency of shipments, the effect of pest reduction measures (if any), and the area of the country where shipments arrive and their subsequent distribution (Hennessey, 2004). Risk analysis software (e.g. @Risk Palisade Corp, Newfield, NY) will be used to analyse the many possible outcomes that the model illustrates to produce a distribution of outcomes: maximum (worst case), minimum and most likely. Outcomes are usually reported as how many viable pests are expected to be introduced into susceptible areas annually and necessary actions undertaken.

Activity 4: Conduct relevant import pest risk analysis (PRA) using current and possible pathways as identified in (1) above.

Following the identification of the pathways in Activity 3, a list of pest fruit flies likely to be associated with the pathways will be generated by any combination of official sources, databases, scientific and other literature, and expert consultations. PRA will then be conducted based on (1) pest categorisation, (2) assessment of probable introduction and spread, and (3) assessment of potential economic consequences (including environmental impacts). The PRA will be judged against the principles of necessity, minimal impact, transparency, equivalence, risk analysis, managed risk and non-discrimination set out in ISPM No. 1: *Principles of plant quarantine as related to international trade* (www.ippc.int). The conclusions from the PRA will be used to decide whether risk management is required and the strength of measures to be used. Pest risk management will identify ways to react to the perceived risk associated with the pests, evaluate the efficacy of the actions, and identify the most appropriate options.

Activity 5: Develop a regional standard based on the PRA for regulating movement of fresh fruits and vegetables (or other commodity pathways) on which participating countries can agree

Based on the result of the PRA, a regional standard will be developed to minimise translocation of unwanted fruit flies between collaborating countries and their trading partners. This may include enforcing rigorous inspections along commodity pathways that pose maximum risk of introduction. Whenever necessary and based on the risk level of identified pest species, State Order quarantine restrictions similar to the USDA Federal Order may be issued to trading partners along risky pathways to prevent the entry or introduction of damaging fruit flies into partner countries. The State Order will establish the necessary actions that must be met before fruits and vegetables could be imported into the country and this may include: (1) from a pest free area recognised by the Plant Health Authority of the importing country, (2) that host plants of harmful pests are grown under an importing country approved pest exclusionary structure or (3) after receiving the importing country's approved post harvest treatment options that may include cold treatment, hot treatment, controlled atmosphere, irradiation etc.

Activity 6: Prepare working instructions or standard operating procedure (SOP) for border inspectors regarding enforcement of the provision of the regional standard

In this activity we propose to develop, in close collaboration with NPPOs and other stakeholders, a Standard Operating Procedure (SOP) as an operational manual for a comprehensive border inspection post so that individual and already existing modules for partner countries can be selected, adapted, and combined for use at the various border crossing points in all the partner countries detailing all rules and operations of the inspectors. This should allow for unified approach to border inspection, management and regulation to enhance regional security.

In doing this, the project proposes to visit all border posts and provide recommendations on improved operation of the countries' inspection services while ensuring that the recommendations meet the needs and requirements for undertaking phytosanitary inspection of the government authority. The approach will be to facilitate country based workshops to obtain the necessary information to develop the planned SOP, discuss various scenarios to test the scope and modality for the SOP, analyse the information obtained at the workshops and cross-reference to the relevant country legislation policy, identify areas in the SOPs that require legislative amendments or new legislation, ensure that each of the separate country SOPs is harmonised with SOPs of all the collaborating countries in the project and, prepare final versions of the SOP in line with information that has been obtained.

COMPONENT 4

TRAINING AND TECHNOLOGY DISSEMINATION: Enhanced technical capacity at various levels of competency to support and sustain the project and dissemination of technological packages to stakeholders

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Background

The project will have several levels of scientific training, interactions and technology dissemination. The activities with NARS and NPPOs and their direct involvement in evaluation of IPM technologies, surveillance, preventative measures and post-harvest treatment will enhance their ability to manage the target pests, which will also translate into capacity for managing other insect pests on other crops. Farmer Field School (FFS) is a component of fundamental importance in the project and should allow direct interaction with the growers, providing feedbacks on the technologies and refinement as necessary.

At advanced level, MSc and/or PhD students selected from partner institutions (as necessary) will be trained in-country or attached to *icipe*'s ARPPIS and DRIP programmes. The students will be trained in fruit fly and MSW IPM and post-harvest treatment. These areas of expertise are in short supply in sub-Saharan Africa and are needed to shore up the scientific, research and development capacity in agricultural pest management of the targeted countries. These students can train additional personnel and farmers enabling the scaling up of fruit fly and MSW IPM throughout the region. Regional meetings/workshops will be combined with training on PRA, fruit fly taxonomy, surveillance and management. This should allow country experts to meet with global experts in IPM and post-harvest treatment and discuss adoption of the results of the project in their countries.

FAO have been involved in the training of community-based groups and extension personnel in several IPM related activities across the globe and have immense experience on fruit fly R&D carried out jointly with the IAEA. Such experience and expertise will be valuable in the proposed project. Training on product inspection at ports will be provided in addition to routine surveillance activity to quarantine personnel. Most of this training, particularly the group training, shall be in-country and combined with on-farm demonstrations and local awareness campaigns on the IPM technologies and application of post-harvest treatment. These groups of trainees will be expected to promote these control packages and disseminate this information widely among small-scale producers in their countries with technical backstopping from FAO and *icipe*. The proposed awareness campaigns will be organised and conducted by NARS, NPPOs and partner international organisations through government extension agencies, radio and TV broadcasts, on-farm open days, manuals, posters and leaflets. Specific activities in this component are outlined below:

Activity 1: Train NARS and NPPOs (training of trainers) on surveillance and pre-harvest management packages—baiting; male annihilation; use of fungal pathogens; parasitoid mass rearing techniques, quality control, release and evaluation of parasitism; and orchard sanitation

Since expertise and capabilities in fruit fly and MSW management are fairly uniformly absent among participating countries, a common training strategy will be adopted beginning with the training of trainers of NARS and NPPOs from partner institutions. In this regard, 3–5 experts will be drawn from collaborating institutions and bodies with close link to the fruit and vegetable sector (producers, grower associations, etc.) and trained specifically in all aspects of control systems (baiting; male annihilation; use of fungal pathogens; ant technology; parasitoid mass rearing techniques, quality control, release and evaluation of parasitism; and orchard sanitation). Selection of individuals for the training of trainers will be based on criteria that place a heavy emphasis on involvement and expertise in the horticultural sector and on the likelihood that individuals will remain closely associated with the sector. Training will be hands-on and field-based at project benchmark sites where suppression trials are ongoing to allow for technology demonstration, promotion and dissemination of the control packages on-farm. In addition to surveillance, training in measures to prevent or detect infested products through inspection, warning to travelling public, detector dogs at airports and mail exchanges, luggage searches and trapping will be provided to quarantine personnel.

Activity 2: Conduct Farmers' Field School (FFS) hands-on training approaches on surveillance and all management packages and awareness campaigns on technology availability

The NARS and NPPOs that have been trained in Activity 1 (training of trainers) will together with the *icipe* carry out FFS hands-on training activities on surveillance and all management packages directly at selected benchmark sites (2–3 per country). As in Activity 1, training will be hands-on and allow for technology demonstration of all the control packages outlined in Component 1, its promotion and dissemination on-farm at the project benchmark sites but as with all FFS trainings, with heavy involvement of growers. This training will be combined with local awareness campaigns on the impact of fruit flies on fruit and vegetable production and availability of management tools.

Activity 3: Facilitate training of local entrepreneurs and representatives of industries in participating countries on bait, fungus and trap production at the pilot facility and operation and use of post harvest treatment

To facilitate uptake of the locally developed bait, fungus and trap and on the application of the post harvest treatment facility, the project proposes to train entrepreneurs, representatives of the horticultural industries, NARS, and NPPOs of the participating countries on the production procedures; operation and usefulness of post harvest treatment. Private construction through loan concession from CFC by participating countries can also be facilitated by consultations with government and industries on the possibility and modalities of establishing and operating such commercial ventures in the countries.

Activity 4: Carry out public awareness to facilitate large-scale adoption and application of the recommended management tools by preparing and disseminating guidelines for implementation of control tools with due regard to market requirements through leaflets, posters, manuals, and radio and TV programmes

Effective public awareness campaigns will be essential to the success of the fruit fly and MSW management strategy that is being proposed. As part of this component, the project shall seek to update the local media (TV, radio, newspaper) on all aspects of the project. Additional public materials such as manuals, posters, leaflets, t-shirts and fruit fly and MSW quarantine video will be developed and distributed to government departments, the general public and school children on recommended management options to fast track information up-take. The goal will be to have a more informed public on the risks associated with fruit flies, MSW and movement of quarantine items.

Activity 5: Advanced level training

Whenever possible, specific research activities in-built in project components 1–4 that are necessary for successful execution of the project will form part of a training opportunity in fruit and vegetable IPM, fruit fly monitoring, classical biological control and post-harvest treatment to several young Africans, at MSc and PhD levels, from participating countries. Students will be enrolled in different universities within and whenever possible outside Africa. The possibility of enrolling students in *icipe*'s well-known ARPPIS and DRIP programmes will also be explored to enable students have access to available fruit fly and MSW management materials, insect cultures and databases.

BENEFIT AND BENEFICIARIES

The immediate beneficiaries of the project will be smallholder producers of the target crops in participating countries. Smallholders will benefit from increased production and access to export markets due to quality production of fruits and vegetables and economic well being of the growers. Validation of IPM options (baiting technique, soil inoculation with entomopathogen and orchard sanitation) will be carried out in 10-15 orchards at each benchmark site during the fruiting season in each target country. In terms of numbers and economic returns, the total area to be covered per country which includes both the trial sites and projected adopters of technology, at least, is estimated at 1,000 ha cultivated largely by smallholders with average fruit plot holdings of 0.5 ha. At these sites, fruit losses will be reduced by at least 30% and quality will be greatly increased leading to improve market prices and export possibilities. It is expected that the initiative will benefit at least 2,000 households representing about 12,000 rural dwellers (~ average family size of 6) at a projected 2-3 benchmark sites in each country. In the case of mango, this should translate into an increase mango production of about 3,000 ton. With an average farm gate price of US$ 0.14/kg of mango this will translate to an annual increment of US$ 400,000 representing about US$ 200 additional earnings per family, which is one third of the current average total family income. In cucurbits, production increase is estimated at 2,000 tons with an annual increment of US$ 200,000.

There are also the added benefits in the form of reduced costs and labour input given that introduction of parasitoids (if they establish) comes at no cost to the farmer and the use of localised spot applications of baits for fruit flies and trunk application for MSW entails minimal application of inputs compared to the current cover spraying of the entire canopy. There are environmental and health benefits since spraying often exposes both the fruits and labourers to danger from toxic compounds. The lost export market will be recouped and this will lead to improved livelihood, economic benefits and increase in foreign exchange to countries affected by the ban due to *B. invadens* and other fruit flies.

Producers who are aware of and have been attempting to access niche markets for organic production of fruits and vegetables may be attracted to packages such as application of baiting technologies that incorporate entomopathogens rather than insecticides. Producers growing target fruits and vegetables for own consumption and local sales will benefit from quality fruits for own consumption and to varying degrees additional income from sales depending upon local market circumstances.

Benefits will also accrue to traders (both small and large scale) in terms of large sales volume and better margins in quality conscious consumers and marketing outlet. Introduction of IPM technologies, improved biological control (classical and inundative) and knowledge on post-harvest treatment plant(s) will improve the export capacity of the eastern and southern African countries. Training on IPM, surveillance and phytosanitary information management will benefit extension personnel, agricultural officers, quarantine specialists and growers in all countries in increasing their capacity in pest management. NARS and NPPOs will improve their capacity in coordinating research, disseminating technical information and providing relevant training to the project. Additionally, training opportunities at postgraduate level will benefit young Africans. At each benchmark site (2-3 per country), farmer groups will be mobilized and a minimum of 100 growers within a farmer group will be trained at each site. In addition to the growers the project will also train in each country at least 50 extension agents, 6 quarantine personnel, 5 local entrepreneurs, and 3 postgraduate students on all aspects of management, prevention, exclusion, inspection and monitoring using the hands-on Farmer Field school (FFS) training approach.

PROJECT COSTING AND FINANCING

The costs of the activities under this project are estimated to be US$ 2,181,696 of which the CFC is expected to contribute the equivalent of US$ 1,500,000. FAO is co-financing the project in the equivalent of US$ 298,000 specifically for activities to be carried out in Mozambique. The BMZ will contribute US$194,700. SAAGA will contribute US$38,996. Total co-financing amounts to US$531,696. Counterpart contribution is equivalent to US$ 150,000 from the proposed PEA–*icipe* and participating countries.

WORK PLAN AND PROJECT ACTIVITIES

Details of the project work plan for each component are provided in Annex 1. Project activities are highlighted in the various project logical framework and components above.

PROJECT MANAGEMENT, MONITORING AND SUPERVISION

The Food and Agriculture Organization (FAO) of the UN through the Intergovernmental Sub-Group on Tropical Fruits (IGSGTF) and International Plant Protection Convention (IPPC) shall be the Project Supervisory Body (PSB) in close collaboration with the Fund. The Project Executing Agency (PEA) shall be responsible for the day-to-day monitoring and management coordination of the project in liaison with the participating partner institutions. The PSB and the Fund will examine all information submitted by the PEA.

The PEA shall also establish a Project Coordination Committee (PCC). This committee shall deal with policy issues and fund mobilisation but will not be directly involved in management issues, which shall be the primary responsibility of the PEA. The PCC will develop and implement fund raising strategies and assist the PEA in seeking international and national support in addition to resolving issues that can jeopardise accomplishment of the project activities. It is expected that the PCC will be chaired by a high-ranking official in the PEA and should include representatives of donor communities, participating governments in Africa and international agencies such as the IAEA.

The PEA shall appoint a Technical Advisory Committee (TAC) to provide technical oversight of the activities and operations that have direct bearing to the technical effectiveness and efficiency of the overall project. The TAC will monitor and evaluate implementation of the project objectives and also suggest and periodically review priorities of the project. The committee shall basically consist of international experts in all aspects of fruit fly and MSW management and quarantine related issues.

The project shall also establish the Project Steering Committee (PSC), which shall develop and supervise the implementation of annual work plans within the framework of the project. This body shall promote the project interests widely at the national level and establish relevant linkages and exchange activities between project components as well as between the project and other relevant regional bodies. It shall also assist in the identification of training needs and subsequently coordinate and organise the implementation of the training project at national and regional levels. The structure of the committee will be decided and regularly reviewed by a regional stakeholders' forum (which shall be the policy and priority setting body of the project) to ensure adequate representation of the member countries as well as categories of stakeholders that have a vested interest in fruit fly and MSW management. The Chair of the PSC shall rotate among the participating countries on an annual basis. Each year, the PSC shall elect a Vice-chair who will assume the position of Chair in the following year.

At each participating country, there shall be a National Project Leader (NPL) who shall supervise project implementation and assure project quality and performance. The PL shall on behalf of government receive, manage and account for resources allocated to the country for project execution. The PL shall also prepare technical and financial reports and annual work plans and budgets according to donor procedures.

Students will be identified from Africa to conduct research on specific topics whenever necessary. Previous activities in the areas of fruit fly research by the FAO-TCP and the *icipe*-led AFFP project have allowed for establishment of links with Fresh Produce Exporters Association of Kenya (FPEAK), Farm-Africa, Kenya Gatsby Trust and GTZ-PSDA funded projects on fruits and vegetables. When fully operational, the project will also link with other relevant projects already active in eastern and southern Africa (like FINTRAC-HDC) to facilitate wider transfer of the technology to smallholders.

The project will be subject to regular annual reviews including at mid-term by the CFC and PSB, to assess overall progress, the continuing relevance of the project activities and allocated budgets, to approve annual work plans and to propose any modifications as required. The project is to be evaluated after its completion, to assess project achievements against objectives, with a view to deriving lessons for other projects and assessing its impact.

JUSTIFICATION ND QUALIFICATION OF PROJECT EXECUTING AGENCY (PEA) - *icipe*

icipe works to improve the well-being of the peoples of the tropics through research and capacity building in insect science and its application. This institutional focus has resulted from the realization that the incidence of pests is invariably linked to the vicious cycle of poverty and underdevelopment. *icipe*'s overall goal is stabilizing food production by reducing quantitative and qualitative pre- and postharvest yield losses due to insect pests, mites, weeds and mycotoxin-producing fungi by contributing to the development of economically viable production systems that are less reliant on external inputs, in particular pesticides, and thus environmentally friendly and sustainable. Having the unique advantage of being an African institution, based in Africa, and mandated to address pest problems at the foundation of poverty, especially in terms of food security and health, *icipe* designs interventions based on a pro-poor set of values that contribute to the achievement of the Millennium Development Goals (MDGs). **The institute's work on fruit flies started in 1999 and represents the first active fruit fly research and management in sub-Saharan Africa culminating in the establishment of African Fruit Fly Initiative (AFFI).** AFFI was renamed African Fruit Fly Programme (AFFP) in 2008. With funds from IFAD, FAO, BMZ and IAEA the programme was established with the main objective of developing and introducing environmentally friendly and affordable technologies for management of fruit flies in Africa. The grants obtained over the years has permitted the establishment of extensive network of collaborators interested in fruit fly research in Africa and linking the initiative with other fruit fly programmes in the world. Major accomplishments of the AFFP includes a comprehensive assessment of the fruit fly complex attacking key horticultural crops such as mango, various cucurbits, citrus and avocado and responses of these complex fruit fly species to attractants and their susceptibility to killing agents. The AFFP was responsible for the first detection of *B. invadens* in Africa in 2003 which is now arguably the most damaging fruit fly species in the continent. Two exotic natural enemies (*F. arisanus* and *D. longicaudata*) have been introduced from Hawaii by AFFP and pre-release studies against the major fruit fly species have been completed and experimental releases started in Kenya, Tanzania and Benin and with request for releases from several other African countries. The programme has developed user-friendly taxonomic tools for easy identification of the fruit fly species that will support implementation activities. AFFP have also developed a database of fruit flies that includes several fruit fly collections from Africa. With funds from the IAEA colonies of the most damaging fruit fly species including *B. invadens* have been established for testing of their response to food attractants, susceptibility to entomopathogens, classical biological control and the planned post harvest related activities. Capacity building activities is at the core of the programme activities of AFFP and it has trained and will continue to train PhD and MSc students, agricultural officers, extension personnel and quarantine officers in various aspects of fruit fly biology, ecology and management, detection and monitoring. Currently, the Leader of the AFFP at *icipe*, Dr. S. Ekesi serves as a member of the International Fruit Fly Steering Committee (IFFSC) that is chaired by Dr. Brian Barnes, ARC Infruitec-Nietvoorbij Fruit, Vine & Wine Institute, Stellenbosch, South Africa (BarnesB@arc.agric.za)

icipe is funded by a consortium of donors known as the Sponsoring Group for *icipe* (SGI), and other private charitable organisations, United Nations organizations and governmental aid agencies. It collaborate widely with sister bodies within the Consultative Group on International Agricultural Research (CGIAR). With such a pan-Tropical mandate on arthropod pests, *icipe* is in a good position to act as a PEA of the current project. Additional information about the organization is available from www.icipe.org.

ASSUMPTIONS AND RISKS

Although the project is designed in a sufficiently robust way to ensure that a good level of results will be achieved even in worst-case scenarios, some risks and assumptions are anticipated. Bait-based technologies, especially those based on food attractants are well developed and relatively easy to use. However, since farmers across SSA have never used this technology, full adoption cannot be guaranteed. The project shall be promoting application of liquid and solid bait. Globally, fruit fly experts are currently advocating for the use of solid bait stations as alternative to liquid baits. *icipe* has the expertise in solid bait development and is well prepared to move towards this direction with prototype solid bait stations that have already been developed in close collaboration with the IAEA and this will be implemented in this project. However, the development of solid bait stations is a complex process and it is impossible to assess confidently the chances for quick success in the field and refinement through research may be necessary during this project or by specific satellite projects but the tremendous benefits of solid stations should justify the effort and offset the research risk that will be involved.

Most farmers are aware of the environmental and health hazards associated with chemical pesticides (Maiga et al., 1999) and for that reason the risk associated with the use of natural enemies (*F. arisanus, P. fletcheri, O. longinoda* and *M. anisopliae*) is minimal. Although recoveries of *F. arisanus* following field releases are already documented from Kenya, there is, however, no guarantee that the parasitoid will establish in all agroecologies across the target countries. There is also risk of negative interaction with *O. longinoda,* which may limit their impact on the fruit flies. Although there is an increasing interest in the use of biopesticides for management of fruit flies, there is always the risk that few farmers may take up such novel biocontrol technology even if commercial suppliers make the product available. Application of the ant technology is likely to be successful. Farmer perception of Hemiptera attendance, their transport to the field as well as aggression to humans may limit adoption. For both *F. arisanus* and *O. longinoda*, a prerequisite for them to flourish in the agroecosystem is a careful use of selective and *soft* pesticide. This cannot be guaranteed and may jeopardise their efficacy in the field.

During the various trainings that will be provided for extension agents, quarantine personnel, growers and graduate students, the project will generate a team of experts in fruit fly management. There is always the danger that trained personnel are lost to the project, especially if attracted by greener pastures outside the country or institution involved in the project.

Marketing risks may arise if there is rapid adoption of technologies and this could result in overproduction, glut in supplies and potential downward pressure on prices. While this is possible, the scale of the project in target countries is unlikely to lead to falling prices. On the international markets, the aim of the project is to recoup lost market due to *B. invadens* invasion as well as expand market share but international markets are characterised by up and downward trends in demand.

Outlined activities evidently seem to be beyond the scope of the project resources, but co-financing funds from other ongoing projects (e.g. FAO and BMZ) and possibly other donors that may join the project at a later date should enable successful execution of specified project activities.

SUSTAINABILITY AND EXIT STRATEGY

Key to the sustainability of any new agricultural approach is stakeholder involvement and feedback. The success of the project activities will depend largely on how well end-users understand and combine knowledge of fruit fly and MSW IPM with their own farming experiences to produce quality fruits and vegetables for domestic use and export. The participatory nature in the project activities should promote project sustainability. Community-based feedback mechanisms, enabling participating NARS and NPPOs to re-define the research agenda in a bottom-up manner and to respond to emerging issues from the farmers' field experiences will promote the sustainability of the programme. The programme will also adequately advocate and lobby policy support from government authorities to ensure that proper attention is given to improving fruit and vegetable production through fruit fly and MSW management and especially development of efficient quarantine systems. The approach of conducting research on-farm, encouragement in adaptation of the technologies and appropriate awareness campaigns that will be developed should allow for wide adoption and sustainable impact of the management strategies.

Educational activities and local research capacity building through NARS, NPPOs and student training will be central to the project exit strategy. In the exit strategy, the project will encourage national research-for-development partners to develop follow-up action plans and undertake resource mobilisation for the generation, testing and sharing of the IPM knowledge and post-harvest treatment technologies with several fruit and vegetable production groups in other localities requiring similar assistance. Towards sustainability of the results, fruit and vegetable producers and other relevant actors within the region will be encouraged to integrate the IPM and post-harvest treatment experiences into fruit and vegetable crop development activities. Community organisers will be encouraged to plan and coordinate local action plans and assist neighbouring communities and countries, with minimal (supervisory) input from external technical agencies.

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BUDGET

Table 1. Summary – Total project cost by category of expenditure

	Budget Requested From CFC							Contribution by				TOTAL
Budget Category	**KN**	**TZ**	**UG**	**MZ**	**FAO**	***icipe***	**Total**	**BMZ**	**FAO**	**SAAGA**	**PEA-NARS**	**BUDGET**
Vehicles, machinery and equipment	25,000	25,000	25,000	25,000	-	175,000	365,000	-	-		-	365,000
Civil Works	-	-	-	-	-	-	-	-	-		-	-
Materials and Supplies	49,500	49,500	49,500	18,500	3,000	30,000	285,000	100,000	19,495	14,000	50,000	404,495
Personnel /Technical assistance/Consultancy	20,070	20,070	20,070	20,190	30,600	149,700	502,000	-	127,000	9,996	100,000	629,000
Duty travel	23,500	23,500	23,500	11,454	12,000	12,000	124,000	-	34,892		-	158,892
Dissemination and training	45,500	45,500	45,500	37,500	-	-	184,800	-	56,000		-	240,800
Operational Costs	16,500	16,500	16,500	5,454	-	8,910	303,878	50,000	60,613		-	414,491
Monitoring/evaluation (FAO & CFC)	-	-	-	-	151,500	-	225,000	-	-		-	225,000
Subtotal - Direct project cost	**180,070**	**180,070**	**180,070**	**118,098**	**197,100**	**375,610**	**1,231,018**	**150,000**	**298,000**	**23,996**	**150,000**	**1,853,014**
Contingency 5% of direct cost	9,004	9,004	9,004	5,905	9,855	18,780	61,551	-	-		-	61,551
Total direct project cost	**189,074**	**189,074**	**189,074**	**124,003**	**206,955**	**394,390**	**1,292,568**	**150,000**	**298,000**	**23,996**	**150,000**	**1,914,564**
Administrative cost	18,907	18,907	18,907	12,400	47,600	90,710	207,432	44,700	-	15,000	-	267,132
Total cost	**207,981**	**207,981**	**207,981**	**136,403**	**254,555**	**485,100**	**1,500,000**	**194,700**	**298,000**	**38,996**	**150,000**	**2,181,696**

Table 2. Summary – Total CFC project cost by Year

	YEAR 1						
Budget Category	**KN**	**TZ**	**UG**	**MZ**	**FAO**	***icipe***	*(1) TOTAL*
Vehicles, machinery and equipment	25,000	25,000	25,000	25,000	-	175,000	**275,000**
Civil Works	-	-	-	-	-	-	**-**
Materials and Supplies	16,500	16,500	16,500	1,000	1,000	10,000	**61,500**
Personnel /Technical assistance/Consultancy	6,690	6,690	6,690	4,200	10,200	49,900	**84,370**
Duty travel	6,500	6,500	6,500	2,000	4,000	4,000	**29,500**
Dissemination and training	12,500	12,500	12,500	4,500	-	-	**42,000**
Operational Costs	5,500	5,500	5,500	-	-	2,970	**19,470**
Monitoring/evaluation (FAO & CFC)	-	-	-	-	50,500	-	**50,500**
Subtotal - Direct project cost	**72,690**	**72,690**	**72,690**	**36,700**	**65,700**	**241,870**	**562,340**
Contingency 5% of direct cost	3,635	3,635	3,635	1,835	3,285	12,094	**28,117**
Total direct project cost	**76,325**	**76,325**	**76,325**	**38,535**	**68,985**	**253,964**	**590,457**
Administrative cost	7,632	7,632	7,632	3,854	15,867	58,412	**101,029**
Total cost	**83,957**	**83,957**	**83,957**	**42,389**	**84,852**	**312,375**	**691,486**
	Year 2						
Budget Category	**KN**	**TZ**	**UG**	**MZ**	**FAO**	***icipe***	**Total**
Vehicles, machinery and equipment					-		**-**
Civil Works					-		**-**
Materials and Supplies	16,500	16,500	16,500	1,000	1,000	10,000	**61,500**
Personnel /Tech. assistance/Consultancy	6,690	6,690	6,690	4,200	10,200	49,900	**84,370**
Duty travel	8,500	8,500	8,500	2,000	4,000	4,000	**35,500**
Dissemination and training	16,500	16,500	16,500	16,500	-	-	**66,000**
Operational Costs	5,500	5,500	5,500	-	-	2,970	**19,470**
Monitoring/evaluation (FAO & CFC)	-	-	-	-	50,500	-	**50,500**

Budget Category	KN	TZ	UG	MZ	FAO	*icipe*	Total
Subtotal - Direct project cost	**53,690**	**53,690**	**53,690**	**23,700**	**65,700**	**66,870**	**317,340**
Contingency 5% of direct cost	2,685	2,685	2,685	1,185	3,285	3,343	15,867
Total direct project cost	**56,375**	**56,375**	**56,375**	**24,885**	**68,985**	**70,213**	**333,206**
Administrative cost	5,637	5,637	5,637	2,489	15,867	16,149	51,416
Total cost	**62,012**	**62,012**	**62,012**	**27,374**	**84,852**	**86,362**	**384,623**
	Year 3						
Budget Category	**KN**	**TZ**	**UG**	**MZ**	**FAO**	***icipe***	**Total**
Vehicles, machinery and equipment					-		**-**
Civil Works					-		**-**
Materials and Supplies	16,500	16,500	16,500	16,500	1,000	10,000	**77,000**
Personnel /Tech. assistance/Consultancy	6,690	6,690	6,690	11,790	10,200	49,900	**91,960**
Duty travel	8,500	8,500	8,500	7,454	4,000	4,000	**40,954**
Dissemination and training	16,500	16,500	16,500	16,500	-	-	**66,000**
Operational Costs	5,500	5,500	5,500	5,454	-	2,970	**24,924**
Monitoring/evaluation (FAO/CFC)	-	-	-	-	50,500	-	**50,500**
Subtotal - Direct project cost	**53,690**	**53,690**	**53,690**	**57,698**	**65,700**	**66,870**	351,338
Contingency 5% of direct cost	2,685	2,685	2,685	2,885	3,285	3,344	17,567
Total direct project cost	**56,375**	**56,375**	**56,375**	**60,583**	**68,985**	**70,214**	**368,905**
Administrative cost	5,637	5,637	5,637	6,058	15,867	16,149	54,986
Total cost	**62,012**	**62,012**	**62,012**	**66,641**	**84,852**	**86,363**	**423,891**
PARTNER TOTAL (YEARS 1–3)	**207,981**	**207,981**	**207,981**	**136,403**	**254,555**	**485,100**	**1,500,000**
GRAND TOTAL							**1,500,000**

Table 3. Total CFC budget by country by partners by project components by year

	KENYA			
Project Components	**Yr1**	**Yr2**	**Yr3**	**Total cost**
Pre-harvest management measures	43,730	18,730	18,730	81,190
Post-harvest treatments	-	-	-	-
Surveillance and preventative measures	13,230	13,230	13,230	39,690
Training and technology dissemination	15,730	21,730	21,730	59,190
Subtotal - Direct project cost	**72,690**	**53,690**	**53,690**	**180,070**
Contingency 5% of direct cost	3,635	2,685	2,685	9,004
Total direct project cost	**76,325**	**56,375**	**56,375**	**189,074**
Administrative cost	7,632	5,637	5,637	18,907
Total cost	**83,957**	**62,012**	**62,012**	**207,981**
	TANZANIA			
Project Components	**Yr1**	**Yr2**	**Yr3**	**Total cost**
Pre-harvest management measures	43,730	18,730	18,730	81,190
Post-harvest treatments	-	-	-	-
Surveillance and preventative measures	13,230	13,230	13,230	39,690
Training and technology dissemination	15,730	21,730	21,730	59,190
Subtotal - Direct project cost	**72,690**	**53,690**	**53,690**	180,070
Contingency 5% of direct cost	3,635	2,685	2,685	9,004
Total direct project cost	**76,325**	**56,375**	**56,375**	189,074
Administrative cost	7,632	5,637	5,637	18,907
Total cost	**83,957**	**62,012**	**62,012**	**207,981**
	UGANDA			
Project Components	**Yr1**	**Yr2**	**Yr3**	**Total cost**
Pre-harvest management measures	43,730	18,730	18,730	81,190
Post-harvest treatments	-	-	-	-
Surveillance and preventative measures	13,230	13,230	13,230	39,690
Training and technology dissemination	15,730	21,730	21,730	59,190
Subtotal - Direct project cost	**72,690**	**53,690**	**53,690**	180,070
Contingency 5% of direct cost	3,635	2,685	2,685	9,004
Total direct project cost	**76,325**	**56,375**	**56,375**	189,074
Administrative cost	7,632	5,637	5,637	18,907
Total cost	**83,957**	**62,012**	**62,012**	**207,981**

	MOZAMBIQUE			
Project Components	**Yr1**	**Yr2**	**Yr3**	**Total cost**
Pre-harvest management measures	25,000	-	19,608	44,608
Post-harvest treatments	-	-	-	-
Surveillance and preventative measures	-	-	14,390	14,390
Training and technology dissemination	11,700	23,700	23,700	59,100
Subtotal - Direct project cost	**36,700**	**23,700**	**57,698**	**118,098**
Contingency 5% of direct cost	1,835	1,185	2,885	5,905
Total direct project cost	**38,535**	**24,885**	**60,583**	124,003
Administrative cost	3,854	2,489	6,058	12,400
Total cost	**42,389**	**27,374**	**66,641**	**136,403**
	FAO			
Project Components	**Yr1**	**Yr2**	**Yr3**	**Total cost**
Pre-harvest management measures	50,500	50,500	50,500	151,500
Post-harvest treatments	-	-	-	-
Surveillance and preventative measures	-	-	-	-
Training and technology dissemination	15,200	15,200	15,200	45,600
Monitoring and evaluation	-	-	-	
Subtotal - Direct project cost	**65,700**	**65,700**	**65,700**	**197,100**
Contingency 5% of direct cost	3,285	3,285	3,285	9,855
Total direct project cost	**68,985**	**68,985**	**68,985**	206,955
Administrative cost	15,867	15,867	15,867	47,600
Total cost	**84,852**	**84,852**	**84,852**	**254,555**

	icipe			
Project Components	**Yr1**	**Yr2**	**Yr3**	**Total cost**
Project coordination	15,000	15,000	15,000	45,000
Pre-harvest management measures	188,900	13,900	13,900	216,700
Post-harvest treatments	37,970	37,970	37,970	113,910
Surveillance and preventative measures	-	-	-	-
Training and technology dissemination	-	-	-	-
Subtotal - Direct project cost	**241,870**	**66,870**	**66,870**	**375,610**
Contingency 5% of direct cost	12,094	3,344	3,343	18,780
Total direct project cost	**253,964**	**70,214**	**70,213**	394,390
Administrative cost	58,412	16,149	16,149	90,710
Total cost	**312,375**	**86,363**	**86,362**	**485,100**

Table 4. Complete cost of operation for Kenya

	KENYA					
			Estimated cost			**Total**
Inputs	Unit	Unit price	Year1	Year2	Year3	**Cost**
Component 1 - Pre-Harvest Management Measures						
1.0 Vehicles, machinery and equipment						
1.1. Vehicle	Lump per year	22,000	22,000	-	-	**22,000**
1.2 Computer, printer, GPS			3,000			**3,000**
2.0 Materials and supplies						**-**
2.1. Trap, baits, fungus, labels, plastic containers, cages, vials etc.	Lump per year		9,500	9,500	9,500	**28,500**
3.0 Personnel/Technical Assistance/Consultancy						**-**
3.1 Secretarial services (1% of technical time/country/year)	Average secretary salary	20,500	200	200	200	**600**
3.2 Tech. assistance (2.2% of *icipe* scientist or consultant time)	Average scientist salary	94,000	2,030	2,030	2,030	**6,090**
4.0 Operational cost						**-**
4.1. Monitoring, traps services, fuel, vehicle repairs, spares etc.	Lump per year	-	3,000	3,000	3,000	**9,000**
5.0 Duty travel						**-**
5.1 Local travel for traps services, per diems, accommodation etc.			4,000	4,000	4,000	**12,000**
Total cost			**43,730**	**18,730**	**18,730**	**81,190**

Component 2 - Post harvest treatment						
1.0 Materials and supplies						
1. Insect culture and maintenance (diet, cages, fruits, vials, etc.)	Lump per year	0	0	0	0	0
2.0 Personnel/Technical Assistance/Consultancy	Lump per year	0	0	0	0	0
2.1 Secretarial services (0% of technical time/country/year)	Average secretary salary	20,500	0	0	0	0
2.2 Tech. assistance (0% of *icipe* scientist or consultant time)	Average scientist salary	94,000	0	0	0	0
2.3 Tech. assistance (0% of *icipe* technical staff time)	Average technician salary	20,000	0	0	0	0
3.0 Operational cost						0
3.1 Fruit dissection, logger monitoring, vehicle repairs, spares		0	0	0	0	0
Total cost			-	-	-	0
Component 3 - Surveillance and Preventative Measures						
1.0 Materials and supplies						
2.1. Trap, baits, fungus, labels, plastic containers, cages, vials etc.	Lump per country		6,000	6,000	6,000	**18,000**
2.0 Personnel/Technical Assistance/Consultancy						**-**
2.1 Secretarial services (1% of technical time)	Average secretary salary	20,500	200	200	200	**600**
2.2 Tech. assistance (2.2% of *icipe* scientist or consultant time	Average scientist salary	94,000	2,030	2,030	2,030	**6,090**
3.0 Operational Cost						**-**
3.1. Monitoring, traps services, fuel, vehicle repairs, spares etc.			2,500	2,500	2,500	**7,500**
4.0 Duty travel						**-**
4.1 Local travel for traps services, per diems, accommodation etc.			2,500	2,500	2,500	**7,500**
Total cost			**13,230**	**13,230**	**13,230**	**39,690**

Component 4 - Training and Technology Dissemination						
1.0 Materials and supplies						
1.1 Paper, training materials, photocopying, printing, CD etc.	Lump per year		1,000	1,000	1,000	**3,000**
2.0 Personnel/Technical Assistance/Consultancy						**-**
2.1 Secretarial services (1% of technical time)	Average secretary salary	20,500	200	200	200	**600**
2.2 Tech. assistance (2.2% of *icipe* scientist staff or consultant time)	Average scientist salary	94,000	2,030	2,030	2,030	**6,090**
3.0 Dissemination and Training						**-**
3.1 Standard training course fee per participant (training of trainers; 4 participants) covering the cost of training materials, books, subsistence and accommodation of trainees, air return ticket, local field travel during training, conference room etc.	Lump per year		2,500	2,500	2,500	**7,500**
3.2 Awareness campaign course fee for approximately 30 participants comprising of printing of awareness materials, allowances for participants, fee for meeting room etc.	Lump per year			2,000	2,000	**4,000**
3.3 Training of entrepreneurs (4), representatives of industries (4) on bait, fungus, trap production and post harvest treatment	Lump per year			2,000	2,000	**4,000**
3.4 Advance level training at MSc	Lump per year		10,000	10,000	10,000	**30,000**
4.0 Duty travel						**-**
Local field travel by NARS conducting awareness campaign	Lump per year			2,000	2,000	**4,000**
Total cost			**15,730**	**21,730**	**21,730**	**59,190**
Grand total (Direct operational cost)			**72,690**	**53,690**	**53,690**	**180,070**

GRAND TOTAL - COMPLETE COST OF OPERATION FOR KENYA						
Pre-harvest management measures			43,730	18,730	18,730	81,190
Post-harvest treatments			-	-	-	-
Surveillance and preventative measures			13,230	13,230	13,230	39,690
Training and technology dissemination			15,730	21,730	21,730	59,190
Subtotal - Direct project cost			**72,690**	**53,690**	**53,690**	**180,070**
Contingency 5% of direct cost			3,635	2,685	2,685	9,004
Total direct project cost			**76,325**	**56,375**	**56,375**	**189,074**
Administrative cost			7,632	5,637	5,637	18,907
Total cost			**83,957**	**62,012**	**62,012**	**207,981**

Table 5. Complete cost of operation for Tanzania

	Tanzania					
			Estimated cost			Total
Inputs	Unit	Unit price	Year1	Year2	Year3	Cost
Component 1 - Pre-Harvest Management Measures						
1.0 Vehicles, machinery and equipment						
1.1. Vehicle	Lump per year	22,000	22,000	-	-	**22,000**
1.2 Computer, printer, GPS			3,000			**3,000**
2.0 Materials and supplies						**-**
2.1. Trap, baits, fungus, labels, plastic containers, cages, vials etc.	Lump per year		9,500	9,500	9,500	**28,500**
3.0 Personnel/Technical Assistance/Consultancy						**-**
3.1 Secretarial services (1% of technical time/country/year)	Average secretary salary	20,500	200	200	200	**600**
3.2 Tech. assistance (2.2% of *icipe* scientist or consultant time)	Average scientist salary	94,000	2,030	2,030	2,030	**6,090**
4.0 Operational Cost						**-**
4.1. Monitoring, traps services, fuel, vehicle repairs, spares etc.	Lump per year	-	3,000	3,000	3,000	**9,000**
5.0 Duty travel						**-**
5.1 Local travel for traps services, per diems, accommodation etc.			4,000	4,000	4,000	**12,000**
Total cost			**43,730**	**18,730**	**18,730**	**81,190**

Component 2 - Post harvest treatment						
1.0 Materials and supplies						
1. Insect culture and maintenance (diet, cages, fruits, vials, etc)	Lump per year	0	0	0	0	0
2.0 Personnel/Technical Assistance/Consultancy	Lump per year	0	0	0	0	0
2.1 Secretarial services (0% of technical time/country/year)	Average secretary salary	20,500	0	0	0	0
2.2 Tech. assistance (0% of *icipe* scientist or consultant time)	Average scientist salary	94,000	0	0	0	0
2.3 Tech. assistance (0% of *icipe* technical staff time)	Average technician salary	20,000	0	0	0	0
3.0 Operational Cost						0
3.1 Fruit dissection, logger monitoring, vehicle repairs, spares		0	0	0	0	0
Total cost			-	-	-	0
Component 3 - Surveillance and Preventative Measures						
1.0 Materials and supplies						
2.1. Trap, baits, fungus, labels, plastic containers, cages, vials etc.	Lump per country		6,000	6,000	6,000	**18,000**
2.0 Personnel/Technical Assistance/Consultancy						**-**
2.1 Secretarial services (1% of technical time)	Average secretary salary	20,500	200	200	200	**600**
2.2 Tech. assistance (2.2% of *icipe* scientist or consultant time	Average scientist salary	94,000	2,030	2,030	2,030	**6,090**
3.0 Operational Cost						**-**
4.1. Monitoring, traps services, fuel, vehicle repairs, spares etc.			2,500	2,500	2,500	**7,500**
5.0 Duty travel						**-**
5.1 Local travel for traps services, per diems, accommodation etc.			2,500	2,500	2,500	**7,500**
Total cost			**13,230**	**13,230**	**13,230**	**39,690**

Component 4 - Training and Technology Dissemination							
1.0 Materials and supplies							
1.1 Paper, training materials, photocopying, printing, CD etc.	Lump per year		1,000	1,000	1,000	**3,000**	
2.0 Personnel/Technical Assistance/Consultancy						**-**	
2.1 Secretarial services (1% of technical time)	Average secretary salary	20,500	200	200	200	**600**	
Tech. assistance (2.2% of *icipe* scientist staff or consultant time)	Average scientist salary	94,000	2,030	2,030	2,030	**6,090**	
3.0 Dissemination and Training						**-**	
3.1 Standard training course fee per participant (training of trainers; 4 participants) covering the cost of training materials, books, subsistence and accommodation of trainees, air return ticket, local field travel during training, conference room etc.	Lump per year		2,500	2,500	2,500	**7,500**	
3.2 Awareness campaign course fee for approximately 30 participants comprising of printing of awareness materials, allowances for participants, fee for meeting room etc.	Lump per year			2,000	2,000	**4,000**	
3.3 Training of entrepreneurs (4), representatives of industries (4) on bait, fungus, trap production and post harvest treatment	Lump per year			2,000	2,000	**4,000**	
3.4 Advance level training at MSc	Lump per year		10,000	10,000	10,000	**30,000**	
4.0 Duty travel						**-**	
Local field travel by NARS conducting awareness campaign	Lump per year			2,000	2,000	**4,000**	
Total cost			**15,730**	**21,730**	**21,730**	**59,190**	
Grand total (Direct operational cost)			**72,690**	**53,690**	**53,690**	**180,070**	

GRAND TOTAL - COMPLETE COST OF OPERATION FOR TANZANIA						
Pre-harvest management measures			43,730	18,730	18,730	81,190
Post-harvest treatments			-	-	-	-
Surveillance and preventative measures			13,230	13,230	13,230	39,690
Training and technology dissemination			15,730	21,730	21,730	59,190
Subtotal - Direct project cost			**72,690**	**53,690**	**53,690**	**180,070**
Contingency 5% of direct cost			3,635	2,685	2,685	9,004
Total direct project cost			**76,325**	**56,375**	**56,375**	**189,074**
Administrative cost			7,632	5,637	5,637	18,907
Total cost			**83,957**	**62,012**	**62,012**	**207,981**

Table 6. Complete cost of operation for Uganda

	Uganda					
			Estimated cost			**Total**
Inputs	Unit	Unit price	Year1	Year2	Year3	**Cost**
Component 1 - Pre-Harvest Management Measures						
1.0 Vehicles, machinery and equipment						
1.1. Vehicle	Lump per year	22,000	22,000	-	-	**22,000**
1.2 Computer, printer, GPS	Lump per year		3,000			**3,000**
2.0 Materials and supplies						**-**
2.1. Trap, baits, fungus, labels, plastic containers, cages, vials etc.	Lump per year		9,500	9,500	9,500	**28,500**
3.0 Personnel/Technical Assistance/Consultancy						**-**
3.1 Secretarial services (1% of technical time/country/year)	Average secretary salary	20,500	200	200	200	**600**
3.2 Tech. assistance (2.2% of *icipe* scientist or consultant time)	Average scientist salary	94,000	2,030	2,030	2,030	**6,090**
4.0 Operational Cost						**-**
4.1. Monitoring, traps services, fuel, vehicle repairs, spares etc.	Lump per year	-	3,000	3,000	3,000	**9,000**
5.0 Duty travel						**-**
5.1 Local travel for traps services, per diems, accommodation etc.			4,000	4,000	4,000	**12,000**
Total cost			**43,730**	**18,730**	**18,730**	**81,190**

Component 2 - Post harvest treatment						
1.0 Materials and supplies						
1. Insect culture and maintenance (diet, cages, fruits, vials, etc.)	Lump per year	0	0	0	0	0
2.0 Personnel/Technical Assistance/Consultancy	Lump per year	0	0	0	0	0
2.1 Secretarial services (0% of technical time)	Average secretary salary	20,500	0	0	0	0
2.2 Tech. assistance (0% of *icipe* scientist or consultant time)	Average scientist salary	94,000	0	0	0	0
2.3 Tech. assistance (0% of *icipe* technical staff time)	Average technician salary	20,000	0	0	0	0
3.0 Operational Cost						0
3.1 Fruit dissection, logger monitoring, vehicle repairs, spares		0	0	0	0	0
Total cost			-	-	-	0
Component 3 - Surveillance and Preventative Measures						
1.0 Materials and supplies						
1.1. Trap, baits, fungus, labels, plastic containers, cages, vials etc.	Lump per country		6,000	6,000	6,000	**18,000**
2.0 Personnel/Technical Assistance/Consultancy						**-**
2.1 Secretarial services (1% of technical time)	Average secretary salary	20,500	200	200	200	**600**
2.2 Tech. assistance (2.2% of *icipe* scientist or consultant time)	Average scientist salary	94,000	2,030	2,030	2,030	**6,090**
3.0 Operational Cost						**-**
3.1. Monitoring, traps services, fuel, vehicle repairs, spares etc.			2,500	2,500	2,500	**7,500**
4.0 Duty travel						**-**
4.1 Local travel for traps services, per diems, accommodation etc.			2,500	2,500	2,500	**7,500**
Total cost			**13,230**	**13,230**	**13,230**	**39,690**

Component 4 - Training and Technology Dissemination						
1.0 Materials and supplies						
1.1 Paper, training materials, photocopying, printing, CD etc.	Lump per year		1,000	1,000	1,000	**3,000**
2.0 Personnel/Technical Assistance/Consultancy						**-**
2.1 Secretarial services (1% of technical time)	Average secretary salary	20,500	200	200	200	**600**
2.2 Tech. assistance (2.2% of *icipe* scientist staff or consultant time)	Average scientist salary	94,000	2,030	2,030	2,030	**6,090**
3.0 Dissemination and Training						**-**
3.1 Standard training course fee per participant (training of trainers; 4 participants) covering the cost of training materials, books, subsistence and accommodation of trainees, air return ticket, local field travel during training, conference room etc.	Lump per year		2,500	2,500	2,500	**7,500**
3.2 Awareness campaign course fee for approximately 30 participants comprising of printing of awareness materials, allowances for participants, fee for meeting room etc.	Lump per year			2,000	2,000	**4,000**
3.3 Training of entrepreneurs (4), representatives of industries (4) on bait, fungus, trap production and post harvest treatment	Lump per year			2,000	2,000	**4,000**
3.4 Advance level training at MSc	Lump per year		10,000	10,000	10,000	**30,000**
4.0 Duty travel						**-**
Local field travel by NARS conducting awareness campaign	Lump per year			2,000	2,000	**4,000**
Total cost			**15,730**	**21,730**	**21,730**	**59,190**
Grand total (Direct operational cost)			**72,690**	**53,690**	**53,690**	**180,070**

GRAND TOTAL - COMPLETE COST OF OPERATION FOR UGANDA						
Pre-harvest management measures			43,730	18,730	18,730	81,190
Post-harvest treatments			-	-	-	-
Surveillance and preventative measures			13,230	13,230	13,230	39,690
Training and technology dissemination			15,730	21,730	21,730	59,190
Subtotal - Direct project cost			**72,690**	**53,690**	**53,690**	**180,070**
Contingency 5% of direct cost			3,635	2,685	2,685	9,004
Total direct project cost			**76,325**	**56,375**	**56,375**	**189,074**
Administrative cost			7,632	5,637	5,637	18,907
Total cost			**83,957**	**62,012**	**62,012**	**207,981**

Table 7. Complete cost of operation for Mozambique

	Mozambique					
			Estimated cost			**Total**
Inputs	Unit	Unit price	Year1	Year2	Year3	**Cost**
Component 1 - Pre-Harvest Management Measures						
1.0 Vehicles, machinery and equipment						
1.1. Vehicle	Lump per year	22,000	22,000			**22,000**
1.2 Computer, printer, GPS	Lump per year		3,000			**3,000**
2.0 Materials and supplies						
2.1. Trap, baits, fungus, labels, plastic containers, cages, vials etc.	Lump per year		-	-	9,500	**9,500**
3.0 Personnel/Technical Assistance/Consultancy						
3.1 Secretarial services (1% of technical time/country/year)	Average secretary salary	20,500		-	200	**200**
3.2 Tech. assistance (4.3% of *icipe* scientist or consultant time)	Average scientist salary	94,000		-	4,000	**4,000**
4.0 Operational Cost						
4.1. Monitoring, traps services, fuel, vehicle repairs, spares etc.	Lump per year	-		-	2,954	**2,954**
5.0 Duty travel						**-**
5.1 Local travel for traps services, perdiems, accomodation etc.					2,954	**2,954**
Total cost			**25,000**	**-**	**19,608**	**44,608**

Component 2 - Post harvest treatment						
1.0 Materials and supplies						
1. Insect culture and maintenance (diet, cages, fruits, vials, etc.)	Lump per year	0	0	0	0	**0**
2.0 Personnel/Technical Assistance/Consultancy	Lump per year	0	0	0	0	**0**
2.1 Secretarial services (0% of technical time)	Average secretary salary	20,500	0	0	0	**0**
2.2 Tech. assistance (0% of *icipe* scientist or consultant time)	Average scientist salary	94,000	0	0	0	**0**
2.3 Tech. assistance (0% of *icipe* technical staff time)	Average technician salary	20,000	0	0	0	**0**
3.0 Operational Cost						**0**
3.1 Fruit dissection, logger monitoring, vehicle repairs, spares		0	0	0	0	**0**
Total cost			-	-	-	**-**
Component 3 - Surveillance and Preventative Measures						
1.0 Materials and supplies						
2.1. Trap, baits, fungus, labels, plastic containers, cages, vials etc.	Lump per year		-	-	6,000	**6,000**
2.0 Personnel/Technical Assistance/Consultancy						**-**
2.1 Secretarial services (1% of technical time)	Average secretary salary	20,500	-	-	200	**200**
2.2 Tech. assistance (3.4% of *icipe* scientist or consultant time	Average scientist salary	94,000	-	-	3,190	**3,190**
3.0 Operational Cost						**-**
4.1. Monitoring, traps services, fuel, vehicle repairs, spares etc.	Lump per year		-	-	2,500	**2,500**
5.0 Duty travel						**-**
5.1 Local travel for traps services, per diems, accommodation etc.					2,500	**2,500**
Total cost			**-**	**-**	**14,390**	**14,390**

Component 4 - Training and Technology Dissemination						
1.0 Materials and supplies						
1.1 Paper, training materials, photocopying, printing, CD etc.	Lump per year		1,000	1,000	1,000	**3,000**
2.0 Personnel/Technical Assistance/Consultancy						
2.1 Secretarial services (1% of technical time)	Average secretary salary	20,500	200	200	200	**600**
Tech. assistance (3.4% of *icipe* scientist staff or consultant time)	Average scientist salary	94,000	4,000	4,000	4,000	**12,000**
3.0 Dissemination and Training						
3.1 Standard training course fee per participant (training of trainers; 4 participants) covering the cost of training materials, books, subsistence and accommodation of trainees, air return ticket, local field travel during training, conference room etc.	Lump per year		2,500	2,500	2,500	**7,500**
3.2 Awareness campaign course fee for approximately 30 participants comprising of printing of awareness materials, allowances for participants, fee for meeting room etc.	Lump per year		2,000	2,000	2,000	**6,000**
3.3 Training of entrepreneurs (4), representatives of industries (4) on bait, fungus, trap production and post harvest treatment	Lump per year			2,000	2,000	
3.4 Advanced level training at PhD or MSc (2)	Lump per year			10,000	10,000	
4.0 Duty travel						
4.1 Local field travel by country collaborators conducting awareness campaign	Lump per year		2,000	2,000	2,000	**6,000**
Total cost			**11,700**	**23,700**	**23,700**	**35,100**
Grand total (Direct operational cost)			**36,700**	**23,700**	**57,698**	**94,098**

GRAND TOTAL - COMPLETE COST OF OPERATION FOR MOZAMBIQUE						
Pre-harvest management measures			25,000	-	19,608	44,608
Post-harvest treatments			-	-	-	-
Surveillance and preventative measures			-	-	14,390	14,390
Training and technology dissemination			11,700	23,700	23,700	59,100
Subtotal - Direct project cost			**36,700**	**23,700**	**57,698**	**118,098**
Contingency 5% of direct cost			1,835	1,185	2,885	5,905
Total direct project cost			**38,535**	**24,885**	**60,583**	124,003
Administrative cost			3,854	2,489	6,058	12,400
Total cost			**42,389**	**27,374**	**66,641**	**136,403**

Table 8. Complete cost of operation for FAO and CFC

	FAO & CFC					
			Estimated cost			**Total**
Inputs	Unit	Unit price	Year1	Year2	Year3	**Cost**
Monitoring and evaluation						
Project evaluation and monitoring	Lump per year	50,500	50,500	50,500	50,500	151,500
Total cost			**50,500**	**50,500**	**50,500**	**151,500**
Component 1 - Pre-Harvest Management Measures						
Pre-harvest management						**-**
Total cost			**-**	**-**	**-**	**-**
b) Component 2 - Post harvest treatment						
Post-harvest treatment		-	-	-	-	**-**
Total cost			-	-	-	**-**
Component 3 - Surveillance and Preventative Measures						
1.0 Materials and supplies						**-**
1.1 Paper, training materials, photocopying, printing, CD etc.			1,000	1,000	1,000	**3,000**
2.0 Personnel/Technical Assistance/Consultancy						**-**
2.1 Secretarial services (1% of technical time)	Average secretary salary	20,500	200	200	200	**600**
2.2 Technical assistance (PRA consultant time)	Average technical salary		10,000	10,000	10,000	**30,000**
3.0 Training and Workshop on PRA and Standards						**-**
Cost already captured for individual countries						**-**
4.0 Duty travel						**-**
4.1 International travel	Lump per year	4,000	4,000	4,000	4,000	**12,000**
Total cost			**15,200**	**15,200**	**15,200**	**45,600**

Component 4 - Training and Technology Dissemination						
Training and technology dissemination	Lump per year	-	-	-	-	**-**
Total cost			**-**	**-**	**-**	**-**
Grand total direct cost of operation			**65,700**	**65,700**	**65,700**	**197,100**
GRAND TOTAL - COMPLETE COST OF OPERATION FOR FAO & CFC						
Monitoring and evaluation			50,500	50,500	50,500	151,500
Pre-harvest management measures			-	-	-	-
Post-harvest treatments			-	-	-	-
Surveillance and preventative measures			15,200	15,200	15,200	45,600
Training and technology dissemination			-	-	-	-
Subtotal - Direct project cost			**65,700**	**65,700**	**65,700**	**197,100**
Contingency 5% of direct cost			3,285	3,285	3,285	9,855
Total direct project cost			**68,985**	**68,985**	**68,985**	206,955
Administrative cost			15,867	15,867	15,867	47,600
Total cost			**84,852**	**84,852**	**84,852**	**254,555**

Table 9. Complete cost of operation for *icipe*

	icipe					
			Estimated cost			**Total**
Inputs	Unit	Unit price	Year1	Year2	Year3	**Cost**
Project coordination and management (across all components)						
Project coordination time (*icipe* scientist at 16% per year)	Average scientist, salary	94,000	15,000	15,000	15,000	45,000
Total cost			**15,000**	**15,000**	**15,000**	**45,000**
Component 1 - Pre-Harvest Management Measures						
1.0 Vehicles, machinery and equipment						
1.1. Equipment for bait, fungus, trap and post-harvest treatment	Lump		150,000			**150,000**
1.2 Vehicle	Lump		22,000			**22,000**
1.3 Computer, printer,	Lump		3,000			**3,000**
2.0 Personnel/Technical Assistance/Consultancy						**-**
2.1 Secretarial services (1% of technical time/country/year)	Average secretary salary	20,500	200	200	200	**600**
2.2 Tech. assistance (100% of technician time responsible for bait, fungus and traps production)	Average technician salary	9,700	9,700	9,700	9,700	**29,100**
3.0 Duty travel						**-**
3.1 International travel			4,000	4,000	4,000	**12,000**
Total cost			**188,900**	**13,900**	**13,900**	**216,700**

Component 2 - Post harvest treatment						
1.0 Materials and supplies						
1. Insect culture and maintenance (diet, cages, fruits, vials, etc.)	Lump per year		10,000	10,000	10,000	**30,000**
2.0 Personnel/Technical Assistance/Consultancy						**-**
2.1 Tech. assistance (5.3% of *icipe* scientist or consultant time)	Average scientist salary	94,000	5,000	5,000	5,000	**15,000**
Technical assistance (100% of *icipe* technician time responsible for post harvest treatment work)	Average technician salary	20,000	20,000	20,000	20,000	**60,000**
3.0 Operational Cost						**-**
3.1 Fruit dissection, logger monitoring, vehicle repairs, spares	Lump per year		2,970	2,970	2,970	**8,910**
Total cost			**37,970**	**37,970**	**37,970**	**113,910**
Component 3 - Surveillance and Preventative Measures						
Surveillance and preventative measures			-	-	-	**-**
Total cost			**-**	**-**	**-**	**-**
Component 4 - Training and Technology Dissemination						
Training and technology dissemination			-	-	-	**-**
Total cost			**-**	**-**	**-**	**-**
			241,870	**66,870**	**66,870**	**375,610**

GRAND TOTAL - COMPLETE COST OF OPERATION FOR icipe						
Project Coordination			15,000	15,000	15,000	45,000
Pre-harvest management measures			188,900	13,900	13,900	216,700
Post-harvest treatments			37,970	37,970	37,970	113,910
Surveillance and preventative measures			-	-	-	-
Training and technology dissemination			-	-	-	-
Subtotal - Direct project cost			**241,870**	**66,870**	**66,870**	**375,610**
Contingency 5% of direct cost			12,094	3,344	3,343	18,780
Total direct project cost			**253,964**	**70,214**	**70,213**	**394,390**
Administrative cost			58,412	16,149	16,149	90,710
Total cost			**312,375**	**86,363**	**86,362**	**485,100**

Annex 1. Project workplans, implementation schedules and responsibilities

	Work Breakdown Schedule	Total	Year 1	Year 2	Year 3	Partners responsible*	Expected Output
1.0	COMPONENT 1: PRE-HARVEST MEASURES						
1.2	Activity 1. Assembling and large-scale validation, adaptation and dissemination of fruit fly IPM package	36				*icipe*, FAO, MoA-N, KARI, KEPHIS, MARI, MAFS, MoA-U, NaCRRI, MoA-M, EMU, Farmers group	IPM package assembled, validated, adapted and disseminated in the countries
1.3	Activity 2. Field-testing of solid bait station as alternative to liquid bait spray for field suppression of target fruit flies.	24				*icipe*	Solid bait stations developed, field tested and validated as alternative to liquid bait spray
1.4	Activity 3. Conduct on-farm validation, adaptation and dissemination of IPM techniques for MSW	36				*icipe*, FAO, MoA-N, KARI, KEPHIS, MARI, MAFS, MoA-U, NaCRRI, MoA-M, EMU, Farmers group	IPM package for MSW validated, adapted and disseminated in the countries
1.5	Activity 4. Establishment a pilot facility for production of bait, fungus and traps	36				*icipe*	Pilot facility for bait, fungus and traps establishment at *icipe*
2.0	COMPONENT 2: POST-HARVEST MEASURES						
2.1	Activity 1. Maintain colonies of *B. invadens* for heat and or cold tolerance testing	36				*icipe*	Colonies of *B. invadens* are maintained for post harvest work
2.2	Activity 2: Determination	24				*icipe*	The most cold tolerant

	of the most cold tolerant stage of *B. invadens* on avocado															stage of *B. invadens* on avocado determined
2.3	Activity 3: Determination of the most heat tolerant stage of *B. invadens* on mango	24													*icipe*	The most cold tolerant stage of *B. invadens* on mango determined
2.4	Activity 4: Large-scale validation trials on avocado	48													*icipe*, KEPHIS, Private sector	Large-scale validation trials on avocado completed
2.5	Activity 5: Large-scale validation trials on mango	48													*icipe*, KEPHIS, Private sector	Large-scale validation trials on mango completed
3.0	COMPONENT 3: SURVEILLANCE & PREVENTATIVE MEASURES															
3.1	Activity 1: Conduct systematic trapping, monitoring and detection for exotic fruit flies	36													KEPHIS, MAFS, MoA-U, MoA-M, *icipe*	Continuous surveillance conducted in the participating countries
3.2	Activity 2: Establish in each participating country a database for the management of surveillance data and information sharing	36													KEPHIS, MAFS, MoA-U, MoA-M, FAO, *icipe*	A database for the management of surveillance data and information sharing established in the countries
3.3	Activity 3:Identify faunistic relationships and pathways for possible introduction and spread	12													KEPHIS, MAFS, MoA-U, MoA-M,	Faunistic relationships and pathways for introduction and spread identified
3.4	Activity 4: Conduct relevant import pest risk analysis (PRA) using current and possible pathways as identified in (1) above														KEPHIS, MAFS, MoA-U, MoA-M, FAO, *icipe*	Pest risk analysis (PRA) using current and possible pathways conducted

3.5	Activity 5: Develop a regional standard based on the PRA for regulating movement of fresh fruits and vegetables														KEPHIS, MAFS, MoA-U, MoA-M, FAO, *icipe*	A regional standard based on the PRA developed for regulating movement of fresh fruits and vegetables
3.6	Activity 6: Prepare standard operating procedures (SOPs) for border inspectors regarding enforcement.														KEPHIS, MAFS, MoA-M, MoA-U	SOPs for border inspectors regarding enforcement is developed.
4.0	COMPONENT 4: TRAINING AND TECHNOLOGY DISSEMINATION															
4.1	Activity 1: Train NARS and NPPOs (training of trainers [ToT]) on surveillance and pre-harvest management packages	8													*icipe*, FAO, MoA-N, KARI, KEPHIS, MARI, MAFS, MoA-U, NaCRRI, MoA-M, EMU	NARS and NPPOs trained on surveillance and pre-harvest management packages
4.2	Activity 2: Conduct farmers' field school (FFS) hands-on training on surveillance and all management packages and awareness campaigns on technology availability														*icipe*, FAO, MoA-N, KARI, KEPHIS, MARI, MAFS, MoA-U, NaCRRI, MoA-M, EMU, Farmers group	FFS training on surveillance and all management packages and awareness campaigns conducted
4.3	Activity 3: Facilitate training of local entrepreneurs and representatives of industries on bait production and operation and use of post harvest treatment														*icipe*	Local entrepreneurs and representatives of industries trained on production and post harvest treatment

4.4	Activity 4: Carry out public awareness to facilitate large-scale adoption and application of the recommended management tools														MoA-N, KARI, KEPHIS, MARI, MAFS, MoA-U, NaCRRI, MoA-M, EMU, Farmers group	Public awareness campaign conducted to facilitate large-scale adoption and application of management tools
4.5	Activity 5: Advanced level training at PhD and or MSc for young Africans.														*icipe*, FAO, MoA-N, KARI, KEPHIS, MARI, MAFS, MoA-U, NaCRRI, MoA-M, EMU	Advanced level training at PhD and or MSc provided
5.0	ADMINISTRATION AND MANAGEMENT															
5.1	Co-ordination meeting															
5.2	Annual Report															
5.3	Evaluation report															

*MoA-N = Ministry of Agric., Nairobi; KEPHIS = Kenya Plant Health Inspectorate Service; KARI = Kenya Agricultural Research Institute; *icipe* International Centre of Insect Physiology and Ecology, Nairobi; MARI = Mikocheni Agricultural Research Institute, Dar es Salaam; MAFS = Ministry of Agriculture & Food Security, Plant Health Service, Dar es Salaam; NaCRRI = National Crops Resources Research Institute, Kampala; MoA-U = Ministry of Agriculture, Animal industries and Fisheries., Kampala; MoA-M = Ministry of Agric., Maputo; EMU = Eduardo Mondale University, Maputo; FAO = Food and Agriculture Organization of the UN, Rome.