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Final Technical Report

Project Title: **Integrating Malaria Control Interventions with Development Strategies in Kenya**

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1. SYNTHESIS

This is the final technical report of a two-year IDRC-funded project on the application of an ecosystem approach to malaria research and intervention in Mwea Division, Kenya. The project was one of eight similar projects in Africa coordinated by the CGIAR-led Systemwide Initiative on Malaria and Agriculture (SIMA) between 2004 and 2006. The other projects were in Uganda, Tanzania, Zimbabwe, Mozambique, Ethiopia, and Ghana. The project involved collaboration and partnership between: International Water Management Institute (IWMI); International Centre of Insect Physiology and Ecology (IWMI); University of Nairobi (UON); residents of four villages in Mwea; and, diverse stakeholders in Mwea including several government departments.

The purpose of the project, hereafter also referred to as Mwea Phase-II, was: *To develop and apply a development-oriented strategy for sustainable reduction of malaria among rural communities in central Kenya*.

The project had the following specific objectives:

- To strengthen cooperation between community, government departments, international and non-governmental organizations towards malaria control;
- To evaluate the impact of integrated anti-malarial interventions on malaria vector populations and prevalence of malaria parasites among the community;
- To assess people's behavioural change towards malaria control actions when interventions are integrated and conveniently phased in the context of an ecosystem approach to human health;
- To conduct further research on the feasibility of seasonally rotating the cultivation of rice and soyabean as an agro-ecosystem strategy for simultaneously enhancing household incomes, improving nutrition and reducing malaria-vector breeding habitat;
- To disseminate information across all levels.

The specific objectives had a combined research and intervention agenda. Thus, the first three objectives involved activities with direct bearing on immediate malaria control among the target communities, while providing a basis for future courses of multi-stakeholder action. The fourth specific objective aimed at contributing to longer-term solutions and sustainability of interventions through an income-generating agricultural activity, which also doubled as an agro-ecosystem management intervention for reducing the breeding of malaria vectors in the Mwea rice irrigation scheme. The fifth objective was on the dissemination of information across all levels.

Mwea Phase-II project was a follow-up to earlier participatory research in the same locality, which was also funded by IDRC from 2002- 2003. It was during the previous phase (i.e. Mwea Phase-I), that residents of four study villages developed action plans in which they requested to be assisted with the implementation of practical anti-malarial measures, among other things. Towards this end, Mwea Phase-II was in the first instance aimed at strengthening cooperation among different actors in order to mobilize people and maximize the utilization of locally available resources for malaria control. The specific intervention being implemented and evaluated was a package, comprising of three inter-linked activities namely: the distribution of long-lasting insecticide-treated nets (ITNs/LLNs); educating village communities and school children about integrated malaria control; and, regular dissemination of the research findings to the community and other key stakeholders.
As in previous IDRC-funded SIMA research in Mwea, the community continued to be involved in all

phases of the research, from negotiation, to data gathering, to design and implementation of the action plans. The transdisciplinary and participatory research methods were used in order to ensure that the anti-malarial strategies took account of socio-ecological characteristics of Mwea, promoted buy-in in the community, and also promoted equity by among other things, taking gender differences into account.

Key findings related to malaria in Mwea included the re-confirmation of a high malaria parasite rate (38%), among children in a study village nearly 5 kms outside of the irrigation scheme. In sharp contrast, there was a complete absence of malaria parasites in children from two other study villages surrounded by rice fields. As expected, the numbers of potential malaria mosquitoes were significantly higher in the latter villages due to a greater presence of mosquito-breeding sites, compared to non-irrigated villages. This ‘paddies paradox’ phenomenon, which was clearly described in the previous Mwea Phase-I, suggested the persistence of the protective effect that cattle were providing to people in irrigated villages, by naturally acting as alternative blood-meal hosts for malaria mosquitoes. There could also still be other socio-ecological factors that research in Mwea has so far not been able to verify as being among the underpinnings of the puzzling differences in malaria parasite prevalence between the irrigated and non-irrigated villages. More efforts should be made to thoroughly understand this phenomenon, with the view of sustaining the factors keeping the irrigated villages free of malaria. Nevertheless, Mwea Phase-II significantly reduced potential malaria risk in irrigated villages by depleting the numbers of malaria mosquitoes found in peoples’ homes. The community in irrigated villages also reported a significant drop in fevers due to malaria, in spite of the available parasitological data not being able to confirm such clinical manifestations of the disease.

The most obvious immediate benefit related to malaria control in Mwea Phase-II was the reduction of malaria parasite prevalence among children, from 38% in the most affected and poorest study-village pre-intervention, to 0% post-intervention. The decline was attributed to the integrated package whose specific elements included: increasing the use of insecticide-treated bed nets from one net per 16 persons in the poorest village pre-intervention, to one net per 2 persons post-intervention; and, participatory maintenance of community education and awareness regarding malaria control. Pre-intervention malaria prevalence measures were made in April 2005 among children less than 9 years of age, while the post-intervention measures were taken in March 2006 in order to capture changes in disease burden following distribution of the insecticide-treated nets in December 2005, and the continuous knowledge dissemination for community involvement in vector interventions. The surveys were conducted by Ministry of Heath staff following ethical clearance by the Ethical Review Board of the Kenya Medical Research Institute (KEMRI).

Other noticeable results of Mwea Phase-II included significant significantly increased participation by the community in environmental management for malaria vector control post-intervention. A marked increase in knowledge levels on causes of malaria and treatment-seeking in the community was also recorded particularly among pupils in the local primary schools that participated in the project. Furthermore, the project demonstrated on an experimental scale the elimination of mosquito-breeding at randomly selected rice plots as a result of rotating rice cultivation with soyabean. The latter, being a dry-land crop, proved effective in mopping up unnecessary surface water during the off-season for rice. This intervention had an even bigger motivation to the farming community in Mwea, since the research confirmed and quantified the value of soya in increasing soil fertility, and in turn, rice yields and income. However, the results clarified that soyabean should not be used as a replacement to rice cultivation in Mwea – but rather as a complementary break-crop instead of cultivating a second rice crop in the course of the year.

From a policy-perspective, results of Mwea Phase-II strongly underscored the need for cross-sectoral cooperation in malaria as a way of facilitating and assisting communities with the following types of solutions which were first suggested during Mwea Phase-I:

1) Immediate solutions that do not require external assistance e.g. covering small puddles of water in vicinity of houses in order to eliminate mosquito-breeding.
2) Immediate solutions with cash requirements, e.g. usage of insecticide-treated nets (ITNs). This type of support proved highly effective in providing immediate relief to the village worst affected by malaria.
3) Medium and long-term solutions requiring technical support and bigger investment of financial resources e.g. improved irrigation water management; crop rotation e.g. of rice and soya; maintenance of natural zooprophylaxis, i.e. enhancing the protective role played by cattle as alternate blood-meal hosts for certain species of malaria mosquitoes.

The following were the main challenges encountered during the application of an ecosystem approach to malaria research and control in Mwea Phase-II:

Academic and Institutional differences: Bringing together researchers from different academic disciplines e.g. social science and natural science, and also from different institutions – particularly ICIPE and University of Nairobi, continued to be a challenging task that needed to be carefully managed at all times. A future generic solution to this common problem may be to make greater investment in the formal training of potential researchers in the methodology for transdisciplinary and participatory research right from the level of first degree at universities in Africa and elsewhere.

Raised expectations: participatory research was as in other SIMA projects found to raise expectations for long-term partnership and continued partial-support among communities, researchers, and other stakeholders. Fortunately this type of dependence significantly declined during Mwea Phase-II, compared to the situation at the end of Mwea Phase-I. It was nevertheless not possible to completely eliminate raising expectations.

Finally, it is recommended on the basis of findings from Mwea Phase-II that: IDRC should consider extending support for SIMA’s ecohealth research and malaria interventions in Mwea - for at least another four years to 2010. Doing so will allow implementation of the current action plans by the village communities, and researchers, and also facilitate the monitoring of multi-stakeholder participation, and track impacts. Continued IDRC support will also make it possible to exhaustively document and widely disseminate the most comprehensive assessment possible. Ultimately Mwea could be presented as an evidence-based success story in the application of an ecosystem approach in controlling malaria, and generally improving human health in a rural area of eastern Africa. This would be considerable achievement for all concerned, especially if the project clearly demonstrated that ecosystem approaches to malaria control were sustainable and effective, without having to resort to a controversial chemical like DDT, which has recently been recommended for indoor residual spraying in malaria endemic areas of Africa.

2. THE RESEARCH PROBLEM

The current project was carried out in the Mwea irrigation scheme, Kenya, where malaria ranks high among the common endemic diseases affecting the local farming community. A previous IDRC-funded study, hereafter also referred to as Mwea Phase-I, recorded a malaria parasite prevalence rate of up to 24% among children aged below 9 years of age in certain villages in Mwea. The research also confirmed the occurrence of considerable mosquito nuisance inside people's houses. The current project was a logical progression from the earlier phase which focused on the characterization of the socio-ecological system in Mwea. The purpose of Mwea Phase-I was to understand interactions between environmental and socio-economic factors, and how these determined the prevailing picture of malaria endemicity.

The main conclusions from Mwea Phase-I could conveniently be summarized under the following three topics: ecological and social determinants of malaria; research methodology; multi-stakeholder collaboration.

Ecological and social determinants of malaria: According to the Phase-I results, malaria ranked high as a cause of morbidity in Mwea and was perceived by the community to be a priority health problem. The disease in this particular area was almost entirely transmitted by *Anopheles arabiensis*, a mosquito that prefers to breed in rice paddies. The mosquito feeds both on people and cattle and rests in large numbers indoors during the daytime. Cattle keeping and irrigation for rice were therefore identified as being among the key agro-ecosystem factors determining local variations in prevalence of the disease. Residents of three out of the four study villages expressed interest to participate in various anti-malarial activities at the community and household levels. Such activities could include educating each other about good hygiene and the importance of environmental management measures, and using insecticide-treated nets (ITNs). They however emphasized the need for external technical and financial support in view of perceived widespread poverty in Mwea.

Based on the village action plans developed during Phase-I studies, it was envisaged that a two-pronged approach to malaria reduction would be feasible, broadly based on the following elements of the generally accepted malaria control strategy: development and implementation of a practical integrated vector management (IVM) strategy; enhanced awareness and education regarding integrated malaria control; improved community access to facilities for reliable malaria diagnosis and prompt treatment.

Research methodology: The study results confirmed that an ecosystem approach to human health had distinct advantages for the development of integrated and sustainable strategies for malaria reduction when compared to the conventional uni-disciplinary approaches to research. Thus, qualitative data during Phase-I studies provided a good understanding of health problems and linkages with agriculture and lifestyles, social issues such as gender and alcoholism, and their implications for productivity. This initial characterization significantly assisted the project team in focusing the research agenda and developing an appropriate sampling frame for household quantitative data gathering. Generally there was a high degree of consistency between the qualitative and quantitative results. Equally important, the participatory process was successful in building local capacities with regard to local skills, knowledge and empowerment.

Another important lesson learned from Mwea Phase-I studies regarding research methodology was that it was essential to up-front have a quantitative and qualitative data-analysis specialist to contribute to the study design and data management procedures. Doing so would ensure that data was analysed in a timely manner and could withstand the rigorous scrutiny required for publication of the results in peer-reviewed journals. Some frustration was experienced in the analysis of Phase-I results after it was realized that the project's available statistical expertise was inadequate for dealing with complex data sets.

Multi-stakeholder collaboration: The community clearly indicated during Phase-I studies that malaria and other health problems in Mwea could only be sustainably controlled if there was cooperation between themselves, the government and other stakeholders interested in the development of Mwea. However, there was a glaring lack of such cooperation either between the community and the government or among the government departments themselves. A stand-off between the rice farmers' cooperative society and the National Irrigation Board regarding the management of the Mwea irrigation scheme was among the most obvious manifestations of the poor relations existing between the government and local communities in Mwea at the time.

Mwea Phase-II was based on the premise that research and intervention activities which are ultimately aimed at assisting target communities should among other things be participatory, integrated and phased, depending on the nature and status of the interventions and technology to be applied, and the prevailing social-economic context. For communities which barely live above the poverty line, as in Mwea, it was reasoned that immediate measures should be pragmatic and aimed at offering relief at little or no financial cost. At the same time, a process for development of longer-term solutions should be initiated to ensure sustainability of interventions. Included in the longer term efforts would be the deliberate education and training of the target communities regarding the problems being addressed, and the building of the necessary research and scientific capacity among the relevant formal institutions.

The Mwea Phase-II project encountered and addressed various challenges associated with transdisciplinary and participatory research, mainly using experience gained in Phase-I studies. These included the streamlining of inter- and intra-institutional collaborative arrangements, and enhancing skills for ecosystem approaches to human health among researchers, post-graduate students and the target community.

3. RESEARCH OBJECTIVES, METHODOLOGY, FINDINGS AND OUTPUTS

The current chapter covers the following sub-headings of the standard IDRC guidelines for preparing final technical reports: research findings; fulfillment of objectives; project design and implementation; project outputs and dissemination; and, capacity-building. The information is conveniently presented under the five specific objectives of the project for purposes of clarity and ease of reference.

3.1. Specific objective #1:

Strengthening cooperation between communities, government departments, international and non-governmental organizations towards malaria control

3.1.1 Introduction

Traditional approaches to research and development in health and other sectors have been predominantly top-down, with limited genuine involvement of local institutions and communities meant to benefit from results of such investments. The approaches have often resulted in inappropriate and unsustainable products and services. Recognizing the importance of redressing this shortfall, the Mwea malaria control project used a participatory and integrated approach to health during its two phases i.e. 2001-2003 and 2004-2006 respectively. This approach, referred to as 'ecosystem approach to health' recognizes that human health and well-being are intimately tied to health of the ecosystems that sustain life.

3.1.2 Activities

The following were the activities planned in order to achieve Specific Objective 1:

a) Conduct a survey to identify community groups, government departments and non-governmental organizations that are involved or have an interest in malaria control in Mwea;
b) Organize a series of stakeholder consultations from the village to District levels, in order to create awareness, build trust, and reviewi and update action plans in order to harmonies community and government efforts in addressing the malaria problem in Kirinyaga District;
c) Identify opportunities for strengthening human capacity for the management of the Mwea irrigation scheme with a view to empowering the scheme's governance structure to address malaria and other health issues;
d) Identify and monitor critical areas requiring community and other stakeholder participation for various specific objectives including operationalizing a timetable for implementation of relevant activities;
e) Disseminate information.

3.1.3 Methods

Building a transdisciplinary research team

A two-day training was organized to expose the Mwea Phase-II research team to methodology for ecosystem approaches to human health. The training, held in August 2004, had the following components: The ecosystem approach to health-rationale, principles and process; Transdisciplinarity; participatory approaches to health; gender in the context of ecohealth; community diagnosis as an approach to Ecohealth.

Multi-stakeholder identification and engagement

The process started with development of a database of relevant community and formal government and non-government organizations in order to provide a basis for cooperation and effective engagement of stakeholders. The process greatly benefited from the stakeholder base used during Mwea Phase-I. The main partners in this database were:

- Communities of the four project villages. Groups included community groups such as the Village Development Committees (VDCs), Community Health Workers and other development groups
- The Ministry of Health-district level and health facilities
- The Ministry of Culture and Social Services, through the Community Based Nutrition Project (CBNP)
- Ministry of Agriculture
- The Ministry of Culture and Social Services
- The National Irrigation Board
- The Multipurpose Rice Growers Management Cooperative
- Community-Based Organizations in different villages
- Faith-based organizations- The Anglican Church, Methodist Church, Catholic Church
- The Ministry of Education
- The Kenya Medical Research Institute (KEMRI)
- Population Services International (PSI)

A series of consultations were held with different organizations with the purpose of creating awareness, building trust, harmonizing community and government efforts in addressing the malaria problem in Kirinyaga District and creating ownership of the project.

Some of the important consultations held included the following:

Stakeholder workshop to launch project

An area-wide workshop to launch the project was held on 19 July 2004.

Village level awareness and planning workshops

As recommended by the stakeholder workshop, the project held two meetings in each of the four villages. The purpose of the meetings was to (i) share the content and strategy of the second phase of the malaria control project (ii) take an inventory of malaria control activities in project areas (iii) forge partnerships for implementation of project activities and (iv) develop an implementation framework.

The meetings discussed the details of the project, comparing project activities with Community Action Plans (CAPS) developed during the first phase of the project. A second meeting developed a framework for implementation of project activities. Through this process, communities became aware of the project and defined ways in which they would be involved. In total, 165 community representatives from the four villages participated in village level awareness meetings alone.

Consultations with the Ministry of Education
One of the project activities under specific objective #3 "*assessing people's behavioral change towards malaria control actions when interventions are integrated and conveniently phased in context of an ecosystem approach to human health*" was to "*organize talks at local schools to educate pupils on important aspects of malaria, including mode of infection, self-protection and treatment*". In order to effectively work with schools, consultations with the Ministry of Education were held early in the project. Following these consultations, the project got clearance to work with 8 schools which were at the time involved in another health program, managed by the Kenya Medical Research Institute (KEMRI) supported by the Japanese Development Agency (JICA).

Health stakeholders workshop
In an effort to strengthen collaboration between the project and other stakeholders, the project supported a district-wide health forum through the District Medical Officer of Health (DMoH). The meeting was officially opened by the Kirinyaga District Commissioner and closed by the Provincial Medical of Health. The purpose of this meeting was to:

- Share and exchange information on health and malaria control programs currently being implemented in Kirinyaga district, with special focus on Mwea division.
- Establish gaps and overlaps between different organizations as a basis for improving collaboration and efficiency.
- Develop strategies for improved coordination and sharing of information between different actors, including the Ministry of Health.

Assessment of health-related capacity of the Mwea Multipurpose Rice Growers Management Cooperative (MRGM)
Mwea Phase-II project had anticipated that the MRGM would take on an active role in malaria control and thus ensure continuity and sustainability after the project ended. The MRGM is a farmer organization, which in 1999 championed a radical split between Mwea farmers and the National Irrigation Board (NIB), the Government agency that had managed the scheme for over three decades. MRGM took over the management of the scheme, and for about two years, it supported farmers with inputs and marketing of rice. MRGM however quickly got overwhelmed by the new responsibility, thus leaving farmers disillusioned and frustrated. By 2004, only a few farmers marketed rice through MRGM. Consultations with the farmers indicated that the MRGM was not in a position to play a key role in malaria control within Mwea. Instead, the farmers proposed that the Mwea Phase-II project should either work with religious groups such as the Christian Community Services (CCS) or trained community health workers (CHWs). With the MRGM out of the sustainability scheme envisioned earlier, the need to support training of trainers (ToTs) to carry on malaria control activities after the closure of the project was considered.

3.1.4 Results

Team Transdisciplinarity
Developing transdisciplinarity is not easy considering that conventionally scientists work hard to remain within their disciplines. While the first year of Mwea Phase-II was challenging, there was significant improvement during the second and final year of the project. Some examples of transdisciplinary activities included the following:

a) Joint review of data collection instruments to ensure inclusion of cross-cutting issues such as gender and other forms of social analysis. This process helped team members understand, appreciate and address issues beyond their disciplinary boundaries.
b) Joint participation in activities. Team members put effort to participate in activities outside their areas of specialization. For example:
   - Different team members took part in the district-wide health consultations held in September 2004, a forum organized to strengthen multi-stakeholder involvement.
   - Members effectively participated in village level awareness creation meetings early in the project
   - Members participated in the participatory evaluation of the project
   - All research team members actively participated in the internationally-recognized 'Malaria Day', which was observed in the different study villages. The malaria day gave communities and schools an opportunity to demonstrate through drama, song and poetry what they had learned through the project.

Community Participation

The project was characterized by high level of community participation. Some of the proxy indicators of this high level of participation included: (i) the high number of members of the community who participated in community meetings; (ii) large numbers participating in malaria control training; (iii) participation in 'Malaria Day' event in different villages; and (iv), end of project participatory evaluation. As a result of this participation, a large proportion of community members have been found to be well-aware of project activities, and the benefits and changes that can be associated with the project. The level of community and multi-stakeholder participation, together with the main outcomes are summarized in the Table below:

Summary of community and multi-stakeholder participation

Date & event	Participants	Number	Outcome
April-May 2004 Establishment of stakeholder database	• Project team • Field Assistants-in four villages	Over 15 organizations	• Inventory of stakeholders for collaboration purposes developed
July 2004: Area-wide stakeholder workshop	• Community • Govt. Depts. • Church-based organizations • Community-Based Org.	48 people	• Awareness on the project created • Areas of possible collaboration with partners identified • Strategies for enhancing participation and cooperation developed.
August 2004: Village level awareness and planning	• Community • Chiefs • Ministry of Health	165 people	• Further awareness on the project created • Establishment of community structures for implementation

April-August 2005 Consultations with Education	• Consultations with the Ministry of Education • Involvement of 8 primary schools in malaria control	Over 400 pupils in 8 schools	• Partnerships to continue promoting activities after formal project closure forged
October 2005: Health stakeholders meeting	• Health stakeholders • Ministry of Health	23 organizations	• Strategies for improvement of coordination and reporting on malaria activities developed
March 2006: Participatory evaluation	• Community • Govt. Depts.	224 people (145 women)	• Information and knowledge of the project, including its achievements, various benefits, challenges and the way forward exchanged. •

3.1.5 Impacts

Improved general knowledge and skills at the community level
The following is a listing of acknowledgements by the community regarding the knowledge and skills they acquired from the project:

- That there exists long-lasting insecticide-treated nets whose effect can last 4 years;
- The importance of bednets in prevention of malaria;
- That malaria is transmitted by mosquitoes and is not due to drinking dirty water, eating mangoes, or being exposed to bad weather;
- That it is the female *Anopheles* mosquito which transmits malaria and that it bites in its largest numbers between 10.00h and 04.00h;
- There are possible dangers of self treatment if malaria is not diagnosed by health personnel;
- That expectant mothers and children are the most vulnerable and that is why some projects tend to provide them with nets at low prices;

Community-perceived tangible benefits
- Malaria incidence has gone down: One village resident observed -"*I used to get an attack every 3 months but since getting a net a year back, I have had no malaria*".
- Homes and surrounding environment are much cleaner;
- Self-treatment, using herbs and medicine from shops, has declined due to greater awareness and less malaria;
- Proportion of people seeking diagnosis in health facilities has increased due to increased knowledge;
- Use of mosquito coils has reduced since nets are now available;

- Burning of cow dung to chase away mosquitoes has declined since bed nets are available;
- Mosquitoes have moved from the bedrooms to the sitting rooms!
- Reduced cost of health: Quote by a village resident – "*The money we used to buy medicine is now available for other households needs*";
- Increased productivity due to decline in sickness.

Impact as perceived by Health Personnel

"*We used to have at least 20 cases of convulsions due to malaria every month but since households received mosquito nets, we hardly get any convulsions or severe cases of malaria*" . This was an observation made by *Susan Muchiri, Sister-In-charge, Murinduko Dispensary.*

3.2. Specific Objective #2:

To evaluate the impact of integrated anti-malarial interventions on malaria vector populations and prevalence of malaria parasites

3.2.1 Introduction

This research component focused on the quantitative evaluation of the impact of integrated anti-malarial interventions. Its specific aims were:

- To enhance awareness on use of vector control tools at community level;
- Determine the extent of implementation of vector control actions by communities in Mwea and assess factors limiting progress of such initiatives;
- Determine the impact of active implementation of IVM on entomologic and parasitological parameters.

3.2.2 Methodology: Project design and implementation

Demographic survey and mapping: Village maps indicating location of homesteads, water points, rice paddies, canals and other aquatic habitats were developed. A baseline household census was conducted in the study villages in order to collect relevant household risk factors for malaria and for use as a framework for sample selection in subsequent studies.

Questionnaire design and administration: Based on the principle of transdisplinarity, a comprehensive questionnaire was developed and administered to 100 randomly selected households per village.

Prevalence survey: Pre-intervention malaria prevalence measures were conducted in April 2005 among children less than 9 years of age while the post intervention measures were taken in March 2006 in order to capture changes in disease burden following distribution of long-lasting insecticide-treated nets (LLNs), and the continuous knowledge dissemination for community involvement in vector interventions. The surveys were conducted by Ministry of Heath staff following ethical clearance by the Ethical Review Board of the Kenya Medical Research Institute (KEMRI).

Vector surveillance: Adult mosquitoes were sampled once fortnightly in 10 randomly selected houses in each of the four villages from January 2005 and to April 2006.The same houses were sampled throughout the study period in the morning (0700-11:00 hours) using pyrethrum spray collection (PSC) method. All collected mosquitoes were identified morphologically to species and further analyzed for the presence of sporozoites using the ELISA techniques.

ITN procurement and distribution: 2800 LLNs were procured centrally through ICIPE and distributed to communities through the community health workers (CHWs). This arrangement provided complete management of the distribution, knowledge dissemination on net use and subsequent monitoring of use to the affected communities.

Village and stakeholder meetings: This component was facilitated through activities of the overall project's specific objective # 1 and # 3. Several community based meetings were conducted whose purpose was to discuss the possible roles of CHWs in malaria control and developing of village-based malaria control work plans to enhance awareness.

Gender considerations: Issues of gender were expressly accommodated in the process of project implementation with regard to selection and training of CHWs, Field Research Assistants and school children. Gender consideration was also apparent in the selection and implementation of the household questionnaires and results derived from the study were analyzed on the basis of gender. The issue of gender was cutting across all the objectives of the current study.

3.2.3 Results

Overall, the number of respondents who reported having slept under a bed net the night to the day the household questionnaire was administered was high during the post intervention assessment (69.7%), compared to both mid term assessment (57.2%), and the pre-intervention phase (47.0%). Thus, there was at least a 32% increase in bed net use in the study villages following the implementation of the IVM strategies.

During the pre-intervention, bed net coverage was generally low in the study sites, with Murinduko showing the lowest coverage at 1 net for about 16.4 persons, while in the other villages coverage was at least 1 net for 3 persons (Table 1). On average the pre-intervention period had 1 net for 6 persons compared to 1 net for 2 persons at post intervention. Net coverage therefore increased from 27% to 59.5%.

The rate of community involvement in environmental management showed a significant increase with regard to clearing vegetation in canals with 0.9% and 14.9% households having reported taking action at the pre-intervention and post intervention survey, respectively (Table 2). The proportion of households involved in filling/ leveling of breeding sites rose from 23.5% (Per-intervention) to 30.4% (post intervention).

Table 1. Bednet coverage and use pre- and post intervention in Mwea Kenya

	Pre-intervention						
	#HH	# Sleeping houses	#People	#children	#Bed nets	Nets /person	Persons /net
Ciagi-ini	107	141	444	112	109	0.25	4.07
Kagio	106	162	482	117	169	0.35	2.85
Mbui Njeru	101	136	390	103	176	0.45	2.216
Murinduko	108	147	460	122	28	0.06	16.43
Total/ Mean					482	0.03	6.39
	Post-intervention						

	#HH	# Sleeping houses	#People	#children	#Bed nets	Nets /person	Persons /net
Ciagi-ini	107	147	479	122	326	0.69	1.47
Kagio	106	162	493	123	272	0.56	1.81
Mbui Njeru	101	136	427	116	304	0.72	1.40
Murinduko	108	147	486	133	219	0.46	2.22
Total/ Mean	422					0.75	2.15

Table 2. Environmental management strategies employed at household level

	Ciagini		Kagio		Mbui-Njeru		Murinduko		Total	
Pre-intervention										
	#	% HH	#	%HH	#	%HH	#	%HH	#	%HH
Clearing HH refuse/proper waste disposal	6	23.1	37	56.1	28	41.2	28	52.8	99	46.5
Filling/Levelling breeding sites	10	38.5	19	28.8	7	10.3	14	26.4	50	23.5
Clearing vegetation in canals					2	2.9			2	0.9
Clearing bushes/vegetation around houses	16	61.5	54	81.8	57	83.8	41	77.4	168	78.9
Others			1	1.5	1	1.5	3	5.7	5	2.3
Total Respondents/ %	26	100	66	100	68	100	53	100	213	100
Post intervention										
Clearing HH refuse/proper waste disposal	56	62.2	70	82.4	44	57.9	35	41.2	205	61
Filling/ levelling breeding sites	41	45.6	45	52.9	13	17.1	3	3.5	102	30.4
Clearing vegetation in canals	7	7.8	37	43.5	3	3.9	3	3.5	50	14.9
Clearing bushes/vegetation around houses	59	65.6	84	98.8	73	96.1	71	83.5	287	85.4
Others	0	0	0	0	1	1.3	0	0	1	0.3
Total Respondents/ %	90	100	85	100	76	100	85	100	336	100

Records of malaria episodes based on the household questionnaire showed a significant decrease in number of persons reported to have had fever within a two-week recall period, from 10.2% pre-intervention phase to 5.6% post intervention (Table 3).

Table 3: Febrile illness episodes reported during the pre intervention and post intervention phases of the study in Mwea

Pre-intervention	Post intervention

	Pop sampled	# HH Reporting fever	# People with fever	Prop. with fever (%)	Pop sampled	# HH Reporting fever	# People with fever	Prop. with fever (%)
Ciagi-ini	444	52	44	9.9	479	24	24	5
Kagio	482	39	45	9.3	493	14	14	2.8
Mbui Njeru	390	36	38	9.7	427	37	40	9.4
Murinduko	460	50	55	11.9	486	24	25	5.1
Total	**1776**	**177**	**182**	**10.2**	**1885**	**99**	**103**	**5.6**

Data on malaria prevalence rates was higher in the non irrigated villages (Murinduko: 38%, n= 63; Kiamaciri: 1%, n= 85) while no infections were recorded in the irrigated villages (Mbuinjeru, n= 53; Ciagini, n= 29) during the pre-intervention or baseline phase (Table 4). Out of a total of 377 blood films screened during the post intervention phase none was found to be positive for malaria parasites.

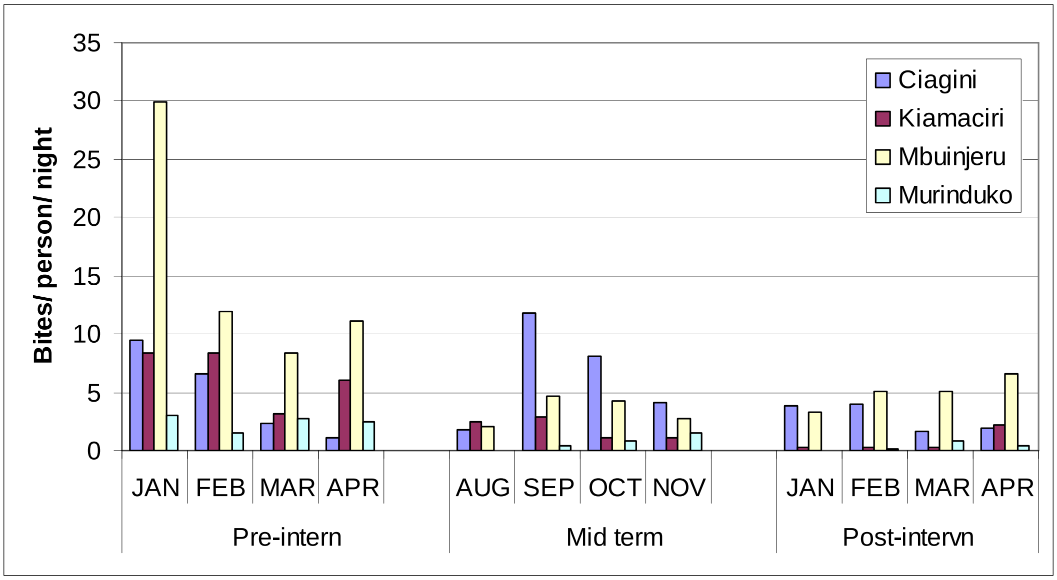
Table 4. Malaria prevalence rates pre- and post intervention in Mwea Irrigation Scheme

	Pre-intervention			**Post Intervention**		
Village	**Total blood films**	**# Positive**	**Prevalence (%)**	**Total blood films**	**# Positive**	**Prevalence (%)**
Ciagi-ini	29	0	0	121	0	0
Kagio	85	1	1	96	0	0
Mbui Njeru	53	0	0	73	0	0
Murinduko	63	24	38	87	0	0

Bed net treatment and re-treatment was perceived to be very important by 81% and 94% of the respondents in the study area pre intervention and post intervention, respectively. Bed net use was perceived to offer protection against nuisance biting by mosquitoes by 95% of the respondents while only 54% associated bed net use with protection against malaria.

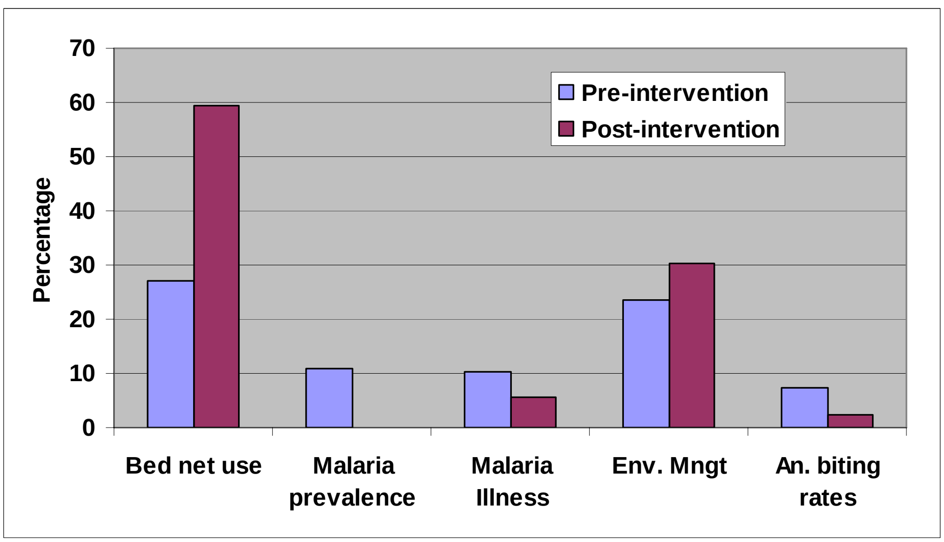
There was a significant reduction in vector densities following implementation of the IVM approach with post intervention *Anopheles* densities (7.73 *Anopheles*/ house) being lower than the pre-intervention measures (20.2 *Anopheles*/ house). A total of 7 *Anopheles* species were sampled showing high species diversity with *An. arabiensis* predominating. The relative abundance of *Anopheles* mosquitoes expressed as biting rates (number of bites per person per night) were equally lower post intervention (2.23 bites/p/n) compared to pre-intervention phase (7.3 bites/p/n).

Figure 1. Relative abundance and patterns of *Anopheles* mosquitoes in 4 study villages in Mwea



Overall, post treatment measurements indicated a general improvement in the outcome indicators tested in the study (Figure 2).

Figure 2: Changes in outcome indicators following IVM implementation



3.2.4 Fulfillment of objective

Objective #2 was modified to encompass the concept of integrated anti-malarial management. The working objective read: "Evaluate the impact of integrated anti-malarial interventions on malaria vector populations and prevalence of malaria parasites". The activities initially earmarked in the grant objective were successfully conducted which included:

- Collection of baseline data on current utilization of malaria vector control practices, and knowledge and perceptions of malaria transmission.
- Monitoring the impact of the combined interventions on malaria entomological and malaria morbidity parameters.
- Initiating an appropriate system for procurement and equitable distribution of long-lasting insecticide-treated nets through Community Health Workers (CHWs).
- Disseminating information

The purchase of two microscopes to enhance malaria diagnostic and treatment facilities at local clinics was not undertaken. It was found out that about ten microscopes had recently been donated by a JICA-funded project to the local sub-District hospital and were largely unutilized.

3.2. 5 Tangible project outputs and dissemination

Key outputs derived from the project included:

- Brochures on malaria transmission and control for communities, schools and stakeholders were prepared and distributed to all study villages.
- An interim technical report was prepared and shared with the IDRC.
- Three draft publications have been developed and are currently being reviewed (Titles: 1. The impact of integrated anti-malarial interventions on malaria vector populations and prevalence of malaria parasites in Mwea, Kenya; 2. Knowledge and perceptions on the causes and transmission of malaria in Mwea, Kenya; 3. Malaria vector control practices in Mwea: an irrigated rice growing scheme).
- One thesis at Masters level has been usefully completed under the current project.
- Members of the research team attended a conference on the SIMA synthesis workshop and resource mobilization in November 2005 in Dare Salaam, Tanzania.

3.2. 6 Capacity building

The project successfully trained 40 CHWs and 4 Field Research Assistants with equal numbers from each of the 4 villages on organization and implementation of participatory community initiatives, aspects of vector biology and malaria control strategies through a holistic integrated approach. Furthermore, 1 student (Mr. Peter Ng'ang'a) completed successfully Masters Studies in Public Health at Kenyatta University. The research team was also effectively trained in PRA approaches.

3.3 Specific Objective # 3:

Assessing people's behavioral change towards malaria control actions when interventions are integrated and conveniently phased in the context of an ecosystems approach to human health

3.3.1 Introduction

The rationale advanced here was that integrated and conveniently phased interventions towards malaria control could enhance behavior change at individual and community levels through their participation in self protection strategies, proper environmental management, and prompt definite diagnosis and treatment seeking, in the context of a holistic approach to human health problems in Mwea. A household survey conducted in 322 households during Mwea Phase-I studies had revealed that: there was a lack of awareness among individuals and families regarding available options for self-protection against malaria. Poverty was also a major factor negatively affecting anti-malaria behavior.

3.3.2 Project design and Implementation

A host of PRA tools were applied to assess actions and attitude towards malaria interventions at household and community levels. These included structured questionnaires, focus group discussions and direct observations of people's behavior. Educational activities and information dissemination were also conducted through training of trainers (ToTs), both men and women, comprising of primary school teachers from local primary schools and village based Community Health Workers (CHWs). After the training, the ToTs would in turn teach primary school children and community, respectively.

Rationalization for training of trainers (ToTs)
At an earlier stakeholders' workshop, community members and institutional representatives had spelt out the available capacities, opportunities and constraints, that would either augment or hold back their active involvement in the Mwea Phase-II project mission. These were listed as follows: :

<u>Capacities and opportunities</u>

- The communities had expressed interest and commitment to address malaria as a priority issue during Mwea Phase-I;
- The study-villages had structures that could support project activities. These included the Village Development Committees (VDCs), Community Health Workers (CHWs), and Self-Help Groups.

<u>Constraints</u>

- Unwillingness of the larger community to participate in voluntary work due to poverty, and also due to inadequate knowledge of the benefits that would accrue from involvement in malaria activities;
- Inadequate skills to deal with health issues, such as malaria control;
- Inadequate skills with which to manage health programs within the Village Development Committees;
- Limited support from government administration.

Description of the process

A community-education specialist was hired on temporary basis to facilitate the training of CHWs and primary school teachers to serve as trainers on Malaria control. The one week course aimed at equipping the trainers of trainers (ToTs) with knowledge and skills to assist them subsequently manage the training of smaller groups on malaria control. The Project team provided detailed technical knowledge and skills on specific areas such as: malaria vector control, soy bean production, the role of behavior change, and cooperation with the local institutions in malaria control. Identification and selection of the participants was a participatory process, involving the community and the district education offices. Community members from the study villages applied set criteria in the process of selecting the participants for the ToTs training. The course assisted trainees in formulating action plans to follow-up on training of residents of the respective villages. Gender issues were addressed, and this generated a great deal of discussions among the participants. The course covered environmental management, change of lifestyles, and health-related behaviour such as self protection against mosquito bites, and agro-ecosystem management interventions of relevance to malaria control based on known mosquito-crop-livestock interactions. The schools and the participating teachers were identified through the Zonal Education office against set criteria. These too were people of high integrity, and were willing to volunteer their time for malaria control activities.

3.3.3 Results

Community knowledge and perceptions

a) Insights on malaria:

- Malaria was perceived to be a major public health disease in the study area.
- Most respondents in the irrigated villages frequently mentioned bilharzia and typhoid, while common colds and intestinal worms were perceived to be most frequent after malaria and typhoid in the non-irrigated villages.
- There were significant variations between villages in the way respondents recognized the signs and symptoms of the disease. For example, feeling cold, fever, and headache were the three most mentioned symptoms in order of frequency in Ciagini village while general body weakness, headache and fever, were the most mentioned symptoms in Kagio/Kiamaciri village
- The majority of the respondents in all the villages mentioned the existence of a link between mosquitoes and malaria disease.
- Protection against mosquito bite was cited as the main reason for using bednets by 95% of the respondents in the total sample.
- A majority of respondents appeared to be aware of the major breeding habitats of the mosquito. More than eighty percent of the respondents related that mosquitoes breed in stagnant water found in swampy areas, small ponds made by animal hoof prints and wheel ruts. other breeding sites mentioned included high vegetation outside houses, rice paddies, rubbish pits, latrines pits, water canals and animal pens.
- The most commonly mentioned method of personal protection was the use of treated mosquito nets (ITNs) mentioned by 79%, followed by use of untreated nets, use of traditional methods such as burning dry cow dung and other plants believed to have repellent effect on mosquitoes. Others included lighting coils at night, insecticide sprays, application of skin

repellents, screening windows and doors with fine wire mesh and regular use of preventive medicines.

Enhancing community knowledge
A total of 44 Community Health Workers (CHWs) were trained as trainers (TOTS) to train people in their respective villages. Larger villages selected 10 CHWs, while the smaller ones selected eight. The selection exercise was undertaken by the villagers following set criteria. The TOTs were men and women who were held in high regard in the community derived from commitment to duty, reliable individuals with ability to mobilize the community without appearing to use coercive approaches. The majority of the participants had at various times previously been trained as Community Health Workers (CHWs) or HIV/AIDS educators.
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Primary schools' involvement
Through the training of ToTs, the Project managed to initiate a malaria awareness and control extra-curriculum activity through participation of primary school children. This will be sustained within the target schools, and hopefully, the Ministry of Education will use it to scale up to other schools in the district and beyond. Through the data obtained from the pre- and post intervention tests it was evident that the project had a notable impact on the children's knowledge base on malaria. Specific achievements included:

- 6 Teacher TOTs trained per village;
- Extra-curriculum malaria activity for local primary schools developed;
- Teacher TOTs assisted in developing Action Plans; Primary class 6 children trained for a period of 6 months.

Assessing behavior change
A process was put in place by TOTs for continous monitoring of progress of activities of the action plan, by researchers, schools and the community. Project team members made periodic and planned visits to schools and villages, sometimes to coincide with ToTs active training and environmental cleaning. Brief progress reports and review workshops with the entire group of trained ToTs provided feedback and sharing. It was also generally agreed that participation at the Malaria Day would be come an annual event in the study villages.

3.3.4 Fulfillment of objectives
All the objectives/activities and outputs under this objective were fulfilled apart from one, producing a PhD on social and gender issues associated with Malaria.
PhD candidate had to defer registration due to onflicitng work schedule.

3.3.5 Outputs and dissemination
Formal brochures on malaria were drafted during Mwea Phase-II. Information contained in these included key scientific findings, and documented and verified information on malaria and malaria vectors in Mwea. The two types to be produced during the project and in follow-up activities were to include: i) fact sheets of a general nature with a wide appeal in schools and in the community; and, ii), scientific information disseminated to government departments and other technical stakeholders. The latter document will be submitted as a separate Output during submission of the present final report.

4.4 Specific Objective # 4:

To conduct research on agronomic and socio-economic feasibility of seasonally alternating rice cultivation with soya bean as an agro-ecosystem strategy for enhancing household incomes and reducing malaria vector breeding habitat

4.4.1 Introduction

During phase I of the Mwea Project, various observations were made regarding the prevailing farming systems, their possible links with malaria and the socio- economic status of the local community. The research findings indicated presence of malaria risks associated with irrigated farming practices. There was a significantly higher vector population in the irrigated villages compared to the non-irrigated. This was attributed to the prolonged (essential and non-essential) flooding of paddies which encouraged continuous breeding of the vector. The results further showed high levels of poverty (a constraint to good health) and poor nutrition in the local community. Vital resources (land, labour, water) were left idle during the off-season for rice growing. Other work in Mwea indicated declining soil fertility resulting in lower rice yields due to steady depletion of soil nutrients by continuous mono-cropping of rice.

The above findings reflected poor habitat management in the irrigated area which if improved would positively impact on the health and economic status of the local community. This led to designing of Objective 4 of Mwea Phase 2 studies. Research would be conducted on feasibility of alternating rice cultivation with soyabean as an agro-intervention strategy for increasing household incomes, enhancing nutrition and reducing the malaria vector breeding habitat.

4.4.2 Rationale

The justification of choice of soyabean-rice cropping system was based on the following reasons:-
i) Improved habitat management – soyabean, a dry land crop has potential to mop up surface water and reduce vector breeding sites. This crop can also stand some degree of water logging as may sometimes be found in black cotton (clay) soil. Soya bean matures early and this would allow it to fit in during the off-rice growing season (long rains) when it can efficiently utilize the rain water resource while saving on irrigation water. No rice is grown during this idle period to avoid exposure to cold weather in May-July, a phenomenon which negatively affects grain filling and extensively reduces yields.
ii) Economic empowerment – extra annual income from soya bean sales would translate into better affordability and improved access to family health needs such as purchasing of treated nets and drugs.
iii) Increased soil fertility and improved structure – soyabean being a grain legume crop has ability to fix nitrogen through *rhizobium* bacteria in the root nodules. Savings on inorganic nitrogen fertilizers would translate to higher purchasing power (as above) and so would reduction of labour costs due to improved workability of the clay soil.
iv) Better Nutrition – the high nutritional value of soyabean and its products when consumed within the household would boost the health and immune status of members especially vulnerable groups like children, elderly and the sick. If soya is processed locally for oil production, a high protein livestock cake is produced which can be commercially sold and fed to local livestock.

From the foregoing alternating soyabean with rice if proved feasible, would give unique advantage of economically empowering communities for better health and enhanced quality of life, hence progress towards attainment of Millenium Development Goals (MDGs). Upscaling of soya cultivation to a scheme-wide (macro) level would have merit over other micro habitat management measures and could aptly complement other vector control interventions in the irrigation scheme..
It was considered important that agronomic studies be conducted to establish the suitability of soyabean crop in MIS, identify the appropriate varieties, the best husbandry practices, the yields and the production constraints thereof. Similarly, it was imperative to conduct economic studies to determine the marketing and profitability of the crop. A major incentive to farmers to grow soyabean would be availability of market and attractive prices that would yield a reasonable profit.

4.4.3 Methodology

The methodology for achieving specific objective #4 in Mwea Phase-II project comprised of conducting studies on agronomic and economic feasibility of alternating soyabean with rice cultivation in Mwea. Sampling of larval anopheline mosquitoes was also undertaken in experimental plots. The following sections summarise the methodology:

Community and dissemination meetings: These were held to sensitise the local people and stakeholders on the rice-soya production system, assess interest and collect other relevant information. Training and dissemination days were held to train communities on cultivation of soyabean, home preparation and utilization methods, and to exchange information on preliminary research findings.

Agronomic, marketing and economic feasibility: Experimental on-station trials were conducted to collect agronomic (crop performance) data and compute gross margins for the same. The agronomic feasibility study was conducted by a post graduate (PhD) student on-station. For the economic and marketing study, structured questionnaires were administered to farmers, processors and marketers of soyabean locally (in Mwea) and nationally. This marketing study was done by an agricultural economics consultant.

GIS Mapping: Mapping using Geographic Information Systems (GIS) was done in the entire irrigation scheme to show prevailing rice production patterns both spatially and seasonally. It was aimed at establishing the main rice crop and ratoon crop patterns, fallow periods and show areas cropped by tenants and outgrowers. The maps were also required to show the water supply regime to the different sections and units in the scheme and hence reflect periods of essential and non-essential flooding. The latter occurred when paddies were left idle but flooded awaiting rotavation, or during fallow periods when long rains water collected and similarly kept the fields submerged. These patterns were broadly expected to show the general management of this irrigated habitat and point at optimal periods where soya could fit in within the annual cropping cycle of the scheme. This would give indications of the scope for soya to dry up the land, reduce vector breeding sites and hence help control malaria.

Vector Control: Entomological studies were incorporated in this study to evaluate the ability by soyabean crop to mop up remnants of surface water following a rice crop and hence capacity to prevent vector breeding during the crop growing cycle. Vector assessment was conducted in the various treatments of the agronomic trials above.

Action Plans for Field Trials: The final level of activities was to develop action plans for farm level trials of rice-soyabean production in Mwea. This was done after obtaining results from the studies above and guided especially by the positive outcome of the agronomic and economic feasibility studies. The action plans were presented and discussed during the soya dissemination day as a way forward during the post-project period.

4.4.4 Results

Awareness creation meetings

The village sensitization meetings on the project were well attended and the general response to proposed soya cultivation was positive. A few farmers in the two irrigated villages recalled their experiences with the JICA pilot project and lauded the soil fertility benefits which were manifested through exceptionally high yields when a rice crop followed a soyabean crop. Some farmers who got high yields of the latter crop were satisfied with the economic returns but a few who obtained below average yields felt they would want to grow it if prices were attractive enough to realize a reasonable profit. It was clear that some of the farmers had not mastered the husbandry practices that were needed for production of high yields and would require further training if the crop were to be introduced. On the whole, the community was excited with the idea of a second crop that would yield extra income above that of the one rice crop per year grown by a majority of the farmers (the tenants). A second crop cycle would also utilize idle labour during the off season for rice. For most of the participants, knowledge gaps were not only identified in the areas of production and marketing but also in domestic utilization and nutritional benefits of the legume pulse. A few mothers said that soya bean products had been recommended by some CBO's for feeding young children but they were skeptical since other local sources were of the opinion that the grain caused cancer, which was actually misinformation. This was a good indication of the need to educate the community on the attributes of soyabean and the right methods of home preparation and utilisation.

Training and Dissemination Days

The midterm field-day was attended by 100 farmers who were taken through the steps of growing soya covering all practices from seed to seed.

The training and dissemination day at the end of the project (28/4/06) became the highlight of the soya studies amongst the local communities and was attended by seventy five people. Those attending included the Training of Trainers (TOTS) group from the study area (previously trained by the project as community health workers), village elders, local farmers, representatives of organized farmer groups, local stakeholder institutions, MIAD technicians and the project research team. The TOTS were both teachers in local primary schools and trainers from the study villages.
The participants showed a lot of enthusiasm on the soya presentations the whole day. The practical sessions aroused a lot of interest especially the home processing and preparation of different soya products followed by the field demonstration on soya cultivation.

The soya processing and products demonstrated were:-home treatment of the grain, making wholesome soya flour, different soya snacks especially roasted and deep fried, soya cake, soya milk, tea and soup, soya meat and sausages, and weaning diets for young children. Mixing of soya products especially blending flour with other foodstuffs was also shown. The participants observed the preparation of these products, asked questions and made notes. Women were particularly excited and said how they appreciated and benefited from this demonstration which they would apply in their own homes. They were grateful to the project for mobilizing and facilitating the District Nutrition Officer to go and train them on all these methods of soya utilization since they had no capacity on their own to access this form of education. The nutrient composition indicated that soya was rich in protein (36-40%) and oil (18-20%) mainly poly-unsaturated fatty acids, hence ideal for building the body, for energy and other protective metabolic activities. It was highly recommended for the young, the elderly and the sick especially people with HIV/AIDS.

The field session was highly educative to the participants. A healthy and thriving soya crop growing in the field was the main focus. All the cultural practices for soya cultivation were explained and the many questions raised by farmers were answered. Several farmers said they would immediately plant soya while representatives of two groups already growing soya appreciated the learning which they would practice on their farms. The latter farmers were led to growing soya from information earlier obtained during the previous field day. Action plans for soya field trials were also presented in this forum mainly to solicit technical and financial support from stakeholders that would facilitate implementation of these plans by farmers.

Rice-soya agronomic Feasibility

The Soya-rice system was found to be agronomically feasible through assessment of the following parameters:-

- Crop yields – Soya and rice
- Soil fertility – Nitrogen content
- Soil organic matter - influencing soil structure
- Gross margin/income - from soya and rice crops

Results of the agronomic studies showed positive effects on soil fertility improvement from growing of soya bean followed by a rice crop. This was clearly demonstrated when the soya-rice treatment was compared with rice-rice and fallow-rice treatments (Table 1). The fertility response trial showed that rice grown after the Soya crop (EAI variety) compared with that of rice-rice treatment gave a significantly ($p<0.05$) higher yield (5531 vs 4667 kg/ha), the difference being 884 kg/ha equivalent to 11bags/ha.

Table 1: Fertility Response Trial

Fertility source	Rice Grain Yield(Mean, kg/ha)
EAI (Soya)	5531a
BOSSIER (Soya)	5345ab
FALLOW	5117bc
RICE	4667c

The extra rice yield translated into additional profit for the farmer. Soyabean like other legume crops is able to fix nitrogen through *rhizobium sp*. bacteria in the root nodules. The soya crop performed well during the cold long rains season (April-July) when the temperatures were unfavourable for rice growing.

The soya-rice production system showed substantial economic benefits annually (two seasons) resulting from both crops . These were quantified to represent direct monetary benefits accruing from soya produce sales and the indirect benefit of extra rice yield induced by residual fertility of the preceding soya crop and translated into cash income. The gross margin analysis from on-station trials indicated multiple benefits in the annual cropping year, associated with Soya cultivation as follows:- Kshs 18,000 /acre from direct Soya yield (700 kg/acre @ Ksh. 50 = Ksh 35,000; production costs = Ksh 17,000/acre) and additional Ksh 8,500 as the quantified value of marginal increase (340 kg/acre @ Ksh 25) in subsequent (after Soya) rice yields. The benefits therefore translated into considerable total profit (Ksh. 26,500/acre) annually for the farmer. There were positive effects on not only soil fertility (via increase in soil nitrogen) but also on soil structure due to increase in organic matter. The latter caused easier working of the normally sticky, black cotton clay soil and land was just leveled after soya growing using light equipment. This reduced the cost of land preparation activities, adding to total monetary benefits resulting from soya cultivation. The data on actual nitrogen and organic matter contents will be concluded when all the soil sample analyses are finalized.

Rice-soya marketing and economic feasibility

The gross margins per hectare for the second rice crop (i.e. after soya) and soyabean were compared and were Kshs 38,160 /ha and Kshs 40,932 /ha, respectively. The benefit-cost ratios (BCR) were 1.59 and 2.70; yields were 3,324Kg/ha and 2,409Kg/ha; and, prices were Kshs 31/kg and Kshs 27/kg for rice and soyabeans respectively. From these, it was clear that second rice crop was more yielding and the farm gate prices were higher than those of the soyabean. However, the gross margins were less than those of the soyabean and the BCR was lower. This implied that even though the second rice crop was higher yielding and sold at higher prices, the associated costs of resources were too high, probably due to over employing of resources. This finding tallied with an earlier finding that all the resources used in production of second rice crop were inefficiently allocated and technical efficiency of rice double- cropping was only 68%.

These findings are important in clarifying that soyabean should not be introduced in MIS as a substitute to rice production but rather as a complementary break-crop. Rice production was more yielding and more profitable than soyabean. In 2004 it was found that a single crop of rice in a year had yields of 4,509Kg/ha and gross margins of Kshs 42,695 /ha which are far above those of the soyabean. Therefore caution should be taken while championing the crop to MIS farmers to use it as a break-crop and not as a substitute to rice farming.

Broadly and in a summarized form, results of the above study showed that soyabean production had increasing returns to scale while second rice crop production had constant returns to scale. The latter was found to be more yielding but with lower benefit-cost ratios and less gross margins. The study recommended the introduction of the more profitable soyabean as a break-crop to rice in Mwea Irrigation Scheme.

Soyabean production would require provision of capital and modern technology as a package and the study recommended the provision of credit facilities to farmers to enable them access such inputs. Local soyabean production was only meeting 5% of domestic demand, the rest being met through imports. The huge imports of raw soyabeans implied that there was market potential of the product locally and the government should protect domestic production by setting appropriate duty levels on imported soyabean. Soyabean marketing margins were different from marketing costs reflecting inefficiency in the market performance. This implied that soyabean farmers did not receive their due share in the final consumer price. The study thus recommended an organized marketing for soyabean in MIS such as farmers' cooperatives to improve the bargaining power in the market. It further recommended a processor-grower vertical integration in form of contract farming in MIS to ensure sustainability of soyabean production and an assured market.

These recommendations showed there was a lot of hope for soya growing in Mwea in view of the big demand nationally but only if marketing and the distortions thereof were streamlined, to allow farmers get the right price for their crop. It was apparent from the processors' side that they needed assured bulk supplies like they currently and consistently obtained from importation. But this would be a great opportunity for Mwea farmers to organise themselves corporately to respond to this challenge and position themselves for higher collective bargaining in terms of better farmgate prices. This information would go a long way in sensitising any interested stakeholders who could help organize the scheme this way for both bulk production and marketing.

Vector Control

The Soya-rice system was found to be effective in vector control by eliminating the vector (larvae) in the soya treatment plots compared to rice-rice and rice-fallow system. Soya bean crop (planted in ridges) effectively mopped up surface water hence showing no evidence of mosquito breeding while the rice plots had high larval scores followed by fallow plots. The latter two treatments represented the typical production systems practiced by farmers in Mwea. Soya bean cultivation alternated with rice crop therefore had potential capacity to reduce vector population and hence play a significant part in malaria control.

Mapping

This captured various features of the Irrigation Scheme (Table and Maps below), key amongst them being:

- i) The 5 sections of the scheme
- ii) The tenant and out-grower areas
- iii) Acreage covered under ii) above
- iv) Annual water supply regime to the different units under ii) above
- v) Rice cropping programme of 2005-2006 with details of water supply, land preparation, planting, husbandry practices and harvesting.

The above features in various maps helped depict the periods of necessary and unnecessary flooding and hence demonstrated where soya cultivation could fit in to reduce the latter.
The out-grower units covered about one quarter of the total irrigated area but were mostly set outside the scheme boundaries. This category could be encouraged to crop their fields with soya after harvesting their rice in March. Similar farmers inside the scheme operate on small parcels adjoining the tenant farmer plots and follow the crop regime of the latter for the main crop. However they also

grow a second crop (from seed) in January to April, a practice found to be sub economical in earlier studies. This group could go for ratoon crop after the main crop, followed by soya in a similar pattern to the tenant farmers. The ratoon crop by tenant farmers lasts between January and March after which land is left fallow awaiting rotavation between April and July. This is the long rains season and is too cold for rice growing. Due to inefficiency of the land preparation activities fields are left flooded throughout this period (table above) and hence continue to encourage vector breeding. This is the season targeted for soya growing. Soya being a dry land crop would break the vector breeding cycle by mopping up excess water, improve the soil structure from increased organic matter making it easier to work the soil and hence improve efficiency of land preparation for the subsequent rice crop. This would leave the entire scheme dry and hence vector free for about three months.

Action Plans

These were developed based on the results of the other components of this study. The action plans were shared between the project team and stakeholders during training and dissemination day (earlier covered). The field trials would provide an intermediate phase between on-station trials already done and full scale adoption of soya cultivation scheme-wide. The on-farm trials would further provide an opportunity to facilitate soya technology transfer and dissemination via the contact farmers involved in the trials. Many farmers volunteered to get involved in the field trials but only about 10 names were provisionally taken per village. This was due to the fact that the farmers were also hoping to be supported not just technically but also financially during implementation of the on-farm trials. Although the research station of MIAD was ready to provide soya seed at a cost and partly disseminate information on cultivation practices, there was no immediate sponsor for financial assistance. This would make it difficult for these very willing farmers to start but it was hoped that by and by a sponsor might become available.

The conceptual framework envisioned in implementation of soya cultivation in MIS was presented on dissemination day as follows:-

- 1. Research – Current component (alongside others in the Ecosystem Approach) by ICIPE Project
    - i) On-station Soya-Rice Trials (Crop performance, Soil fertility, Economics, Vector assessment)
    - ii) Economic feasibility (Market study, profitability)
    - iii) Mapping – Projections on scope for habitat management especially for vector control, using Soya in MIS & adjacent outgrower areas
    - iv) Action plans for field trials (Volunteer farmers)

- Field Trials – Would assess crop performance on-farm
    - - Volunteer farmers – To be Contact Farmers for field trials and demonstrations. Would play central role in dissemination of soya farming to neighbourhood communities.
    - - Already registered 10 farmers per village
    - - Provide Research-extension-farmer linkage
    - - Require Institutional support:- – Technical, financial, marketing, processing, utilization and related information
    - - Stakeholder institutions that could offer support - NIB/MIAD, MoA, MoH, KARI, NGOS, CBOs

- 3. Scheme-wide Soya cultivation: – Upscaling from successful field trial phase
  - Long term objective. Success of this phase to be determined via popular scheme-wide adoption and sustainability of soya farming.
  - Would largely depend on socio-economic factors - market and profitability.
  - Improved habitat management scheme-wide expected to reduce vector breeding and economically empower local communities for better health.
  - This component to be integrated with other current measures for effective malaria control.

4.4.5 Conclusion and Recommendations

It was evident that alternating rice mono-cropping with soya crop was highly beneficial with respect to increasing household incomes, enhancing nutrition, replenishing soil fertility and improving vector control. This farming system if adopted scheme-wide would go a long way in improving the habitat management of the Mwea Irrigation Scheme and positively impacting on health and economic empowerment of the local communities. The dissemination process especially through field trials would continue to ensure that farmers were well grounded in soya cultivation and facilitate wider adoption of the soya-rice system. IDRC could help in financially supporting implementation of such field trials as shown in the Action Plans. Technical and any other support from local stakeholders, NGOs, CBOs and Extension and Research agencies eg MOA, KARI, MIAD, and MOH/ CBNP would similarly go a long way in ensuring success and sustainability in adoption of soya technology. Presence of MIAD in the project was a valuable asset as farmers could continue to obtain soya seed and information from this research station.

5. Specific Objective #5 : Summary only (details covered under specific objective 1-4)

Disseminate information across all levels

This objective had four activities: (i) an area-wide consultation workshop at the beginning of project to review objectives and share views with the community and other stakeholders; (ii) involvement of the media to take place during Malaria Day; (iii) production of a project brochure, summarizing the process and results of the project; (iv) Conduct a participatory evaluation workshop at the end of two years to assess the impact of the project. All these activities were achieved and have been covered in more detail in the preceding sections (specific objective 1-4).

Dissemination of project information adopted different strategies to create awareness to a large number of stakeholders as well as creating visibility of project results. The methods involved:

- Quarterly reports-combining all specific objectives;
- Training of the research team in ecosystem approaches to human health;
- Stakeholder workshop, through which the project was launched in July 2004;

- Village-level awareness and planning meeting;
- Training of Trainers (ToTs) who were to take lead in community and school education;
- End of project participatory evaluation;
- The Malaria Day Event

As are result of the dissemination activities:

- A large number of people in the study villages and local organizations became fully aware of the project;
- The level of knowledge on malaria among the community and school children increased;
- The project initiated a potentially-sustainable process of consultation and cooperation among the community and various other stakeholders including government departments, particularly the ministry of health.
- Overall, there was an increase in knowledge and awareness regarding malaria transmission and control, leading to increased community and other stakeholder participation in various interventions.

6. PROJECT MANAGEMENT

The Memorandum of Grant Conditions (MGC) for Mwea Phase-II project was signed between IDRC and IWMI in February 2004. The disbursement of the first installment of funds from IDRC to IWMI was in March 2004, while the corresponding transfer of the relevant operational and staff-time funds from IWMI to the implementing institution, International Centre of Insect Physiology and Ecology (ICIPE), was effected in May 2004. Consequently, the two-year period for actual implementation of project activities spanned the period May 2004-May 2006. However, the project was granted a no-cost extension to 19th August 2006, in order to allow for the completion of dissemination activities still pending as at May 2006.

IWMI was therefore the Recipient Institution of the grant from IDRC, while the Participating Institution responsible for the implementation of most activities was ICIPE. University of Nairobi was the third collaborating institution, through the departments of animal production and community health. The collaboration among the three organizations constituted a key activity of the IWMI-hosted Systemwide Initiative on Malaria and Agriculture (SIMA).

Overall project leadership was by the SIMA Coordinator, Dr. Clifford Mutero, based at IWMI's office in Pretoria, South Africa. Dr. Mutero participated in the project through regular visits to chair project meetings in Kenya , and frequent email communication with the Project Facilitator in Kenya, Dr. John Githure, who is the Head of Human Health Division at ICIPE. Dr. Mutero was also responsible for collating the project reports and forwarding them to IDRC. In order to ensure that Dr. Mutero and IWMI were represented in day-to-day operations in Nairobi, IWMI generously seconded Ms Gayathri Jayasinghe to the project from mid 2005. Ms Jayasinghe also served as a substantive research team member in her capacity as a biometrician.

Project coordination and management at ICIPE was organized at two levels in order to handle decision making and actual operations in the field. An informal Steering Committee (SC) was formed comprising of research team members: Dr. John Githure as Project Facilitator and Chair of monthly and ad hoc project meetings; Ms. Charity Kabutha (in-charge of specific objectives 1 and 5); Dr. Josephat Shililu (specific objective 2); Prof. Violet Kimani (specific objective 3); Dr. Lucy Kabuage (specific objective 4); and. Ms. Gayathri Jayasinghe (Data management). The SC had the following tasks:

- Evaluate and ensure project objectives and activities were carried out, and decide on corrective actions where necessary;
- Liaison with the Ministry of Health and other stakeholders involved in malaria research in Mwea Division;
- Participate at monthly meetings to review progress and quarterly work plans.

The Project Facilitator was responsible for organizing logistics and liaising with the Finance Dept for the Financial reporting and with the Research team for the Technical reports. The Research Team comprising of 'the specific objectives' leaders and data manager were responsible for the day-to-day coordination of the progress of the project by ensuring the objectives were met. They were also responsible for the recruitment of village field assistants who worked full time on the project. Each of the 'specific objectives' leaders was also responsible for timely delivery of quarterly progress reports of his/her objective to the Project Facilitator.

The model used for project management involved the hiring of the UON researchers and one consultant as part-time staff of ICIPE, in order to facilitate administration and logistics including, payment of monthly honoraria. This model was effective in ensuring that all the activities were implemented in reasonable time. It also provided the many stakeholders involved in the project with an organization – ICIPE, that they could approach in connection with any issues they would have liked to discuss.

However, the non-ICIPE senior staff often expressed frustration at what they perceived as ICIPE's lengthy internal processes, particularly regarding disbursement of funds for urgent activities, and occasionally the payment of monthly honoraria. ICIPE's Human Health Division also lacked a mechanism to promptly resolve conflicting demands for logistics among projects funded by different donors but concurrently implemented by the Division in the same study sites. Efforts to integrate logistics for the IDRC-funded project with one funded by another donor seemed to unfairly favour the latter. In future joint activities, the non-ICIPE research team members would prefer to have funding for most of their needs channeled by IDRC directly through their respective departments at the university.

Finally, the project was accomplished within the budget provided and there was no major re-allocation that had to be done. IDRC however allowed savings on certain operations to be used to compensate some staff-time for IWMI staff (C. Mutero and G. Jayasinghe). The two team members were largely funded for their involvement in the project from IWMI core resources. IDRC's disbursement of project funds was timely and facilitated smooth implementation of various activities.

7. IMPACT

Mwea Phase-II effectively met the dual objective of integrating research with development. Examples of both reach and impact were evident at the end of the two-year period. In the first instance, community and multi-stakeholder participation in malaria control activities increased significantly compared to the time when Mwea Phase-II came to an end in 2003. Cooperation by the community was boosted by the distribution of the long-lasting insecticide treated nets as a means for immediate relief from mosquito nuisance and malaria among residents of the study villages. It was comforting to note that the most dramatic positive difference occurred in the poorest village, Murinduko, where malaria parasite prevalence among children dropped from 38% to zero. Additional enthusiasm in the project was evident in the participation of primary school children in various activities including the Malaria Day event. The many village assistants and community health workers enlisted in Mwea Phase-II also contributed to the community's enhanced sense of project ownership.

The impact of Mwea Phase-II manifested itself in various ways evident among the different participating institutions. The Ministry of Health recognized the important role the project had played in mobilizing communities and other stakeholders in Mwea. Towards this end, MOH enlisted the support of the project in promoting greater participation in malaria control, culminating in the 2006 Malaria Day event.

Furthermore, the National Irrigation Board (NIB) viewed Mwea Phase-II project as a good opportunity for renewing NIB relations with the Mwea farming community, particularly through the activity of alternating rice with soya. NIB took great interest in both the malaria control and economic dimensions of Mwea Phase-II. The rice-soya research at the NIB experimental station also attracted a great deal of attention from other institutions. For instance, one Centre of the Consultative Group on International Agricultural Research (CGIAR), which was not involved with Mwea Phase-II, approached NIB towards the end of the project for collaboration to further advance research on soya production in Mwea.

Still at another level, ICIPE, University of Nairobi, and IWMI, all significantly strengthened their capacity for transdisciplinary and participatory research related to human health. Following the success of the earlier IDRC-funded Mwea Phase-I, ICIPE brought other projects on board in Mwea, which were firmly built on knowledge and goodwill acquired during both Mwea Phase-I and Mwea Phase-II.

8. OVERALL ASSESSMENT

Mwea Phase-II was successful and fully justified the investment of time, effort and funding. Being a follow-up to the earlier two-year Mwea Phase-I, the project also overcame a general concern expressed by other SIMA projects without a definite phase-2 component, that: 'participatory research naturally raises expectations for long-term partnership and continued partial-support among communities, researchers, and other stakeholders'. Apparently research involving an ecosystem approach would need to be continued over a period of at least 4-5 years in order for sustainable interest and possible impact to be evident among the various stakeholders. Mwea Phase-II brought the working relationship initiated during Mwea Phase-I between the community, research partners, and other stakeholders to a point where each group clearly appreciated its role and had rational expectations from the collaboration.

9. RECOMMENDATIONS

IDRC should consider extending its support for SIMA's ecohealth research and malaria intervention in Mwea - for at least another five years. Doing so will allow implementation of the current action plans by the village communities, and researchers, and also facilitate the monitoring of multi-stakeholder participation, and track impacts. Continued IDRC support will also make it possible to exhaustively document and widely disseminate the most comprehensive assessment possible. Ultimately Mwea could be presented as a truly success story in the application of an ecosystem approach in controlling malaria, and generally improving human health in a rural area of eastern Africa. This would be considerable achievement for all concerned, especially if the project clearly demonstrated that ecosystem approaches to malaria control were feasible and effective, without having to resort to a controversial chemical like DDT, which has recently been recommended for indoor residual spraying in malaria endemic areas of Africa.

10. APPENDIX:

The following scientific outputs have been forwarded to IDRC under separate cover, pending the completion of several others, particularly journal publications:

10.1 Draft journal and other scientific manuscripts

i) Malaria vector control practices in an irrigated rice-growing scheme: The case of Mwea in central Kenya -- (*P.N. Ng'ang'a , J.I. Shililu, C. Kabutha , V. Kimani, L. Kabuage, G. Jayasinghe, E.W Kabiru J. Githure and C. M. Mutero*) .

ii) Community's Knowledge and perceptions about malaria transmission and bednet use in a rice irrigated scheme in Central Kenya: implications for malaria control -- (*P.N. Ng'ang'a , J.I. Shililu , C. Kabutha , V. Kimani, L. Kabuage, G. Jayasinghe, J. Githure and C. M. Mutero*).

iii) Economic assessment of some aspects of production and marketing of soyabean as a break-crop to rice monocrop in Mwea irrigation scheme – (*J.N. Kuria et al.*)

10.2 Research instruments

i) Training teachers as facilitators of malaria control activities in primary schools.

ii) Training of community trainers (TOT) in malaria control

iii) Action plans for rice-soya field trials, from researchstation to the farm.

iv) GIS mapping of the Mwea Tebere irrigation scheme

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