

Deriving from IDRC Consulting Contract Report **103694**
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Evaluation Report

DOCUMENTING OUTPUTS, OUTCOMES AND LEARNING
FROM ECOHEALTH PROJECTS: COMMUNICABLE DISEASES

Malaria in Africa Ecohealth Projects

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October 2007

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1. Introduction

A group of five Ecohealth projects under the general theme of Malaria and Agriculture have been supported in East and Central Africa. Historically they arose as part of a CGIAR initiative, and while one that arose earlier was supported through two phases of research, the others were funded to carry out baseline work. An extensive review of this whole initiative was carried out for IDRC. The field projects not only had an individual validity and interest as studies of the interaction of agriculture and malaria under specific environmental and farming conditions, but they also had a natural coherence and constituted an Ecohealth Research Programme.

To fit the needs of the Communicable Diseases Review that aimed to document outputs, outcomes and learning from Ecohealth Projects, this selection of material from the larger review has been made, with a Project and Programme focus. Issues of networking and of administrative structures for the future have been omitted, not of course because they were unimportant but because the projects have validity as such, and also there are potentials for the future development of research on Agriculture and Health more broadly using them as well-documented sites with well-motivated staff and with potential for research capacity development as well as for research on malaria control in relation to African agriculture

2. Assessment of Five African Malaria and Agriculture Projects.

The projects are described and assessed individually. Because they in reality constitute a research programme there follows a trans-project summary addressing some of the key questions in the terms of reference. Some other key institutional aspects of the projects are then analysed comparatively and conclusions drawn. Because the work was commissioned by IDRC there is an emphasis in the projects review on the role of IDRC, although other agencies, particularly IWMI, very much determined the context within which they operated.

In evaluating the specific projects there are many aspects that have to be taken into consideration: the degree to which they bring malaria and agriculture together; the way in which they tackle the environmental and ecological aspects of malaria and its control (the 'Eco' in Ecohealth); the emphasis in methodology upon transdisciplinary working, equity and community participation; and the actual advancement of science, public policy and the health of communities achieved by the work. When listed in this way it is apparent that the research workers are attempting many things at the same time, with budgets that would be considered by most funding agencies as very restricted.

It is also necessary to bear in mind that, with the exception of the Mwea site, which has received four years of funding for two phases of the project, each project has been funded for two years of baseline research, much time has been spent on building up relations with communities and other stakeholders, and therefore the review is looking at the initial descriptive phase of the work, about a year of field data collection, at each site. At this stage one would usually be simply monitoring progress in a project and the first major evaluation would come 4-5 years into the projects (e.g. as in the large Swiss NCCR Programme which has similar methodological approaches and concerns, though different research objectives).

At the present stage of the work (except in Mwea) one can therefore:

- assess the particular features of each site and its appropriateness for in-depth work on malaria-agriculture interactions and likely capability to yield useful results,
- consider the objectives of the research and aspects of the objectives that can be tackled by cross-sectional surveys,
- observe the team that has tackled the baseline work at each site and the various reports they have provided, and
- review their methodology and see how far the results so far provide a base for an intervention or intervention trial phase, for ongoing applied work, and for building capacity at all levels
 - in ecological and environmental aspects of malaria and agriculture,
 - in intersectoral work,
 - in Ecohealth and
 - in transdisciplinary research.

In practice we are also able to assess actual research capacity building in Ecohealth as this has progressed rapidly in several projects.

i. Kenya: MWEA

Mwea has a special place in the series of SIMA projects. It is older than the others and in many ways the archetype. Here Clifford Mutero first applied the Ecohealth approach, having reached a similar position as a result of his own experience. The Mwea project was always at least one phase ahead of the other projects. Moreover Dr. Mutero and the Mwea staff advised those developing the other projects. It is also the only project that has been in action long enough to have a series of published outputs and where the work has really developed far enough to be usefully evaluated. A good deal has been achieved and written up.

Mwea is a large irrigation scheme, primarily directed towards rice cultivation but also supporting a substantial cattle population. It therefore combines two major aspects of the interaction of agriculture and malaria: irrigation and livestock. Because the local malaria vector is the more zoophilic member of the *An. gambiae* complex, *An. arabiensis*, the interaction of livestock, which provide alternative blood meal sources for the mosquitoes, and irrigation water that facilitates year-round breeding of the mosquitoes, provides an interesting ecosystem for malaria transmission.

The first phase admirably studied all the likely determinants of malaria in the four villages, giving a multidimensional picture of the process. However, the design, with limited resources, is inadequate to determine the relative roles of the different factors involved. Because there are only four villages in the study, and many of the variables are at community level, the sample size for two of the most important suspected determinants is one (a single village for each possible combination of the attributes rich/poor and irrigated/not irrigated).

Therefore, the key issue for which Mwea is widely known: the inverse relation of livestock keeping to malaria, is far from proven. The change in mosquito density is but weakly associated with an undramatic gradient in cattle-keeping, and as a possible intervention this has not been followed up. The original principal investigator would like to see a change in the irrigation scheme rules, permitting

as lawful the keeping of livestock, particularly cattle. But the data are scarcely adequate to act as a basis for policy in this way, and in any case the ban on cattle is openly flouted on a large scale and is probably dead.

The second thrust, reducing the duration of standing water in the rice fields, does not link closely to the rather clear inverse relation of mosquito density and malaria prevalence. In particular, the highest malaria prevalence was in a village far from the irrigation area, so that it is far from clear how mosquito reduction within the formal irrigation scheme will impact the malaria problem. Murinduko is indeed not far from surface water, but that is not part of the irrigation scheme. The question then arises as to how far the inhabitants for this poor and unirrigated village, Murinduko, come into contact with the irrigation scheme. Since those who live on the scheme must surely be more in contact with the local ecology, and yet are found to have a much lower malaria prevalence, there are questions about the sources of local transmission. That the village clean-up operations have been accompanied by a massive fall in prevalence in Murinduko suggests that there might have been local breeding of vector anophelines. This requires further investigation. The observed differences between the villages in malaria initial prevalence rates are far from trivial.

The work so far has shown large local differences in malaria prevalence, has described the complex environmental and social dynamics possibly causing these differences, and has apparently shown that community-based activities can reduce the malaria level where it is high. These findings are important but only indicative. If these findings are to be more widely applicable, and if we are to understand what are the key components needed to change the malaria levels, it will require larger scale studies and community randomized trials of interventions, as much to understand the biological and social system as to measure the success of the interventions.

Draft publications on community aspects of knowledge about malaria and bed net use, and about vector control practices have been prepared. The descriptive material is useful, but the analysis does not yet focus on the key questions that need answering if transferable findings are to emerge from the work.

There are three main issues that arise in relation to future work. First, there can be little doubt that major contributors to the success of the project have been the numerous, committed, and dedicated inputs by the senior project staff. This is as it should be, but it raises questions of appropriate inputs for scaling up the various interventions, and the need for estimates of their cost.

Second the pre-intervention prevalence data show a major difference between the village remote from the irrigation scheme (38%+) and other villages (<2%). Moreover there was a dramatic fall to zero after bed net introductions. Surely this needs both confirmation and explanation.

Third, a difficulty with the otherwise admirable Ecohealth practice of collecting large amounts of contextual data is that highly important findings are sometimes not followed up and rigorously tested, because the burden of descriptive data is so great. Obvious ways of taking this forward are to look at other neighbouring villages, to collect incidence data as well as prevalence, to push both the vector abundance/malaria scarcity and the cow abundance/malaria scarcity hypotheses much harder: we really need to be sure about the answers as they may be the keys to understanding malaria in the area.

None of this is to criticize what has been achieved, but rather to emphasize the need for long enough time for these questions to be addressed. Also, so far as malaria is concerned, there is need to move into a more focused hypotheses-testing mode from time to time. This also raises problems of cost of studies of adequate statistical power when variance is between communities rather than between individuals.

ii. *Uganda I: SANGA*

The Ugandan SIMA I project is addressing malaria problems of settling nomadic pastoralists. This is a new area for research and of considerable interest. Because the process of settlement is ongoing, the topic can be addressed, initially at any rate, by a cross-sectional approach which allows controlling for many independent variables.

The research question was defined by the community in an overt manner. Over 15 years ago, the formerly nomadic Hima pastoralists of SW Uganda were put under great pressure to settle, not only by the Ugandan Government but also by the President of Uganda, who happens to be a Hima himself! Over the next decade settlement gradually took place, so that by 2002 about 40% were fully settled, a comparable proportion were static but living in the manner of nomads with slightly improved housing, and far fewer were still nomadic. The people now complained that they had done as had been requested, but the consequence for the settled group was that they had much worse malaria than the nomadic people, and that their children were dying of the disease.

The researchers suggested a hypothesis to explain the mechanism by which the people's observation could have been generated. If the chief local malaria vector were *Anopheles arabiensis*, the zoophilic member of the *An. gambiae* complex, not only could the malaria change be due to changing agriculture, there would also be a potential control measure by applying insecticide to the skin of livestock.

The Sanga project was essentially tackling a new question, which had not been addressed previously in Africa and had received little attention globally. The consequences of nomad sedentarization are not well understood, and the specific effects upon malaria were unstudied. The broader questions of zoonophylaxis have been much more studied, especially in South Asia and other areas with highly zoophilic vectors. If the initial contention by the community, that nomads who settle get more malaria than those who continue to be nomadic, had proved true, then the hypothesis that this is due to reduced deviation of *An. arabiensis* away from children by cattle was open to rigorous testing and again is relatively original as a question. The project showed that the nomads were not selectively protected; and also that *An. arabiensis* was absent from the area (or very rare). Had it been present, the proposed intervention of applying pyrethroid residual insecticide to the cattle (in place of the usually applied acaricides that the people apply weekly) would have been relatively novel for Africa. There has been some experimentation in Pakistan and the idea was mooted for use in Kenya where might also have a role in future research in Mwea.

The more general statement of the problem: 'What are the health consequences of nomadic pastoralists settling?' is of broader relevance, though SW Uganda is unusual in that settlement by

nomads who continue to farm livestock is a possibility. The *consequences of settlement, for both the environment and for the whole life of the pastoralists, are so complex that an Ecohealth approach is by far the best way to start*, as is even clearer with hindsight than it was at the start. The close interaction of the two main perceived problems of the people there, water and malaria, has meant that a whole series of issues has arisen needing study. Indeed it has been clear at each site that starting from an Ecohealth approach uncovers a vast and expanding series of questions needing investigation, posing difficult problems of resource availability for the research.

Prior to the main first phase of research, a detailed 'community diagnosis' was undertaken, involving the extended research team as well as facilitators from outside. A great deal of material was collected, using rapid rural appraisal techniques, and much effort was put into the report of this, which took up much time. There was substantial overlap of this approximate information with the more careful house-to-house socio-economic survey of over 400 households in Phase I, and the latter data were much more useful as they could be linked to epidemiological and ecological data at the individual and household level.

While with hindsight, less time could have been spent on writing up the community diagnosis, the main function of this diagnosis was to involve the community and other stakeholders, and this it did very effectively. It also brought together the various disciplines and started off the pattern of transdisciplinary work, which was crucial to the project.

The issues of gender equity were also on the table from this Phase: the LCI (local council at village level) structure already made formal provision for women to be represented, and women were not shy to make their views known in the various public meetings, though detailed gender roles gradually emerged from both the community diagnosis and the baseline surveys of phase one. A more difficult aspect of equity concerned the more complex separation of pastoralists and cultivators, a longstanding layering of society which is changing in subtle ways and is taking several years to understand.

The community diagnosis and subsequent activities involved other stakeholders in health generally and in agriculture at district, sub-county and academic levels; malaria control staff at national level were involved in the field research design and early activities and were kept informed of progress throughout. Several other funded malaria studies were about to be added to the project when the unexpected stop in IDRC core funding completely disrupted this.

The Phase I research built upon the community diagnosis, and upon a workshop where senior team members from Mwea shared their experience and expertise. Since the key research question was about the effect of sedentarization upon malaria, detailed studies of 8 villages with some 4,000 people, including nomadic, transitional and settled households, were undertaken. The pressures on time of senior staff from the (then) two Universities of Makerere and Mbarara meant that continuity of fieldwork was maintained by two of the senior research team, with intermittent inputs by several others.

Two key decisions for this phase were (i) to use MSc students in their research year to be the core of the field survey activities, and (ii) to base the research in a previously derelict research station at Sanga in the centre of the project area. Although shortage of resources prevented this being done as fully as intended, residence of the students in the research centre, and the staff where possible, had the consequence of extreme transdisciplinarity. The students (veterinary, sociology, vector ecology,

molecular biology, anthropology), technicians and staff lived together for the year, (and close to the study population), and each became thoroughly conversant with each other's work to the point where external assessors felt that each student understood the whole project. *This was a particularly useful piece of serendipitous research capacity building in Ecohealth and, given some infrastructural rehabilitation, the Sanga Centre could become a residential inter-institutional research training centre.*

Also, there was daily interaction with the local administration (LC3 Chairman and others), with the veterinary extension officer, the sub-county health officer and the people of Sanga. The two final reports on Phase I were written so that the narrative report could be given to members of the local communities and the scientific report to professionals in the area. The two gaps in funding: one where the NCRST had mismanaged some funds and the other, when the funding stopped after Phase I for reasons unrelated to the project, were extremely difficult to handle, since the community felt that that the project appeared to be unreliable.

In reflecting on the first phase, all the staff closely involved felt that the Ecohealth approach had opened new doors for them, that the community felt it was their programme, and that the staff had not done things that way before. One senior veterinarian said that he realised he had not really understood the pastoral community very well before the project. The tradition in Uganda has been for very individualistic research, with a focus on the problem and study, often neither seeing the problem context nor the community. Both staff and graduate students, with 4 months of training, experience of participatory methodology, and the fieldwork, felt they knew much more about the community. In the work there had been much freer information flow with the community. They were also particularly grateful to Canadian IDRC staff and also SIMA staff who had carefully directed them to the wider picture.

People had found that the knock-down house catches showed them far more mosquitoes than they had believed could be in their houses. It was found that people did not link mosquito larvae in pools to the adult mosquitoes, so children were given larvae in a container to take home so that everyone could see pupation and the emergence of adult mosquitoes. The immediate examination of blood slides was appreciated, though the laboratory burden on technical staff was heavy. Field trials of near-patient dipstick tests had been planned to accompany Phase II, but may now have to take place elsewhere. One staff member who moved to the new Gulu University took the final reports with him to the new Vice-Chancellor and there is already a multiplier effect.

Another of the research staff, from Makerere Department of Gender Studies, also found the highly integrated way of working new and helpful. While the work had initially focused on the social impact of malaria, there were major issues of resource reallocation and vulnerability as a result of the settlement process, with moves towards mixed farming, effects of a more cash-related economy on the balance between men and women over access to resources, and effects on the family. The links between various environmental features fostering malaria and the household, and distances from household to health care facilities, are being elucidated in greater detail by a combination of GIS and the gender data.

The interim "bridging" proposal gave a full summary of the findings of Phase I with a good balance between the biological and social science results so far. The proposal for the four months is phased to cover, *first*, the transfer of the results to the community and involving the community in developing a research agenda for Phase II, building capacity for both research workers and the community; and *second*, institutional capacity building for execution of the intervention trials of Phase II. As with the

other projects, this bridging proposal is predicated on the occurrence of a second phase. If there is not to be a further catastrophic gap in activity, a rapid response will be needed. Probably an outline proposal is required now, with the details of interventions to be added as the bridging work is carried out in the field and the community makes its needs clearer.

The Sanga project is much more closely linked to a specific field facility than has been the case for the other projects. This has been its great strength. The way that all students stayed there for the baseline year was above all responsible for the highly interdisciplinary work and research capacity building. Because the IDRC project formed the core of that work, while at the same time ancillary projects, funded from other sources, were being put in place (e.g. to meet related community health needs and to do research on water policy in relation to malaria and on artemisinin treatment linked to near-patient diagnosis at both community- and facility-based levels), the abrupt removal of the possibility of a continuing phase II created substantial linked problems. Because the Sanga project was not using the facilities, they became unusable for the other linked projects. These now are going elsewhere, to mutual disadvantage.

One area that emerged as needing attention is that of HIV/AIDS, where pastoralists are severely neglected, but the project has not become involved in that area as it clearly requires continuing involvement once begun. This is an example of the kind of challenge the Ecohealth approach faces: once a community is engaged in identifying real problems, what are the ethics of a research team – and donor – backing out?

iii. Uganda II: BUSHENYI

Bushenyi District in SW Uganda is a relatively prosperous agricultural area which has in recent years had a massive increase in malaria burden. Malaria surveys of 1965-67 showed a very low prevalence and the area was classified as hypoendemic with epidemic potential. The situation is now very different, with malaria as the highest priority disease. This is part of a general increase observed in south-west Uganda, but more pronounced. It has been suggested that the increase of fishponds in Bushenyi may be contributing to the levels of malaria transmission being seen, and more generally that much of the malaria may be linked to agro-environmental change. The projects aimed to assess, in an Ecohealth context, the importance of fishpond management to malaria vector breeding, with a view to using environmental management in malaria control there. The project has a particular strength in spatial data (and GIS).

The role of fishponds in vector-borne disease, and especially malaria, is an important issue, tackled in many countries, but it is highly country-specific and within countries depends on the species of mosquitoes and local environmental features. Since the very serious increase of malaria in Bushenyi is not fully explained the project is fully justified. Moreover since rather similar studies are being undertaken in Kenya (unknown to the investigators and to the reviewers until a few weeks ago) there will be considerable comparative interest in the findings.

The project has followed the standard Ecohealth approach involving research workers from several relevant disciplines, and extensive interaction with the community and local officials. Relations with the community were clearly good in the field, partly because of material assistance to the health centre but also as a result of the regular field work. The ponds were quite numerous and several

villagers visited had developed pond systems substantially. One master's student, who had worked on the malaria economic aspect of the project, hopes to do a much fuller study on the potential for fishpond development. The roles of women were studied and it was found that malaria prevalence was significantly higher in women.

The research team suffered some disruption, partly due to the departure of the medical officer and some other staff changes. Though they were replaced with more able people at the senior level, there was perhaps a less close-knit team than on some projects. The formal administrative arrangements were carefully made.

The vector surveys showed breeding of anophelines at a variety of sites. Results in the report showed a great preponderance of *Dracaenia* and yam leaf axils as breeding sites. Small collections of water on fallen banana leaves were also important. These three sites were responsible for two thirds of all anopheline larvae found, whilst fish ponds, in the sub-county where they were common, only yielded 1.5% of the total number of larvae. A reviewer was able to see and confirm the breeding at these sites. However, the calculations relating larval yield to total area or volume of the different habitats were not seen and these data should be checked before publication. As the yams (whose leaves are used to feed the fish) and *Dracaenia* (used to demarcate boundaries) are agriculture-related, the data so far indicate a preponderance of anopheline breeding related to agricultural activities.

Such vector hazard as there is in Bushenyi from fishponds, appears to be largely due to anophelines breeding in disused fishponds. This has obvious policy implications, if this can be confirmed. Short-term interventions to stop breeding in these disused ponds can be undertaken, possibly involving a comparison of *Bacillus thuringiensis* and a chemical larvicide, to both determine practicable methods of larval control and also quantify the role of these ponds in overall malaria transmission. These should be feasible in a Phase II. The very high local productivity of small tree-hole and banana-leaf breeding sites may outweigh the role of ponds but needs confirmation. There are significant similarities between the Bushenyi results and those from other groups in Western Kenya, suggesting that the *findings so far are more than of local relevance*.

Since another outcome of Phase I is a strong interest of one of the researchers to continue with an in-depth look at the economics of developing fishponds more extensively in the area, this provides an opportunity to also study the longer-term ways to ensure that disused fishponds are not enabled to persist in the area.

The epidemiological evidence showed a high level of parasitaemia, averaging 60% in the poorer sub-county with ponds and 40% in the other. The clinical observations undertaken at the same time are seriously discrepant, with spleen rates of 2.5% and 0.8% respectively. Levels of jaundice of 11.8% were reported from the richer sub-county and are hard to believe.

Preliminary studies showed a fall in malaria incidence by household with increasing distance from fishponds (which also represent the main location for yams. Further spatial analyses are planned and should be of great interest. Observations on the duration of disease per month show what may be artefactual differences between the sub-counties.

The vector ecology, spatial analyses and work on fishpond ecology are of real interest. The socioeconomic data are harder to interpret, and with only 45 minutes per household head for completing a 16-page questionnaire there may be some misinterpretation of questions. There are

some important findings in phase I but, compared to some projects, there is less the feel that one investigator has the time to understand, critique and integrate analyses for the whole project.

The proposals for interventions follow logically from the findings of phase I, though some of them may prove more complex to implement than the investigators imply. They are also expressed in a somewhat top-down manner and may require substantial joint exploration with farmers if they are to succeed.

iv. Tanzania: MVOMERO

The interest of the project particularly derives from its agricultural base. The project is a collaboration between the National Institute for Medical Research of Tanzania, which has a particular emphasis on malaria in its work, and the former Agricultural University of Morogoro, now known as SOKOINE University. It is founded upon a longstanding acquaintance between the two leading investigators from the two institutions, and the field work is situated less than an hour's drive from Morogoro. An area has been located where a 65 km road transect passes through 6 types of agricultural production from sugar cane on a large and small scale, irrigated rice, rice and maize, through to livestock rearing, all on a relatively gentle gradient and without dramatic climatic differences. Thus the major variable is the type of agro-ecosystem and its consequences for livelihood, economy and behaviour.

The work so far has been aimed at determining the relation between agro-ecosystem type and malaria transmission and burden. The study has therefore been primarily a comparative cross-sectional survey of seven villages from the different agricultural systems, measuring the levels of malaria parasitaemia in approximately 1100 people per village on each of 4 rounds during a year, but also investigating many behavioural variables relevant to malaria and carrying out KAP studies of malaria-related topics. Vector ecology and agronomic studies were also made. The comparative approach is interesting, especially the variety of agronomic practices, and this is relatively original work for Africa. A limitation has been the single village for each system so that there is no measurement of within-ecosystem variation, but it is hard to see how this could have been avoided without a larger budget, as spreading the samples over several villages for each agro-ecosystem would have created a great deal more work and reduced interaction with each community.

Since the descriptive work is at too early a stage for specific hypotheses, it is hard to comment on the originality of the research as such. The methods are standard ones. The molecular typing of the *An. gambiae (sensu lato)* has not yet been reported and is crucial for planning next steps. There are two paradoxes in the results so far which need further elucidation: (1) the village with much the lowest malaria prevalence, 7.4%, had by far the highest calculated EIR, of 168 infectious bites per year. If there are no calculation errors, one needs an explanation of the very low prevalence rate as it could be important for planning control; (2) there is a contrast between the very thorough knowledge about malaria plus statements in the KAP study about its priority, and the explanations in the community discussions of why it has a low priority. As results were incomplete at the review some of the statements made are provisional. Substantial bodies of data on economic activities and from a KAP study about malaria have been collected, but critical analyses have not yet been made.

There is a need to think through the baseline data with great care in planning Phase II research. The malaria prevalence rates in children are, except for Mtibwa, over 20% and up to 76%, which is consistent with the EIR of over 15 and up to 100 per annum. This suggests a high degree of transmission which is relatively unlikely to be controlled by environmental methods alone. It may be

more productive to use the social science data to optimize application of National control methods and then to assess the added value from incorporating environmental methods. The intervention study design for this may be epidemiologically difficult and need to be of a relatively large size. The specific contributions of working in rice production (especially bird scaring at night) can be more precisely assessed and methods to reduce biting that are locally appropriate can be developed.

During the field visits it was clear that very good collaborative relations with local government at the grass roots level had been made. Within the study area at Mkindo was a farmers' field school, a well run organization that had people from all over Tanzania coming there for courses. This provides a very good means of disseminating knowledge of the project and its results, as well as helping to get agricultural extension workers involved in health promotion (a recent course had clearly been giving attention to HIV/AIDS as the flip-chart outputs on the walls showed).

The strong involvement of the agricultural university staff among the research team in the malaria work was very apparent. From every aspect this was a good feature of the project. There is a danger that they may be over-optimistic about what can be achieved by modification of agricultural activities (this is crucially dependent on the baseline transmission level) in malaria in these localities, and advice to the community should not run ahead of data, but the enthusiasm of the Morogoro staff is really encouraging, and provides a long-term future for integrating agriculture and health issues in Tanzania because of their key role in educating scientific farmers. The undergraduates already visit the study area during their field classes. This situation supports the view that it makes sense in the medium term, if the malaria projects flourish, to extend the project scope to other vector-borne diseases. Moreover the presence of Masai pastoralists in the southern part of the study area may provide issues in common with the Sanga project.

The epidemiological surveys also included data on filariasis, urinary schistosomiasis and hookworm. We have looked at correlations with malaria by village (Figure 1), finding $R^2=0.72$ for filariasis (which makes good sense if they share a common vector), $R^2=0.46$ for hookworm and 0.06 for *Schistosoma haematobium*. The project team have analysed the pattern of polyparasitism in an interesting way, but their interpretation that treating other parasites might reduce the frequency of malaria does not follow from the data.

There is general enthusiasm for the Ecohealth approach among both parts of the team and due attention has been given to all its principles. The sites are interesting, though more malarious than is good for seeing an impact of environmental management. Further investigation of the highest and lowest villages for malaria prevalence is needed. There will need to be a combination of creativity and rigour in designing phase II. The institutional bases are excellent. Ecohealth is well placed to influence both medical (and especially malaria) applied research and agricultural education nationally.

v. Zimbabwe: ZUNGBWI

This study of a small rural area of Zimbabwe, where changes in cultivation appeared likely to produce breeding sites for malaria vectors, could not be visited for logistical reasons¹. However, the final report on the project was particularly carefully written and detailed, and there were photographs of the quite small study site. For these reasons, it was possible to get a detailed view of the study.

¹ The researchers were not going to be available in Zimbabwe at the times when it would have been possible to visit

Curiously, the actual description of the site, its dimensions and morphology, was the one weakness in the documentation, but there were photographs available.

Vleis are valley bottoms that hold water, with or without a visible stream, and they provide grazing, water sources, fruit and some cultivation. It is possible to develop irrigated agriculture there, but in the study site this could only be achieved for a subset of the people. The study was undertaken to determine the effects of the cultivation upon malaria transmission whether due to environmental or socio-economic changes. It then aimed to see how malaria might be controlled in that situation. Once some of the results were obtained and also after the community had expressed its priorities, three additional questions were studied: the effects of hydrological variables upon mosquito species, the conflicts related to vlei cultivation, and the role of HIV/AIDS in the community. The last two of these were each studied by a graduate assistant as part of an MPhil programme.

The methodology was largely descriptive, as might be expected for Phase I work, and substantial effort was devoted to interdisciplinary development of questionnaires to cover the three areas of socio-economic interest to the study; livelihood and gender analysis, conflicts over resource use, and community perception of diseases. A variety of social science methods was used in addition to individual questionnaires, including focus group discussions, social mapping, narratives, diaries and observations. The focus groups were usually separated by gender. The basic demography is not recorded in the reports, so it is often difficult to relate samples or subgroups to the whole. By contrast, both soil and water environmental details were recorded, and the 'community diagnosis' involved a wide range of methods.

It was clear that the study meticulously followed Ecohealth principles and involved staff with the community very fully. The study was very responsive to the issues that emerged from this interaction – internal conflicts and HIV/AIDS – and handled them very well by augmenting the study but without losing the focus on malaria and agricultural change. Gender roles were carefully examined. The physical micro-environment was studied in a more systematic and rigorous manner than in the other studies. This study gave the impression, more than the others, of careful thought being continuously given to each of the results as they emerged, so that new aspects were added and others discontinued along the way, in a productive and thoughtful manner. There was a very good combination of disciplines and approaches (but with the usual lack of medical epidemiological input) and the reports showed a high degree of transdisciplinarity in the analysis and the synthesis of the results. Attention was drawn by the principal investigator to the high costs, in time and funds, of this type of research and particularly the high investment of time at an early stage.

Very few mosquitoes were found, and there was little objective evidence of local malaria transmission, although it was perceived by the population as a major health problem. The reasons for this discrepancy were not fully determined, in spite of thoughtful analysis of the various data sources. Such malaria cases as occurred might have been exogenously acquired. Prevalence surveys revealed no cases, and there is doubt over the validity of 'clinical malaria' at the nearby health centres. A suitable dipstick test might clarify this. The project has made arrangements for microscopy on clinical cases.

Further studies were put in place to elucidate the malaria situation, and detailed work on hydrology and mosquito breeding has been set up. These need to be supported in Phase II to give a rounded picture. The overall Ecohealth approach has been used to such good effect that we feel the request for continued support is well justified, subject to a good proposal, as the returns will be great, even if less

relevant to malaria control.

This detailed study of a small community has led to a well-rounded picture of health and agricultural aspects of a changing society which is of both local and more general interest. It was carried out in a very difficult political and economic environment. As a body of work it is both original and meticulous.

3. Summary of key strengths and research potential of each Project.

The key strengths and opportunities shown by each project reviewed are summarized, in the context of their future research potential, and as a basis for developing the Programme.

i) At **Mwea**, the key achievements are the comprehensive study of the situation, very thorough development of community participation, apparent success of community-based interventions in the village with a high malaria prevalence, and a mature group with a history of working very well together (even though there have been recent strains). The cattle hypothesis to explain the low parasite prevalence on the irrigation scheme is suggested but not proven by the currently available data; and more longitudinal data are needed on the effectiveness of the community interventions aimed at control, as well as the transmission epidemiology distant from the irrigation scheme.

The site is an example of irrigated rice cultivation at an altitude where malaria can be a substantial problem but where the malaria prevalence appears much lower than in surrounding areas. It also has a well-documented long and complex history (Mwea was a model for irrigation schemes in the early post-colonial era), and continued studies are potentially very productive.

The excellent work on soya-bean cultivation as an intercrop needs to be taken to the level of operational implementation. It is important to determine rigorously the explanation for the low prevalence of malaria on the scheme; and the sustainable efficiency of the control at the remote village must be determined, as if the excellent mosquito net results are maintained, and this can be related to the degree of community involvement, this would be of importance.

The capacity building experience and strength of Mwea is particularly in relation to training of trainers (TOT), both at village level and local professionals (school teachers) as well as developing the overall context of capacity building outside the research community.

ii) The Uganda I or **Sanga** project tackled the problems of changing rural livelihoods and environments in relation to malaria. In particular the community had asserted that malaria had become much worse as the formerly nomadic pastoralists had settled. Such a change could have resulted from reduced deviation of mosquitoes towards cattle, consequent upon small herds housed away from people. This would be expected to result if *Anopheles arabiensis* were the primary vector. The baseline research showed that the settled pastoralists had a comparable malaria burden to their nomadic neighbours and that *An. arabiensis* was not present. The complex consequences of settlement for surface water supplies emerged as a major source of increased mosquito breeding, and a large body of data was gathered on many aspects of the livelihoods of the pastoralists.

The site is of particular interest as in an area of formerly low malaria transmission which has increased, it is undergoing massive environmental changes due to human activities and livelihood change, settlement of nomads and incipient urbanization; it has populations of people, livestock and

wildlife interacting closely. Major water resource changes are taking place. Population density is uneven, and there are some relatively isolated households.

In Phase II a group of environmental interventions aiming at reducing vector populations breeding in new water bodies, and at reducing resting mosquito populations within traditionally thatched huts, will undergo trial. Separately funded work on water policy, water and diarrhoea, and on both community- and facility-based diagnosis and prompt treatment, will address other priorities of the community and interlock with Phase II.

This site has demonstrated a specific advantage for research capacity strengthening. The previously discussed research station centrally located within the study area with laboratories, offices, accommodation of various types and in need of refurbishment, showed its potential in Phase I when the 5 masters' students doing much of the field work lived there and by the end of their work each student had a grasp of all aspects of the project, so that external reviewers were unable to decide on the initial discipline of the students. With appropriate rehabilitation of the facilities this site can be an outstanding interdisciplinary research station.

iii) The key finding to date from the *Bushenyi* (Uganda 2) study is that the vector hazard from fishponds appears to be largely due to anophelines breeding in disused fishponds. This has obvious policy implications, if this can be confirmed. Short-term interventions to stop breeding in these disused ponds can be undertaken, possibly involving a comparison of *Bacillus thuringiensis* and a chemical larvicide, to both determine practicable methods of larval control and also quantify the role of these ponds in overall malaria transmission. These are feasible in Phase II. The very high local productivity of small tree-hole and banana-leaf breeding sites needs to be appropriately compared with the role of ponds. It may outweigh them, or it may not. There are significant similarities between the Bushenyi results and those from groups in Western Kenya, suggesting that the findings so far are more than of local relevance.

Since another outcome of Phase I is a strong interest of one of the researchers to continue with an in-depth look at the economics of developing fishponds more extensively in the area, this provides an opportunity to also study longer-term ways to ensure that disused fishponds do not persist in the area.

iv) The *Mvomero* project in Tanzania has adopted a comparative approach, with a series of villages along a 45 km road transect which passes through 6 different agricultural ecosystems. The initial work has been a comparison of malaria prevalence rates, backed up by descriptive material on the agriculture, livelihoods, and socio-economic circumstances of the communities. This project was later in starting than the others (and was separately funded), so that data are still being analysed. The malaria results show a large variation of the prevalence between agroecosystems, with very low rates in organized sugar-cane areas and much higher levels under rice irrigation.

The site covers a range of agricultural activities at an altitude where transmission is variable and possibly open to manipulation by changing cultivation. It is within an hour's drive of the Agricultural University.

The strength of this project's capacity building is its close link with the Agricultural University of Morogoro and the strong participation of the faculty there. This gives an opportunity for influencing many agriculture students there with Ecohealth principles.

v) The **Zungwi** project in Zimbabwe has adopted the most comprehensively Ecohealth approach to a very small area and the findings are carefully interlinked. A deep insight into community dynamics and conflicts was obtained early. Future plans for this site sharply pose some of the priority issues raised in section 5(ii) below. Malaria is found not to be a substantial problem, but HIV and social conflicts are. While the absence of malaria can be further investigated, community problems are in other directions, yet need attention.

4. Trans-Project Summary Analysis of the Research Programme

i. Integration of the Ecohealth approach into the projects

All the projects reviewed have been following the Ecohealth methodology in their background data collection during phase one of their work, and the Mwea project has applied them similarly in its second phase. The other projects have not reached their second phase due to resource constraints.

It is very clear that in the first, descriptive, phase the Ecohealth approach has been very helpful in providing a broad view, full examination of context and close interaction with stakeholders at all levels. The research workers themselves have hugely benefited from this as they all readily state. It has meant, however, that there are large amounts of data which are indicative of many relevant issues, but collected too rapidly on a small budget for one to be able to rely heavily on counter-intuitive findings. The research workers are left in some doubt, therefore, as to how far to devote much time to the full analysis of very detailed socio-economic data, since conclusions arising from that analysis will require confirmation, and this has resource implications. What it certainly does do is to provide enough information to allow specific questions to be formulated for later phases and to allow students to make the necessary calculations for study design for the trial of proposed interventions.

The more difficult questions will concern the extent of Ecohealth-type inputs into the second phase: clearly community participation in that phase will be crucial in the development and implementation of interventions. However, the assessment of the selected interventions will require substantial resources and rigorous design if valid conclusions are to be reached, the more so if both environmental and mainstream interventions are to be implemented concurrently.

ii. The projects as facilitating the Ecohealth approach within IWMI and other CGIAR organizations.

So far as the five component projects of SIMA are concerned, it is doubtful that any, apart from Mwea, have had any impact upon IWMI or the other CGIAR organizations as yet. It would be quite extraordinary if they had.

These are small teams, beginning very modest projects, in sites remote from the main offices of IWMI, (which had received a negative appraisal of an earlier different plan for SIMA even before the projects started). It is notoriously difficult to influence the CGIAR centres towards health. Major international organizations such as WHO have struggled to do so over many years with very limited success. The

one major field project on malaria and agriculture under CGIAR auspices in (West) Africa, lasted only as long as one particular research director and a sympathetic director-general remained at WARDA. Health as a whole in IWMI has been probably 'sidelined by being mainstreamed' within that organization.

Moreover, allocation of funds from the centre to the CGIAR centres is effectively by competition between them for limited resources, so that what is espoused by one will tend to be ignored by others. ICIPE, the home-base of Mwea, is not strictly a CGIAR centre and is both less well funded and more liable to internal competition between projects. Hence it would be highly unlikely for the SIMA projects to have had an influence on CGIAR as yet. All this is not a criticism, but a statement of reality.

In fact, the one project that has reached Phase II (Mwea) **has** been able to interest a CGIAR Centre in its agricultural innovations using soya as an inter-crop. Once the projects have research outputs in the agricultural area, the CGIAR Centres will begin to show real interest.

The research outputs and the expertise of the staff, gained in generating those outputs, have a reasonable hope of affecting CGIAR in the longer run. The project teams have spent the baseline period in learning how to operationalize Ecohealth concepts and to work in interdisciplinary terms, with great success. Over the next decade, given continued support, the senior staff will become recognized for their work in agriculture-health interactions. When, for example, agriculturalists with health expertise are needed for the governing Boards of CGIAR institutes, they will get appointed and be able to influence policy. The same process is likely to apply in relation to WHO expert committees, FAO and other international agencies, and to the board of ICDDR, B, which is the one field-based international health research organization.

Similarly, at the research project level, post-doctoral workers who have learned their research philosophy as graduate students on the SIMA projects, will presumably carry those ideas into the various research institutes and other organizations that subsequently employ them. These ways of affecting the CGIAR Centres form a serious and worthwhile approach that requires – as do all worthwhile research strategies – effort sustained over decades. It bears remembering that the insecticide-treated mosquito net approach to malaria control had an efficacy trial in 1983 and only now are we getting the national programmes and seeing treated net use measured in tens of millions.

iii. The projects as contributors to the Evolution of Concepts and Practice of the Ecohealth approach.

Thanks to the various materials and conferences provided at the time of grant-writing, and the subsequent advice from the Mwea team to those finalizing or revising their proposals, the SIMA projects have closely followed the Ecohealth pattern as provided to them. All the principal investigators have clearly interiorised this and applied it in practice. Their staff and students have done the same, rather in proportion to their involvement in the fieldwork. All now have experience, and a practical as well as a received understanding of the Ecohealth approach.

The project staff have, as yet, not begun to help the further evolution of Ecohealth as a concept. They have not had the time or experience, except at Mwea where the most senior staff have helpfully acted as propagators of the concepts, but have not, as yet, developed the theory further.

If the work in the field continues for several more years, and the pressures of fieldwork are not so heavy as to drown out reflection, *we believe it is likely that there will arise from the researchers - probably the younger ones rather than the principal investigators - critiques of Ecohealth and development of ideas that will contribute to its evolution at the theoretical level.* This would be the highest form of success. Again, comparative examples are useful. In the Swiss NCCR programme which started from a rather comparably sophisticated conceptual basis, on 'syndromes of global change', it took six years before two sets of critiques that moved thinking along arose from the postdoctoral workers involved, driven by Latin American and European workers. The pragmatic approach is so strong in East and Central Africa, however, that it could take longer. That said, with a facilitated network and some encouragement, evolution might be faster and give an indigenous voice to the development of Ecohealth and transdisciplinarity theory.

iv. Capacity Building

The field projects have shown diverse, complementary, and serious attention to research capacity building and also to local capacity building. Although this area was not explicit in the terms of reference, it is implicit in Objective 1.3 and we believe it deserves the explicit attention given to it by the project teams, most particularly by team members from Universities and Institutes of Higher Education, for whom teaching is as important as research. If a key aim of the projects is to disseminate Ecohealth ideas and methodology, the use of masters' students on this scale is an effective way to do it.

At the research capacity building level, institutions have followed their customary patterns. Thus the Mwea project improved the capacity of a few members of ICIPE staff and also provided a niche for a productive MSc student and possibly others in the second phase.

The Zungwi (Zimbabwe) project, based at the Lake Kariba research station with strong University ties, made greater use of graduate students for the fieldwork, both for the main malaria-related studies and for special studies, requested by the community on HIV/AIDS, and one which arose from the irrigation work on conflict resolution in relation to water use. The project thus should provide 2 MSc and 1PhD degrees from the first phase of the work.

Both the Ugandan SIMA projects tended to use MSc students in their second (research) year as the key field workers. Five such students were involved in the Sanga project and six in the Bushenyi project. These two projects also aim to use graduate students in the intervention phase, preferably working for their doctorates.

As noted earlier, a particularly effective base for strengthening research capacity occurred in the Sanga project, which was located in an abandoned rural research station in the centre of the study area. Very basic board and lodging was provided for all the 5 MSc students in the rather dilapidated buildings and was fully utilized. It had the consequence that they exchanged experiences and expertise continuously for a year. External reviewers at one review were, indeed, impressed that all understood the whole project and that it was not possible to tell who was originally a vet, an anthropologist, or a molecular biologist. It is still hoped to build on this experience in later phases of the work and to develop the research station as an interdisciplinary and intersectoral research training centre; though the Centre is at great risk of being irretrievably lost due to the break in field work

As the leader of one Ugandan project is now also the Dean of Science in the University in N. Uganda there is a further opportunity to pass on the Ecohealth Concepts.

The Tanzanian project, run by the National Medical Research Institute is well placed to influence capacity building in malaria control there. It is also of particular research capacity strengthening interest because of the partner institution, the Sokoine University in Morogoro, which is a specifically agricultural university and also is relatively near to the field study site. Three of the Morogoro senior staff are involved in the project and have already gained an interest in and growing understanding of malaria. This has major implications for education of agricultural graduates and farmers. The students will visit the field site (they already do so for agricultural training) and gradually gain an understanding of the interaction of malaria and agriculture as part of their education.

v. The quality and usefulness of the research outputs so far

The projects examined have, even at this very early stage, cast much light on the local malaria situation at the various sites studied. In several cases the malaria levels have been lower than expected on general climatic grounds, and these justify careful causal analysis. In some others the infection rates are high and one could doubt that any agricultural interventions will have a substantial effect on malaria transmission.

What all of the projects have done is to provide richly contextualized accounts of the local malaria situation. These can and should be used to dissect out issues that need attention, both there and more widely, both to optimise the agriculture to limit malaria transmission and to work out locally important aspects of implementation if the standard malaria control methods are to work in the locality. For example, the human behaviour patterns of residence in temporary shelters by the irrigated rice fields, in order to scare birds, may make the presence of insecticide-treated mosquito nets at home inadequate to protect against transmission and additional measures may be required. These study sites, and the work begun at them, will therefore have an important role in complementing the 'mainstream' interventions that are being so intensively studied throughout the world.

While extensive bodies of socio-economic data have been collected in most projects, they have not usually yet been examined critically and analyses have sometimes taken them too much at face value. More basically, almost all projects have had trouble with database design for the very large amounts of data collected by an Ecohealth project, and could have made good use of assistance at crucial times.

In most of the projects, the epidemiology was relatively weaker than other aspects (e.g. the community-based analyses, vector ecology and GIS). This was due to several factors, including the difficulty of obtaining medically qualified researchers within the project budgets, the scarcity of epidemiologically skilled doctors, and the costs of working with quantitatively adequate population samples to test hypotheses.

The projects have largely coped with these problems in the baseline phase by using parasite prevalence rates as the measure of malaria transmission. Careful analysis of the age-prevalence curves will be needed and has not yet always been done. No team has attempted serious collection of incidence data because of personnel and resource constraints, but these are likely to be needed for

assessing interventions. Calculation of the entomological inoculation rates have sometimes been done, on the basis of limited data, and these calculations were not always correct – some (hopefully all) will be revised and checked in the process of preparing manuscripts for publication.

vi. The added value of natural resource management based interventions

The natural resource management interventions are more controversial, but the scientific and public health situation is more fluid than it was. In the narrow sense, an NRM approach has a limited role in the highly endemic areas of Africa. However, malaria is more heterogeneous in intensity than is generally believed and there are large populations in East and Central Africa lying near to the altitudinal limit of malaria transmission (Table 1), and in southern Africa near to the southern latitudinal limits to transmission, where natural resource management becomes important again.

There is however a changing scene in malaria control in East Africa. Due to recent controversies over modes of insecticide use, there has been a move towards combining all available control measures. While this may lead to economic problems, it has a holistic tendency and, where agricultural methods of transmission control are of low cost or are self-funding they may be favoured as part of the 'integrated' control programme.

vii. Institutional Aspects of a continuing Programme

a. Funding and Constraints on Activity

There are significant differences in the way that research programmes affect the income of investigators in universities and in international research institutes involved in the research projects. In the latter, staff are paid at a reasonable rate (full time or part time) and the financial pressures are primarily at an institutional level: the institution will find large well-funded projects more attractive in terms of their viability, overheads and scientific production relative to administrative burden, in general terms.

Universities in East Africa do not pay their staff adequately. Consequently a research project is viewed not only as a scholarly and scientific opportunity, but also as a way to provide necessary income, whether in terms of field allowances, honoraria or other direct benefits. Good staff will either have a single large grant with a substantial honorarium or will be juggling a number of projects, each of which provides smaller allowances. However one may deplore this system, it cannot be ignored in designing any research and particularly an interdisciplinary project. Using local consultants is a more up-front way of operating, but it does not have the key benefit of involving students and of research capacity strengthening.

The resources available for research differ between universities and international research institutes. The latter usually have a pool of well-maintained vehicles and sometimes drivers, and a variety of laboratory and field resources, with also skilled support staff. By contrast, the universities often lack adequate transport, financial and other support staff are poorly trained by comparison with those in international research institutes, and procedures may be very slow. Yet the universities have access to students early in their careers, when they are most open to inspired leadership and when their value systems in research are being developed.

In summary, therefore, staff in international research centres tend to have the facilities and support, adequate time for research and a supportive context, but are under strong pressures to publish in well regarded journals of a disciplinary type. By contrast the universities usually have much less favourable support and contexts, much less time because of teaching commitments, but rather less discipline-oriented pressures, good access to other disciplines if they choose to take them up, and even better access to students of various levels.

An ideal programme needs a mix of research centre and university work. Enlightened differences and flexible arrangements in funding patterns can get the best out of each.

There is a sharp limit in the extent to which able research workers will initially commit themselves to Ecohealth research projects. For example, the approach:

- requires a heavy investment of time and effort in activities which will have a low pay off in short run,
- may lead to publications in less prominent journals,
- is not conducive to rapid promotion, and
- requires continual effort on the part of those with different viewpoints, disciplinary approaches and value systems to understand.

Nevertheless it is possible to recruit outstanding researchers to research of this type provided that funding is adequate to meet these extra costs; that there is a prospect of continued support in the medium term, provided that the research quality is high; and that there is sustained commitment by funding agencies with this orientation.

There are important differences between International Research Centres (IRC), National Research Organizations (NRO), and Universities (UNI) that are not fully recognized in relation to conducting Ecohealth research². Ecohealth is about mode of work and about process, more than just about output.

There is a gradient from IRC and through NRO to UNI, in terms of research support --logistics, well found laboratories, time of staff available for research. The IRC end is high cost, quantitatively productive, capable of higher research training, possesses relatively well developed facilities. But they are resource-hungry, tend towards disciplinary foci (unless directors work hard to push the other way) and are highly directed toward visible research productivity in the scientific literature. NRO are more closely allied to practical aspects of control, have an ability to transfer results into practice, but vary by country and have less of an educational role.

These pressures are less at the local university end (except in long established universities) where local processes are towards practical involvement. Ability to influence undergraduate students is great and in the newer universities cross-disciplinary collaboration is easier. But resources are miserably inadequate, teaching takes most of the available time, logistics are difficult. However, on the other side, ability to change the way students think is at its greatest here.

Responses to gaps in funding for specific projects elicit different responses: IRC's switch to better-funded topics; NRO's tend to tackle simpler projects and lose morale; universities return to teaching and the commitment to research falls.

² Indeed to research of all types to a lesser degree, so far as developing countries are concerned.

b. Continuity of Activity

The unfortunate interruption of funding, for reasons not to do with the projects, after the baseline year(s) had a disastrous effect on the research progress, the morale of staff and the trust of the community. Only in Tanzania where the research group were from the National Research Institute was it possible to get some rapid local support for continuation. This was not possible for the University-based teams.

The teams had difficulty in understanding the sudden change. It did not appear to be necessary; there was no direct link between the IWMI-based overall SIMA project and the individual field projects with their separate funding. If a community is heavily involved in a project, sudden policy changes for reasons which these communities cannot be expected to understand will have a strongly negative impact. This is likely to result in the field research workers being blamed unjustly; making restarting of the work a much larger task.

Unfortunately, this now means that the projects have an uphill task to restore faith in it by communities, researchers and some government agencies. There will be a view that, if this is what Ecohealth means in practice, it is worse than ordinary top-down research that takes little notice of what the community thinks. We believe that, had the research continued, the problems over IWMI and the central co-ordination could probably have been solved more easily.

More generally, and even in the absence of the various recent problems, there was a gap between phases I and II of the Mwea project. In Ecohealth projects there needs to be a mechanism whereby proposals for a further phase of work are evaluated in good time so that funds are in place (and indeed in the research account in the developing country institution) by the date at which the preceding phase ends. Also, in the event that either the research funding source is going to cease or it is decided not to fund the next phase, several years' advance notice is needed. There are two reasons for this:

- firstly, the community needs to know in good time so that things can be wound down in an orderly way; and
- secondly, there needs, in the case of the E. African Universities, to be time set aside for data analysis.

The situation is unlike that in countries where adequate salaries are paid, and once research is done there will be time in subsequent months to write and disseminate papers. In the case of the SIMA projects, the researchers will need to immediately switch to other projects if the project funds cease, so making writing up very difficult.

There are undoubtedly great administrative difficulties for IDRC as for other funding agencies in the way of maintaining continuity of funding, but this could be made easier by the following change in procedure, which also has wider relevance.

We recommend that, in future, thought be given to planning for a 3-year first phase for projects of the type being reviewed here. IDRC has found it difficult, for various good reasons, to maintain continuous funding for community projects in East Africa. Even if the first phase collects most of its data before the end of year two, the process of analysis and writing up will take over 4 months in any

worthwhile project; the results then have to be digested and turned into a full proposal for the next phase.

Whilst a concept note for Phase II can often be drafted from preliminary results, a detailed proposal for an intervention trial of any sort is going to require the detailed results, taking at best another 2 months. If the funding agency then takes 6 months to process the application (and this is in practice doing well for any agency), it will mean a total of 12 months from cessation of fieldwork to the go-ahead for the next phase of the project. If this is budgeted, including continuing to work with the community in the third year of Phase I, the necessary continuity can be maintained. To quote from Bopp's careful 2002 evaluation of 3 Ecohealth projects in Africa. "In participatory work, timing is important and maintaining momentum is critical".

viii. Conclusions and Lessons learned from the Projects

The Projects. At the time of the November 2005 conference, that brought together all the projects, and many of their staff, to present their work to each other and discuss it as a group, it appeared that much had been done with limited resources and that many issues and opportunities had been opened up. Experience during the present review has served not only to confirm but also to strengthen this view.

We conclude that the various projects have achieved a great deal in a relatively short time in terms of baseline studies, that each of the projects has a site which raises many relevant and significant questions concerning malaria in agricultural communities, and that these are sufficiently diverse that the current projects comprise a research programme.

The array of projects at present included in the programme includes a good diversity, not only of agricultural situations but also of types of research organization, disciplines and combinations of disciplines, and ecological contexts. There are also diverse approaches to capacity-building. This has two consequences: one is that it makes for a well-balanced programme (even on this small scale) and the other is that there are great opportunities for comparative meta-analysis of issues. There are sufficient questions arising in common across the programme that networking opportunities can now be very effective in both summarizing the experience of the group on various topics and formulating steps for further study. This latter potential is only now ready to be tapped and this comparative approach should be very well developed in parallel with phase II in most of the projects.

Malaria. The work has shown up significant issues that involve both agriculture and malaria, and these are set out in section 5(iii) below. In all malaria control, implementation – especially in the longer term – is a much more complex task than is generally assumed and it is going to be crucial to have a set of sites at which a holistic understanding of livelihoods, environment and behaviour is available so that implementation of any combination of control measures can be achieved in a sustainable way. The SIMA projects provide just such an array of sites in East Africa.

Research Support. The actual levels of funding have been low for the scale of work expected, and the funding agency has not adequately taken into consideration the different types of organization represented among those executing the projects. The gap in funding between Phases I and II has been highly disruptive of the research and especially of relations with the communities. As shown by the one project that had already reached Phase II, the majority of the benefits, to both science and the

community, begin to be apparent only in Phase II. It is therefore unfortunate to have the second phase delayed.

Community based interdisciplinary work, if it is to become established as a sustainable activity, requires deep changes in both research and community behaviours, and they will take a substantial period to become established; especially as such work puts researchers at a disadvantage compared with their peers in the short run. The benefits will become apparent and habits established in a period of 6-8 years.

If an Agriculture/Malaria research programme is to make a significant contribution and to establish an Ecohealth approach, it will work best with a rather larger group of projects than in the present portfolio. Even with five or six projects as at present, and with adequate funding, an annual spend of 1 million dollars is needed; with a full set of projects over a ten-year period the total funding would be 10-20 million dollars. This is a very small proportion of the current global malaria research budget. If it exceeds the investment that one agency is able to commit, it will be necessary to form a group of donors and this will necessitate a rather larger remit than has been the case so far, and greater clarity of aims, as discussed elsewhere in the report.

The preliminary broad phase has provided an admirable perspective for the researchers and community to get a deeper understanding of their malaria problems. But, as they move on to Phase II, attention has to be paid to Medawar's comment that "the task of the scientist is to solve problems, not merely to grapple with them". And although we would wish to replace 'the scientist' with 'the community and scientists together' the remainder of the statement holds true, and the problem of moving to interventions but having a design able to evaluate the effectiveness of those interventions will be considerable, especially as the interventions of most interest to the IDRC are at community level and also may need to be assessed concurrently with other more conventional control methods.

5. Options for Going Forward

Consistent with the overall structure of this evaluation, this final section is presented from the two broad perspectives of a technical analysis of the 5 SIMA projects and the organization structure of the overall arrangement. As with the previous analysis, the separation is for purposes of emphasis; in reality, the substance and structure of any research programme and/or network must necessarily be consistent.

i. Scientific Directions for Developing the Programme

When successful, the projects result in a complex but insightful picture of the functioning of a community in relation to its water sources, livelihood, environmental changes and malaria. This can provide a good basis for wise action that requires both malaria-specific and other interventions. Sometimes (more often than expected) it becomes clear that the agriculture is not greatly affecting the malaria: this does not excite malaria control agencies nor agricultural ones (although it has great importance in increasing the freedom of agriculture change from doing harm to health), but can be a

really important finding for the community. Some of the most careful and helpful analyses are place-specific, or appear to be on a micro-scale and not easily transferable.

The research work carried out to date under the EcoHealth umbrella can usefully be developed in several different ways, depending upon the primary goal of the work (or funding foci). Each has both strengths and limitations, and at this stage it is useful to canvas the range of things that a follow-on from SIMA might become. We can look at aims, objectives, activities and structure.

For the existing projects, for which only baseline data have been gathered (with the exception of the prototype project in Kenya, which is at the end of a second phase), there could be the continuation of the present programme of work for the areas already under study. Indeed, continued funding is a *sine qua non* for any of the wider options, since without it IDRC will lack credibility as a responsible funding agency and able researchers will look elsewhere for support and be deterred from an Ecohealth approach.

ii. Nature and Challenges of Ecohealth in Scientific Terms: an analysis of the implications of its particularities for the elements in a developing Ecohealth Programme.

Careful examination of Ecohealth policy documents shows that there are at least four key aspects of the Ecohealth projects related to SIMA, and to which the IDRC documents give emphasis. They are

1. Environmental approaches to malaria control in an agricultural context.
2. Malaria control by and for agricultural communities.
3. Consulting the community and designing studies and interventions to address their felt and expressed needs, and which they can play a major role in implementing.
4. Building research capacity in Ecohealth, and strengthening community capacity.

There are also some others, which are not analyzed separately because they follow almost inevitably from addressing the four primary aspects. For example, items 1, 3, 4 imply an interdisciplinary approach, and item 3 explicitly, and the others implicitly require attention to gender issues in both analysis of problems and devising solutions.

We feel it is useful to look at these elements separately before moving to the more specific future options. This is because, whilst good Ecohealth projects may combine several of them, there are sometimes situations in which decisions have to be made about priorities, and these are best made explicitly, so that they can be discussed with funding agencies and National control programmes, rather than getting introduced as a mixture of things that give problems later. For example, in an agricultural malaria control programme it may be proposed to use both treated mosquito nets and some environmental measures. But that may make it extremely difficult to determine whether the environmental measures are efficacious, as the nets will have a very large relative effect. This may necessitate very large study populations, with a consequent rise in cost, if the environmental intervention is to be assessed. As there are always opportunity costs of increasing the number of interventions it is important to think through the implications of combined interventions, still more those that are polyvalent, if the phase II studies are to be well designed.

The four key aspects need attention in further developing the research projects carried out to date. They can usefully be developed in any of these four main directions, and usually in several, but the

shape of the programme will sometimes depend crucially on which is considered by IDRC and/or other partners as the primary goal of the work (or the focus for seeking additional resources). This is a cause for concern to some of the team leaders in deciding what will be both best for their communities and also fungible by IDRC or another agency, and in particular in designing Phase II interventions. Each option has both strengths and limitations. The construction of a programme on the basis of the current work will need to incorporate several of the key elements, but decisions will have to be made on priority emphasis, and it is helpful to first analyze the components as follows:-

1. Ecosystem approaches to malaria control in agricultural communities

The original goal of the research was based around the concept that agricultural practices affect malaria transmission and that consequently malaria might be reduced by appropriate environmental management. This will tend to be the case where malaria transmission is relatively low.

Transmission is best measured by the basic case reproduction number, usually termed 'BCRR', and more simply reflected in the number of infectious bites per person per year or EIR, entomological inoculation rate. If the BCRR is below 1 then malaria will die out. If it is somewhat above 1 malaria will spread and there will tend to be a relation between the BCRR and the malaria burden on the community. Reducing transmission will cause the amount of malaria in people to fall. If the BCRR is very high, the malaria burden in people will tend to saturate, so that small or even moderate changes in the BCRR will have little effect on the malaria burden. Unfortunately, the vectors of human malaria in sub-Saharan Africa are very efficient, giving a very high BCRR in much of the region. Environmental management methods will tend to reduce mosquito vector density, which has a linear relation to BCRR and hence are relatively ineffective at high initial levels of BCRR. Where the vector is *An. arabiensis*, which is relatively inclined to feed on animals other than man, as, for example, at Mwea, changes in livestock housing and density may give rise to larger effects on transmission, proportional to the square of the change. Both of these broad categories of intervention will have rather smaller effects than will residual insecticides on walls or on bednets. These will shorten the life expectation of adult vector mosquitoes with a very large effect upon the BCRR.

The consequences of these epidemiological processes are that, in very broad terms, changes in agricultural practice will have less effect upon the human malaria burden in much of Africa than in some other continents. On the other hand, because so much of the world's malaria is in Africa, there are parts of Africa where there will be a significant impact, especially where altitude or latitude reduce the temperature, and in some semi-urban and plantation agriculture situations where transmission is already much reduced. Nineteen million people in the 4 countries with evaluated projects live at altitudes of 1500-2500m, and a further 49 million at those altitudes in Ethiopia, Burundi and Rwanda (Table 1)

2. Malaria Control and Mainstream Control Methods

If the primary goal of the work be that of controlling malaria for those in the study area, then it will be logically appropriate to use the methods included in the National control programme, and particularly those which are highly effective. These will include prompt treatment of symptomatic malaria, usually now by artemisinines in combination, and use of either insecticide-treated mosquito nets or of insecticide residual spraying of walls to reduce malaria transmission.

It is not clear how far these latter interventions fall within the IDRC remit for phase II. It can be argued that to withhold these highly effective interventions is unethical. From a more purely research viewpoint, however, IDRC does not have a comparative advantage in this mainstream area; moreover their very efficiency will make it difficult to evaluate the effects of environmental non-insecticidal and agricultural interventions. From the research viewpoint the involvement of communities may contribute much to mosquito net coverage. The communities under study by IDRC may have particular features that need attention if the mainstream interventions are to be effective when locally applied by or for them.

The reality of implementation of government interventions may make a stepped wedge design possible if IDRC moves rapidly, so that the environmental interventions are brought in rapidly for trial, and the mainstream interventions follow on after an interval of a year or more.

3. Community Ecohealth

The third direction in which the projects might develop would be to give most emphasis to the stakeholder and Community Participation aspect of the Ecohealth. During what has been usually called the community diagnosis phase of the projects, a variety of community priorities emerge, several of which may not be about malaria. There is then a dilemma as to whether to pursue the community's or the research project's (as set out in the funding application) first priority. In practice this has been coped with by remaining within the project document priority and either setting aside some funds to cope with other community priority topics, or to purchase things the community rates highly, or by writing separate grant proposals to other agencies for meeting these priorities.

Once the first phase has been completed the problem may become more acute: the objective data may show that malaria is either not the dominant problem or that it may be best tackled in some other way than agriculturally. If the community and data are simply followed, the topics under study may become so diverse that there is no longer an agriculture and malaria programme. This is where the Ecohealth process strongly overrides Ecohealth objective.

In the medium term and of wider relevance, the projects will contribute to Ecohealth theory, and there is a need for IDRC to review its own concept of Ecohealth with a view to both increasing its intellectual coherence and also clarifying its similarities to and affinities with rather similar (though not identical) concepts such as sustainability science (in the USA) and transdisciplinarity (in continental European usage). Whilst Ecohealth has distinctive features as used by IDRC, if IDRC wishes to involve other funding agencies in its programmes, the current singularity of usage may impede mutual understanding and collaborative programmes.

4. Ecohealth (Research) Capacity Building

Here the main aim is to create individuals and teams well placed to work in an Ecohealth manner to tackle pressing health problems. Fortunately this objective is compatible with each of the preceding three emphases and the practical question is about how far capacity building plays an important role. *The projects so far show very positive and diverse approaches to capacity building.*

The current array of projects makes diverse and important contributions to research capacity strengthening for Ecohealth work and to building local operational capacity within communities.

Each project has provided the basis for masters' and doctoral research, with a different balance depending on the project circumstances. The one project with an implemented phase II, Mwea, has a most impressive set of women's groups able to both influence community activities and teach other villages.

iii. The Case for a continuing and evolving Malaria and Agriculture Ecohealth Programme

There are several strong arguments for a programme of work in the Ecohealth tradition on agriculture and malaria as a complementary activity to the highly focused main line intervention programmes currently being heavily and rightly supported. There are five key reasons:-

1. Two Modalities of Malaria Control

The implicit, and in some cases explicit, objectives of the projects have been to solve particular problems of the relation of agriculture to Malaria; to broaden and deepen our understanding of the malaria-agriculture relationship; to apply and to promulgate the Ecohealth Approach; and as a result to improve the lives of people in developing countries in a sustainable way whilst strengthening their research capacity.

The approach being taken by IDRC within the Ecohealth framework seeks to do three very difficult things: (i) to change the behaviour of rural communities; (ii) to alter the way in which field research in malaria is done and the behaviour of research workers; and (iii) to alter the priorities of research in another sector, agriculture, in a sustainable way, so that all these changes become self-propagating.

The evidence suggests that the first two of these things can be achieved by charismatic individuals and sustained resources while the third is particularly intractable with scarce un-ring-fenced resources because pressure will always be towards areas of comparative advantage within the sector. Given these problems, is the effort worthwhile? We consider that it is:

- For reasons derived from both the history of malaria and public health, and the epidemiology and control of malaria; and
- Because the work that has been begun under SIMA represents one of the perpetual strands of a balanced approach to disease control.

In terms of the latter, these strands may be characterized as the 'particular' and 'general' ways to tackle malaria. The 'particular' has a history exceeding a century and has taken one or two very powerful tools for malaria control and applied them forcefully and at great expense to achieve results that may be spectacular in the short run, effective in the medium term and, except under initial circumstances of low enough transmission to permit eradication, less impressive in the long term because of exhaustion of resources, decreasing motivation, competing needs, and technical problems. The use of indoor spraying of residual insecticides during the attempts at global eradication of malaria in the 1950's and 1960's was the greatest success of this approach, and the collapse of eradication in the 1970's its greatest failure.

The other 'general' strand in the battle against malaria has attempted to combine several approaches to reducing malaria including environmental modifications (often undertaken with several other aims

also in mind), timely management of fever, and other measures which have, in areas of limited transmission, gradually reduced and in some cases got rid of malaria. The short-term effects have not been dramatic, those in the medium term have varied, but the long term consequences have sometimes been very successful. In this way much of the malaria of the USA and Europe was got rid of. A mixture of general public health measures, primary health care and socio-environment change have achieved this.

Much of the history of malaria control can be read as battle between protagonists of these two sorts of approach, but this has owed more to the personalities of the leaders involved than to necessity. Both approaches need to be kept in play, especially at present when some of the more recent weapons against malaria do not tidily fit into one or other category. For example, the insecticide-treated mosquito net is at present rightly promoted as a powerful specific tool to be used on a massive scale in vertical campaigns, yet its long-term use will probably depend on its becoming incorporated into cultural norms, so that it is simply a part of everyday life.

The present malaria scene is relatively dominated by the vertical approach and use of several extremely powerful control tools for malaria deployed massively at great cost. An increasing number of them are being brought into highly endemic malaria zones. There is under these conditions a special need to also foster, on a very much lower cost scale, the 'general' tradition in parallel, as a corrective to the exclusive reliance on external intervention to implement control, as a multiplicative control measure in the areas of very high endemicity and as a sustainable backstop to failures of the big campaigns. This the Ecohealth approach is able to do.

2. Locally Appropriate Actions

The 'one size fits all' position does not apply to all populations. Even where the key material intervention is the same as elsewhere, the approach to delivery and use may have to differ in populations with special life styles: nomadic pastoralists, forest hunter gatherers, populations inhabiting large swamps, may require a different approach if use of bednets or IRS is to be feasible. The IDRC projects in the current programme are well placed to tackle these issues.

3. Revival of Anopheline Larval Control Research

The role of source reduction (breeding site interference) or larval control in the control of malaria is undergoing something of a renaissance at present, after a long period of neglect that was due to the success of residual insecticides from the 1950's and supported by the epidemiological models of malaria transmission that showed, among the three vector-related control modalities, the extreme relative efficacy of reduction of adult mosquito longevity, high efficacy of reducing the person-biting habit and relatively less effective reduction of vector density in reducing malaria transmission. This meant that larval control would be most effective in low malaria transmission situations and where the mosquito vectors were least competent. These characteristics markedly contrast with those in much of sub-Saharan Africa where highly efficient vectors lead to a huge excess of potential transmission.

Some of the initial revival of interest in controlling vector breeding came from those with limited familiarity with transmission dynamics or with experience in other continents with poorly competent vectors. There is general agreement that the greatest potential for larval control in Africa is in urban

situations (low area, high population), plantation agriculture (high degree of control over environment and population, often at raised altitude), and in areas climatically marginal for malaria transmission, due to higher altitude or latitude. More recently there has been an increased appreciation of the patchiness of malaria transmission intensity, even outside the three lower transmission areas described above, with some indication of the degree of reduced transmission achievable from source of reduction, which may reach an order of magnitude.

There is a substantial current reawakening interest in the use of larval control in the reduction of malaria in sub-Saharan Africa. The use of microbial insecticides (*Bacillus thuringiensis* and *B. sphaericus*) with their lack of human toxicity has led to efficacy trials in areas with an endemicity of malaria that would have previously excluded them from consideration for larviciding. Efficacy trials have been promising and elementary economic calculations have given costs for a densely populated area (a rural settlement) in the order of \$1 per head annually for the insecticide and its application (but excluding the supervision that follows from the research being conducted). It is the nature of science to follow trends and likely that the limits of efficacy may be further extended.

4. Supplementary Role of larval control in endemic areas?

Least attention has been paid to the potential of source reduction under conditions where highly efficacious control mechanisms such as insecticide treated mosquito nets are concurrently used. This may become a newer aspect of larval control research.

Historically, prevention and treatment have been widely separated in malariological thinking. Indoor Residual Spraying (IRS) was done by government operatives and seeking treatment was a household activity; indeed until 1992 the latter was scarcely considered an aspect of malaria control at all! The insecticide treated mosquito net now sits uncomfortably between them. It is for prevention but its use is a household activity. With 'Permanet' treatment the governmental role is confined to distribution and subsidy at most; the best hope of prolonged use is that it will become a habit, and as much as a part of going to bed as a mattress or sheet. Health seeking behaviour is now emphasized. The views of the public health manager who seeks methods requiring minimal community participation and those who say that community involvement is essential are now complementary rather than at odds with each other, or at least they should be!

We know that, in holoendemic malaria, IRS alone, though it will greatly reduce malaria transmission, is not able to stop it, even with the addition of regular chemotherapy and in the absence of drug resistance. The relation between transmission and disease burden is complex, but only at relatively low levels does it tend towards linearity: that is to say, a rather small reduction in transmission (such as might be produced by environmental means/mosquito density reduction) will have very little effect on morbidity at high levels of transmission but much more at low levels. Recent work has suggested potential for low cost source reduction having up to a tenfold drop in transmission. The effect of superimposing low cost resource reduction by the community upon high efficacy net or IRS implementation has not been assessed. There is an impression that it might be small but this has not been investigated: it might prove to be multiplicative rather than additive or swamped. This possibility needs attention.

5. Fallback Value.

Very high cost, often externally implemented, malaria control programmes depend upon external funding, currently buoyant. Experience shows that long term persistence is not always a feature of external projects, and then the brunt falls upon the community. It would be wise, to say the least, to develop community driven work as a backup against this eventuality.

6. Sustainability.

However, the next operational issue for malaria control as a whole and for larval control in particular, will be sustainable effectiveness and it may be that what can be done in a small area as a research project may prove very difficult to sustain in practice. Moreover most entomological research work will have limited interest in the complex social dynamics of community-based interventions over a long time period, so that either that research may not be done, or that some, perhaps over-enthusiastic optimism may be followed by an even less justified pessimism. This work is most likely to be done with a hope of persistent action and effects by work with an Ecohealth approach.

iv. In the longer term

The review of projects has shown that it is difficult, and sometimes inappropriate, to confine projects to malaria alone. In most projects HIV/AIDS has been an issue; however it is such a huge issue, already receiving attention from other organizations, that it is beyond the reasonable scope of even a much augmented programme, and is not in a direct sense open to environmental management. By contrast, other vector-borne diseases than malaria are an increasing problem for agro-ecosystems and farmers, need rather similar research methodology to malaria, and are often open to environmental management. The vector-borne zoonoses are also of direct relevance and need a similar research approach. Therefore, while the need to relaunch the malaria and agriculture work is the over-riding priority, once that is firmly established the review would recommend extension of the programme to other vector-borne disease of rural dwellers and their livestock in the medium term, probably initially where a VBD is of importance in one or more of the malaria project sites.

Moreover, there is a reviving interest in Agriculture and Health, in the broad sense. Whilst some of that is at the high policy level, there is a real need for operational work and research in the field to bring a sense of reality to the issues. A major outcome of the present research programme has been to develop at least one site in each of the three East African countries well suited to act as a field research base for not only Agriculture-Malaria research but Agriculture-Health research and development, combined with the necessary with interdisciplinary research capacity building.