Managing applied research: experiences from a post-harvest pest control project in Ghana

Julia Compton

The aim of this paper is to make some suggestions about improving the management of applied agricultural research projects in order to improve the speed and quality of benefits to farmers. Factors influencing research success are described under four headings: choice of objectives and approach to work; choice of research methods; project organisation and management; and liaison with other organisations. Examples are given from the experience of the Ghana Ministry of Food and Agriculture/UK Overseas Development Administration Larger Grain Borer (LGB) Project, a recently completed three-year post-harvest project with a 25-person team.

Important features of this project's approach included: maintaining a focus on practical results; building upon farmers' own experimentation; involving commodity traders in research and extension; basing research around farmer decision situations rather than packages; and addressing the extension problems raised by the development of a range of technical options.

Research methods which were integral to the approach included: a participatory research-extension cycle; the framing of research questions to obtain critical data needed for decision-making; rapid survey methods; rapid field methods of sample analysis; rapid proxy methods for client evaluation of trials; and frequent re-examination of the programme by the whole research team. Favourable organisational features of the project included: a 'critical mass' of researchers organised in an interdisciplinary team with an anti-hierarchical ethos; extensive group training for the whole research team; monthly meetings and quarterly reports used as management tools; a supportive institutional setting; flexible funding arrangements; and good central administration.

Finally, it is argued that where a farmer-participatory approach is adopted, this should not be a grafted-on activity, but an integral part of all project work. It is therefore necessary to look closely at all research questions and technical methods to make sure that they are compatible with this approach. In particular, work is still needed in many technical disciplines to develop rapid field methods of sample analysis which are compatible with rapid, participatory field studies.

1 Introduction

The aim of this paper is to make some suggestions about how to improve the management of applied agricultural research projects in order to increase the speed and raise the quality of benefits reaching farmers. The paper uses examples from the experience of a recently completed post-harvest pest control project, the Ghana/UK Larger Grain Borer (LGB) Project. Projects are clearly not the only possible format for applied agricultural research. However, they are a very popular mechanism for channelling investment in research, because they offer the possibility of defining clear objectives, inputs and a time-frame for the work. This makes it important that lessons about project management should be widely shared.

The paper begins by reviewing some of the common problems of applied agricultural research projects. Next it provides some background information on the LGB project. It then discusses four determinants of success in adaptive research project planning and implementation, giving examples from the LGB project. These are: choice of appropriate objectives and approach to work; choice of appropriate research methods; factors relating to project organisation and management; and good liaison with other organisations. It is argued that simultaneous attention to *all* these elements is necessary for project success. The paper concludes with a summary of the lessons in research project management 'which can be drawn from the LGB project's experience.

2 Common problems of research projects

Over the past two decades there has been much discussion of problems in applied research, and many suggested solutions, notably increased farmer participation in research. Despite this, a disappointingly large number of research projects still take a long time to achieve practical results for farmers. There is still a big gap between the 'frontiers of development thinking', as exemplified by many ODI Network Papers, and the practice of most agricultural researchers.

Applied research projects commonly:

(a) *are too slow in achieving results.* While research is by its nature an open-ended activity, with no absolute guarantee of achieving results within a particular time limit, a visitor to many applied research projects quickly gets the impression that things could be speeded up a bit. Sometimes there is no sense of urgency or clear direction to the research. In other cases cumbersome research methods delay results, or the work is hampered by administrative problems, such as delays in the procurement of supplies or in making financial transfers.

(b) *are too academic.* There is often an unacknowledged conflict between the aims of the project and the need of professional researchers to 'publish or perish'. This can lead to irrelevant or poorly-targeted experiments, to slow, over-precise research techniques and to concentration on peer-reviewed publications at the expense of outputs for agricultural extension and ultimately for farmers.

(c) *come up with inappropriate technologies,* or technologies which can only be used by a minority of farmers (usually the richest). This often occurs when farmers are not consulted by researchers, or when only rich, 'progressive' farmers are consulted.

(d) *develop a useful technology, but fail to anticipate the detailed practical problems faced in using it on the farm.* Often researchers (through the medium of the extension service) exhort farmers to use the 'correct' procedures or equipment, rather than looking at the materials actually available to farmers and seeing how they can best be used. Locally adapted solutions tend to be more cost-effective in the short-term and more sustainable in the long-term.

(e) *'re-invent the wheel'* due to ignorance of what has been done earlier or elsewhere. This problem can occur when developing both technologies themselves and new research methodologies.

(0 *limit themselves to validating existing farmer practices.* Sometimes researchers restrict themselves to giving a sort of 'official seal of approval' to existing farmer practices, after checking that they 'work' to the researchers' satisfaction. For example, researchers may hold up so-called 'best farmer practices' (e.g. timely harvest) as a model to all, rather than searching for the reasons that other farmers do not use them (often not because of ignorance but because of time or other constraints). This is certainly an improvement from the days when farmer practices were disregarded or despised by researchers, but it represents a poor return on the research investment.

(g) *become isolated from other research and extension organisations.* Project ideas and results, even if good, may not be taken up by others without sustained investment in developing personal and institutional links with other stakeholder organisations. This can be a particular problem for projects which are developing new ways of working, such as farmer participatory research. It is also a perennial problem between research and extension in many countries.

Problems (b) - (d) are typical of traditional, 'top-down' research projects. Heavy criticism of this type of research has led to many recent projects and institutions putting, rightly, more emphasis on farmer participation in research. Unfortunately, farmer participation does not solve all problems, and participatory research projects may be particularly vulnerable to problems (e) - (g). They may also face additional problems such as lack of cost-effectiveness due to the very narrow applicability of results or the high costs of achieving them. For a discussion of this issue see Magrath *et al.* (1997) in this volume.

3 Some background on the Ghana/UK LGB Project

The Larger Grain Borer (LGB) *(Prostephanus truncatus)* is a small dark-brown beetle which is a serious post-harvest pest of stored maize and cassava. It originates from Central America, but was accidentally imported into Africa about 15 years ago and has since spread through 11 African countries. LGB can cause losses of 30% or more in maize value within a six month storage period. Farmers consider it to be a very serious problem. In fact, it was first brought to official attention by a group of Tanzanian farmers who marched into the Ministry of Agriculture to ask for help. Many millions of dollars have been spent in trying to control the LGB and limit its spread, and at least five international and donor organisations are currently involved in research into its biology and control.

The joint Larger Grain Borer Project set up by the Ghana Ministry of Food and Agriculture (MoFA) and the UK Overseas Development Administration (ODA) formed part of this international effort against the pest.[1] The project was established in January 1993 and ran until August 1996. Its overall purpose was 'to reduce post-harvest losses on the farm caused by insect infestation'. The project had two national managers (one British and one Ghanaian) based in the capital city, Accra, and a national component which was mainly concerned with monitoring the spread of the beetle, eradicating outbreaks in new, isolated areas, raising awareness of the new pest and producing and distributing extension materials. The research component of the project, which had 20-25 staff positions and a budget of £0.74 million over 3-5 years, was based in Volta Region in southeast Ghana, where the LGB had first entered the country. In this area LGB had already become established as a serious pest. The main objectives of the research component were to investigate the economic and social impact of the LGB, to develop and validate a range of technical options for maize storage, and to develop appropriate means of advising on these options.

Box 1. Recommendations and outputs by the LGB project research team

- Storage hygiene to prevent carry-over of LGB — # F
- Experimenting with platform woods to prevent LGB carry-over — #
  - changing platform woods — # F
  - smoking platform woods — *
  - chemically treating woods used in platforms — *
- Attention to good variety husk cover — # F
- Timely harvest — # F
- Treatment of maize in husk with recommended chemicals — *# F
- Shelling and treating grain with recommended chemicals — # F
- Shelling at an 'action threshold' of infestation — * F
- Improving the barn roof cover, especially using plastic sheeting, to exclude insects or thermally disinfest — * R F
- Using builders' lime made from oyster shells between cobs — *C R
- Using wood-ash between layers of cobs — # C R F
- Publicising methods which **do not** work against LGB:
  - smoking the store — # F
  - neem leaves — * F
  - previously-recommended maize storage chemicals, normal sun-drying — * F
  - dehusking maize — #
- Release of *Teretriosoma nigrescens* for biological control of LGB — # F
- A training game for extension staff on maize storage decision-making and cost-benefit analysis — * F

The project also tested and rejected as ineffective several more methods including improved sun-drying techniques, pulling visibly infested cobs from store (*F*), selecting and re-stacking visibly uninfested maize, neem oil, and several commercial dusts and insect growth regulators.

Notes: * Investigated for first time (in LGB outbreak area in Africa)
Method not new, but significant modifications or additions to recommendation made for local conditions
C Effective only for certain store climates
R Research is continuing to confirm and extend project results
F Farmers' input critical in developing or modifying recommendation

Source: Boxall and Compton, 1996

The research team was generally considered to be successful in meeting its three objectives. In three and a half years the team developed or significantly modified 11 main possible recommendations for farmers (Box 1), released a biological control agent for LGB (*Teretriosoma nigrescens),* carried out a detailed study of the socio-economic impact of LGB (Magrath *et al.* 1996) and produced various extension materials including a training game for extension staff. The team also made 11 published innovations in research and extension methods (Box 2). The Government of Ghana is currently continuing work on LGB in newly-invaded parts of Ghana with its own resources, largely using methodologies developed by the project.

By the end of the project, the LGB appeared to be a much less pressing problem for most farmers in the research area. In a 1996 survey of extension agents in Volta Region 65% of villages in maize-growing areas were said to have less LGB infestation than previously. In half of these villages extension staff said that the lower levels were due to farmers taking action against the pest.[2] Only in 18% of villages was it said that there was more LGB infestation than in previous years, and nearly half of these cases were in areas where the pest was reported for the first time. Moreover, the proportion of villages in maize-growing areas in Volta Region in which extension agents rated LGB as a 'serious' problem dropped from 31% in 1993 to 13% in 1996.[3] It is likely that climatic factors and the reduced storage period of maize in 1994—95 (due to shortages and high prices) were the main causes of the general decline in LGB populations over the project period. Nevertheless, farmer uptake of project recommendations is likely to have been partly responsible for the failure of LGB populations to bounce back, although no proof of this will be available for several years. Most farmers in the immediate project area are now aware of the LGB threat and take action to prevent LGB build-up in their stores, which is likely to be important in reducing overall LGB population build-up in villages.

4 Important aspects of managing applied research: objectives and approach

Five general aspects of the LGB project objectives and approach are discussed here: maintaining a focus on practical results; building on farmers' own experimentation; involving small-scale commodity traders in research and extension; basing research around farmer 'decision situations'; and resolving the extension problems posed by the development of a range of technical options.

Maintaining a focus on practical results for farmers

As mentioned above, there is a potential conflict in research between producing published scientific papers and producing practical results for farmers. Projects wishing for practical results must motivate scientific staff to give priority to the latter.

A high degree of farmer interest in finding a solution to LGB damage, plus frequent contact between farmers and researchers, were the key factors in giving the LGB Project a sense of urgency and keeping researchers focused on achieving practical results. It is hard to get distracted by arcane scientific questions if you continually have to face farmers who want to know exactly how far you have progressed since you last met them! This degree of farmer interest may, however, have been somewhat particular to the project and its circumstances: maize is an important food staple, and LGB is a new, destructive and high-profile pest in Ghana (Magrath *et al.* 1996).[4] Pressure for results also came from the Ministry of Food and Agriculture and the donor agency, which set tight deadlines and checked progress through quarterly research reports. However, for most project staff, farmer interest was the largest single source of motivation to produce results quickly.

Nevertheless, the conflict between time spent producing results and time needed to write them up for an international audience was not completely resolved within the LGB project. At least three ex-project researchers are now writing up academic papers in their own time, and there is a chance that some of the results will never be published outside project reports. Unfortunately, project reports have a short lifespan, as LGB staff learned when we failed to locate more than a small fraction of the reports produced by a very large, ten-year agricultural development project which immediately preceded the LGB project in the same region. Although farmers in several regions of Ghana now have access to project results, not all results have spread to neighbouring countries. Even for researchers in the same country, internationally-published papers may be the only available source of information on project work after a few years have passed. This makes documenting project activities an important concern (and one which should help other, similar projects avoid the hazard of 'reinventing the wheel'). There is, however, no easy solution to this conflict of priorities, and in the immediate project environment seeking solutions for farmers must remain the focus.

Building upon fanners' own experimentation

Farmers in the project area were very concerned about LGB damage and had themselves begun actively to experiment with control methods (Motte *et al,* 1995). Over 60% of farmers visited in village studies had made some change to their storage practices within two years of first experiencing LGB damage (Magrath *et al.,* 1996). Some of the innovations they tried are shown in Box 3. While this summary indicates that farmers had some success with their experiments, failures were even more common and were often penalised by heavy losses to LGB. Experimentation by individual farmers is a slow and risky process, particularly in the post-harvest area since, unlike in cultivation where small patches can be devoted to experimentation, farmers normally use their entire maize store as an experimental unit?[5] Thus, the project saw the collection, discussion, testing and improvement upon farmers' ideas and experience as providing an important service to farmers.

Project activities which aided collation of farmers' experience included: frequent village visits and observation of stores, which made farmers aware of researcher interest in and respect for their ideas so that they regularly volunteered information (Magrath, 1993; Magrath *et al.,* 1996); focus group meetings with farmers to solicit opinions about proposed storage

Box 2. Methodological innovations in post-harvest maize research made by the LGB Project

• A method for rapid field assessment of insect numbers in maize cobs	*P*
• A method for rapid field assessment of weight loss in maize cobs using a visual scale	*F P*
• A method for rapid field assessment of value losses in maize cobs	*F P*
• An improved weight loss assessment method for laboratory work (the 'modified count and weigh method')	
• Testing and improving pheromone trap design for LGB	
• A method for determining the relationship between price and insect damage in maize grain, using panels of maize traders	*F P*
• A method for farmer group evaluation of treatments in maize storage trials	*F P*
• A method for cost-benefit analysis of maize trials based on farmer practice and trader valuation	*F P*
• An extensive method of monitoring the impact of a biocontrol agent for LGB	*F P*
• Training maize traders as extension agents for on-farm maize storage	*F P*
• Decision trees for advising on multiple technical options and focussing research	*F P*

Note: *F* Farmers' input critical in developing or modifying method
P Method useful in farmer-participatory research

Source: Boxall and Compton, 1996

Box 3. Examples of farmer experimentation with storage pest control
(Roughly in order of most common to least common practice, where known)

Smoke the store (build a fire underneath)	N
Layer neem leaves or spread neem leaf slurry between cobs	N
Layer wood ash between cobs	P
Use subsidised cocoa chemicals (e.g. lindane, organophosphates and fungicides)	N/P, H
Use the previously-recommended maize storage chemical (pirimiphos-methyl)	N
Get someone with 'good hands' to stack the store	U
Change the wood of the store to get rid of carry-over infestation	P
Cover store with a galvanised iron roof to heat up maize	N
Cover store with a plastic roof to exclude insects	E/P, H
Winnow and sun dry maize grain to remove insects	N/P
Move stored maize inside house to escape infestation by flying insects	N/P
Store maize on farm to escape high insect populations in village	P
Fumigate maize with phostoxin pellets	E/P, H
Appeal to supernatural forces	U
Put palm-oil residue in store to encourage predatory ants (one farmer)	U

E - effective against LGB
P - partially effective
N - not effective
H - likely to be harmful to health in some cases or if not done properly
U - unknown effectiveness; not tested by project.

methods before embarking on trials (Magrath *et al,* in this paper); and monthly project meetings in which interesting field observations were shared with all project staff (see below). The project also made it a priority to provide information (via extension) to farmers about unsuccessful and/or potentially dangerous pest control methods. It is common for researchers and extension services to limit themselves to giving information about recommended practices, failing to mention things which do not work. Farmers, however, need good information about *all the* options available to them, since they may not be in a position to adopt the officially-recommended options (because inputs are unavailable or expensive, or simply because the proposed solutions are very inconvenient).

Involving commodity traders as well as farmers

Despite the fact that the price paid by traders for farm produce provides the main economic incentive driving the adoption of new technologies, it is not common for commodity traders to become involved in agricultural research aimed at small-scale farmers. By contrast, researchers in the world of large-scale commercial farming often depend on links with trading companies and large retailers for market research, extension and product development work (Schwartz, 1994). Many otherwise admirable participatory research projects fail to involve traders, possibly because of a long-standing mistrust of 'exploitative' traders in many cultures. For example, many participatory plant breeding projects depend on farmers, rather than traders, to judge the saleability of different cultivars. However, it is usually traders who have the best knowledge of what quality of produce the market demands, and traders are therefore in a good position to judge the economic benefits of many new technologies such as new varieties or pest control measures. The LGB project involved traders in pricing maize from trials and in developing a simple model of the relationship between insect damage and value loss (Compton *et al,* 1995 and forthcoming; Magrath and Compton, 1995).

Private commodity traders can also potentially play an important role in agricultural extension, especially in post-harvest technology. In Ghana, small-scale traders travel widely and arguably reach more farmers than the extension services (Motte, 1995). Moreover, in most of West Africa the majority of traders are women, who can often talk one-to-one with women farmers (who again comprise the majority of farmers, particularly for food crops) more easily than can the mainly male agricultural extension staff. Women are more likely than men to come into contact with traders, as in many areas they have the primary responsibility for selling household maize. Since most traders themselves come from a farming background, they have experience of on-farm storage, and are therefore well able to understand the concerns of their suppliers.

In the LGB project area, there were several reasons why traders were willing to act as informal extension agents for new insect control methods in stored maize. First, richer traders often give production credit to farmers which is secured through a lien on the farmer's maize store. This gives them a direct interest in the maize quality, as it influences both the farmers' ability to repay and the value of the collateral (i.e. the contents of the store). Second, many traders compete to keep particular farmers as their regular suppliers. In order to maintain farmer goodwill, traders often buy the whole store, including both good and insect-damaged maize; profit margins on the latter are smaller and less certain, so traders have an interest in maize held by farmers being kept in good condition. Traders may also provide other services to their regular suppliers, one of which is the procurement of chemicals used in storage for farmers in remote villages.

Over 500 maize traders were trained in storage pest control by the LGB project and their new knowledge was rapidly passed on to farmers and other traders (Motte, 1995; Semakor, 1995; Gbedevi, 1995; Compton *et al.,* 1995). It is common for traders to be with the farmer at the time the maize store is dismantled (traders may even help to shell the maize). Insect damage is very visible at this time and this therefore provides a good opportunity for traders to exchange information with farmers about storage pest problems and potential solutions.

Basing research around fanner 'decision situations'

The farming systems approach to research has traditionally concentrated on developing 'packages' of technical recommendations suitable for different 'recommendation domains' (types of farmer and farming system). Packages generally prescribe a season-long sequence of recommendations, as in the examples of maize storage packages given in Box 4. Validation for packages is normally provided by replicated trials in which the entire package is compared to local practice.

The problem with such packages is that most small-scale farmers do not follow them. It is common for farmers to adopt only parts of a package, which makes results unpredictable (and sometimes technically worse than previous local practice). For example, many maize farmers in Ghana, having been recommended the first package shown in Box 4, have adopted the narrow ventilated maize crib but either do not dehusk the maize cobs, dehusk them without treating them with insecticide, or leave them in the crib far longer than recommended. The fact is that small-scale farmers rarely make season-long plans. Instead they make a series of separate decisions throughout the season, based on the options and constraints at each moment. An example of maize storage decisions made by farmers in the project area is given in Box 5.

The concept of 'decision situations' is not new but it is often ignored by agricultural researchers (e.g. Norton, 1976; Norton and Mumford, 1993). Adopting this approach leads to the following research questions being posed.

- What options are currently available to farmers at each decision point?
- Are additional options needed?
- What information do farmers need to make better decisions?

These are quite different from the research questions addressed when developing a package.

The LGB project started out with a traditional farming-systems approach, and after the first year of working with farmers switched to a decision-based approach. After some understanding had been gained of farmer decisions and constraints, tools such as decision trees (Feakpi *et al.,* 1994) and a value loss model (Compton *et al,* unpublished) were used to model farmer decisions, to point out critical gaps in knowledge and to focus research on issues of relevance to farmers.

> Box 4. Examples of season-long technical maize storage packages promoted in West Africa
>
> *Domain 1: Larger-scale maize farmers*
>
> 'Use a recommended high-yielding variety, dehusk cobs at harvest and spray with an approved chemical, load them into a narrow ventilated crib, shell as soon as dry, treat with an approved chemical and store in sacks until disposal.'(CCDP, 1994)
>
> *Domain 2: Small-scale farmers*
>
> 'Use a recommended variety with good husk cover, harvest at the recommended time, select only cobs with good husk cover, clean the structure before putting in the new maize, smoke when weevil infestation is noticed.' (Ouattara, 1987)

Developing a range of technical options: from research to extension

Since farmers (particularly small-scale farmers) operate under a variety of different circumstances, it is unlikely that a single technical solution will suit all of them. Once this is recognised, it is not (in theory!) difficult for researchers to develop a range of technical options and for the extension service then to present farmers with a choice of options or the recommended adaptation for their particular circumstances. While this is certainly likely to be more effective than transmitting a single message to all farmers, it does have its costs. In particular it means that the task of extension staff becomes considerably more complex.

At the beginning of the LGB project the agricultural extension service in Ghana, as in many countries, was mainly geared to the transmission of single technical messages to contact farmers through the Training and Visit system. Many senior agricultural extension staff were initially doubtful about the concept of multiple technical options, which was seen as creating more

Box 5. Examples of sequential farmer storage decisions in the project area

What storage structure shall I build? *(traditional crib/improved crib/katchalla basket store/inverted cone/platform/kitchen loft)*

What roof should it have? *(long thatch/short thatch/tin/plastic)*

How should I store my maize? *(cob/shelled, husked/dehusked, selected/non-selected)*

Should the maize store be smoked? *(no/initially/occasionally/daily)*

Should I use a chemical? / Which chemical? / How much? *(recommended maize insecticides/non-recommended commercial insecticides/neem/ash/lime)*

If I only have a little chemical, how can I use it best? *(apply more thinly/apply to bottom layers/apply to outside/don't bother as it won't work)*

My cob maize is infested with insects - what should I do? *(leave/shell and keep/shell and sell/select and restack/dehusk and keep)*

My shelled maize is infested - what should I do? *(sell/treat with chemical/select/sun-dry)*

work for front-line extension staff and potentially leading to confusion on the part of both farmers and of some less well-educated extension staff. However, project experimentation showed that many front-line staff welcomed the change. Having more than one option to offer meant that they felt better equipped to respond to farmers' questions. Many also said that they preferred dialogue to the previously-dominant lecture format of meetings with farmers (Feakpi, 1995).[6]

The development of multiple technical options by the LGB project led to new research questions being raised in the area of agricultural extension methods. The challenge was to develop suitable training and supporting technical material to help extension staff advise interested farmers on the options most suited to them and to perform simple cost-benefit analyses to aid decision-making. The project developed decision trees, a training game to teach cost-benefit analysis and risk assessment (Compton, 1995) and other decision-making aids for extension staff (Feakpi *et al.*, 1994). They were used in pilot training exercises for extension staff in three regions in 1995. Development and testing of extension materials emanating from the approach is still underway (Compton, Motte and Addo, unpublished). A small part of the material currently being tested is shown in Box 6.

Some of the initial doubts of senior extension staff did, however, prove to be well-founded. Sustaining a dialogue-based extension format requires more dedication, technical understanding and empathy with farmers than a top-down lecture format, and not all front-line extension staff were prepared for this. Moreover, incorporating information on multiple options into a farmer group meeting, which is likely to remain the most common extension format, is not easy.

Since, however, the single-message extension system is increasingly being recognised as unsatisfactory, more work must be done to resolve these problems. One option is to group farmers at village level (according to various relevant criteria such as resource endowment and degree of initiative), but this is still a resource intensive activity. It is only likely to be possible on a wide scale if local para-extensionists are trained to perform some of the tasks (Defoer *et al*, 1996). In many cases the unresolved question is, how far does the extension agent (or para-extensionist) need to go in matching farmers with technical options? Or, conversely, how able are farmers to chose the 'best' option from a menu? This is likely to vary according to the nature of the technology in question. Where technologies are 'knowledge intensive' and have only long-term effects it is likely to be more problematic than with material technologies such as pesticides or new seeds, the results of. which are usually evident in the short-term (SWI, 1997).

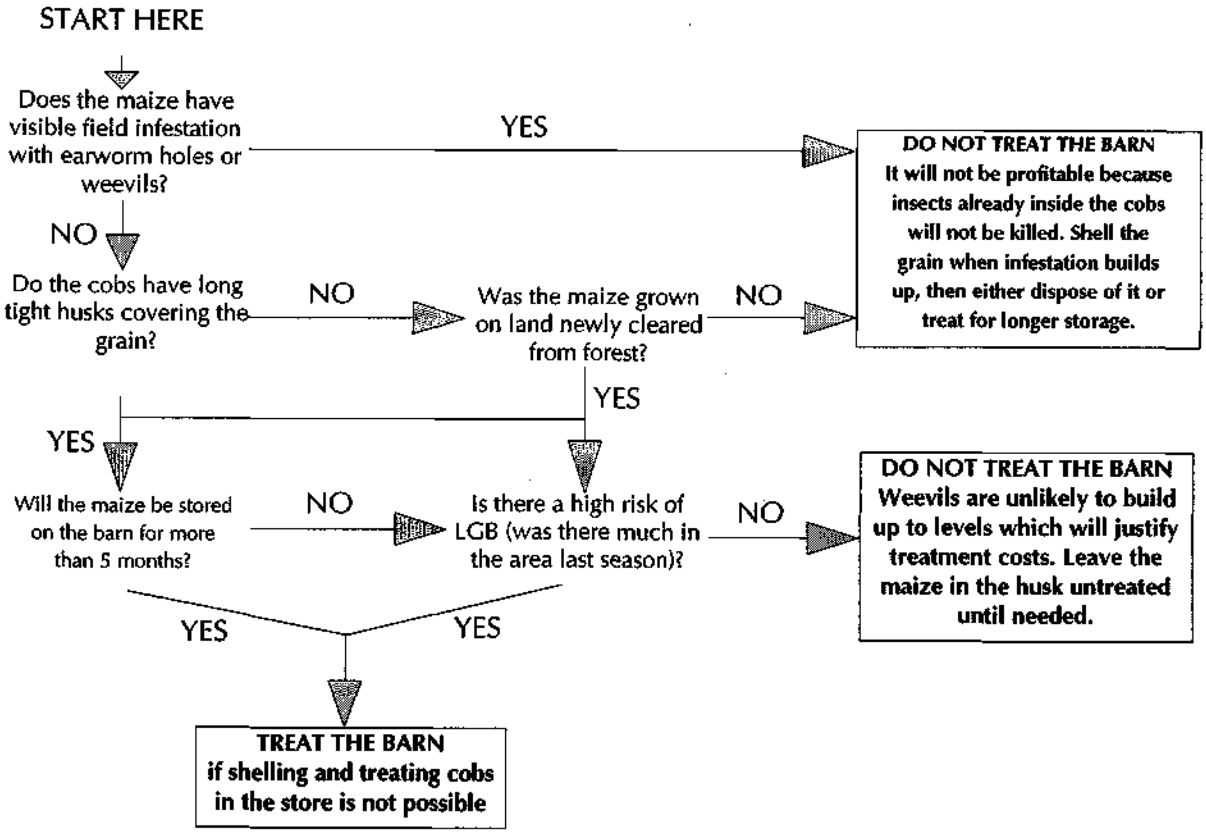
5 Important aspects of managing applied research: choice of research methods

The choice of research methods is a critical factor in both project productivity and in enabling farmer participation. Technical researchers, such as plant protection specialists, traditionally base themselves in the laboratory or research station, where they spend many hours taking detailed scientific measurements. Socio-economists, on the other hand, are (or were) famous for organising large-scale random farm surveys and then retiring to a computer to analyse them for the next year or two. Both are often too busy to talk to each other as much as they might have planned.

In many projects, the (welcome) advent of participatory methods has only partially solved this problem. Farmer participation is often sought only at the beginning of the research cycle, in the 'diagnostic'

Box 6. Testing materials for aiding decision-making: Example of a decision tree and associated case studies

DECISION TREE: SHOULD I TREAT THE MAIZE BARN WITH A CHEMICAL?*



* Note: 'Barn' is a common word for a store containing maize on the cob

Case studies for testing 'user-friendliness' of the decision tree with extension staff:

Case study 1
Charity, who is a trader living in Toh-Kpalime, had a small maize harvest in the minor season. She grew a local variety with long, tight husks. She plans to stack it in the barn in December and sell most of it in March to help with expenses for next year's planting. Although Toh-Kpalime village has LGB, Charity has never seen it in her barn or any of her neighbours' barns. Her husband has been using 'Actellic Super' chemical while stacking his large maize barn and is very happy with the result, so Charity wants your advice – should she invest in the chemical too?

Case study 2
Emmanuel, who is a farmer in Dormabin, had a large minor season maize harvest in early December. He sold off the major season harvest very quickly because it was too wet to store, but he plans to stack the maize from this new harvest after Christmas and keep it until May or June when prices are high. He hopes to be able to buy a bicycle with the money from sales. He says he cannot shell his maize because he has nowhere to keep the bags, and would like to know if it is worthwhile treating the barn with chemical, as he had a little LGB infestation in this barn last year and is afraid it will be worse this year. He grows Abeelehi (an improved variety with fairly good husk cover). The maize field was cleared from bush this year. Should he treat the barn?

Source: Compton, Addo and Motte unpublished.

phase. A common scenario is that the first participatory farm surveys are conducted by a multidisciplinary group, but the scientists then disappear into the laboratory to analyse all the samples they have collected, while the socio-economists find themselves left to write articles about the poor functioning of multidisciplinary teams! The main reason for this seems to be that the development of rapid, participatory, field-based methods in technical subjects has not kept pace with the development of such methods designed for the socio-economic component of research work.

Choice of research methods is discussed here under two headings: farmer and trader participation in research and the use of rapid methods.

Fanner and trader participation in research

Client participation in research is often presented as a moral issue, but for an agricultural project engaged in technology development it is also a practical imperative. At the very least, agricultural research projects should carry out effective 'market research' with all types of farmers before they commit themselves to any particular areas of work.

A large literature on participatory research is available, and details of the particular approach used by the LGB project are given in a companion paper to this one (Magrath *et al.,* in this paper). Thus, only a brief outline is given here.

The LGB Project followed a 'research-extension cycle' involving both farmers and maize traders (see Figure 1 in Magrath *et al.*, ibid). The project encouraged as much research work on farm as possible, on the grounds that contact with farmers maintains researchers' sense of urgency to solve their problems (see section 4) and also helps generate new research ideas. Introductory discussion meetings to find out how farmers viewed the storage pest problem were followed by close observation of farmer storage practices and meetings to discuss possible pest control options with farmers. Station trials were evaluated by farmers (as well as researchers), and maize from the trials was valued by traders (but see also Box 8). On-farm trials took place in farmer-managed stores with researcher-managed, farmer-applied treatments, evaluated independently by farmers and researchers. Researchers observed practical problems and technical difficulties (e.g. dose calculations for insecticidal materials) and tried to solve these with farmers. Sample analysis for surveys and trials was conducted on farm, in the presence of farmers, who were encouraged to watch and question methods and results. Extension recommendations were tested with farmers, and new methods for helping extension workers advise farmers on the choice between technical options were explored. MoFA extension agents were trained in new maize storage techniques, and fed back information to the research team (Box 7). Maize traders were also trained as informal extension agents (see Section 4). Experience from one round of the 'research-extension cycle' fed into the next round.

> **Box 7. Feedback from extension to research: getting the details right**
>
> Actellic Super® (permethrin/pirimiphos-methyl) dust was, at the beginning of the LGB project, the only recommended chemical for LGB control commercially available in Ghana. It was first developed for this purpose in Tanzania (Golob 1988) and is now a well-known chemical used in several African countries. In the first year of the project, therefore, extension training covered the use of Actellic Super® dust for storage of shelled maize grain, using standard international recommendations. The chemical proved popular, especially with larger farmers as well as other people storing maize as a commercial enterprise, such as traders and civil servants. However, project meetings with extension staff and visits to farmers who had used the chemical highlighted a number of problems with its use, including some confirmed reports of control failures, and some cases in which farmers feared failure due to seeing insect holes in the treated sacks of grain. Further trials by the project (Ofosu, 1994) verified the official recommendation and led to a number of small but important changes in detail. These included: changes in the dose (two different doses are now recommended depending on the planned period of storage); changes in the method of measurement of maize to be treated; emphasis on the need to winnow and clean the maize grain very well before treatment; and the proposal of a means of detecting control failures using a home-made sampling spear (insect holes in sacks are not a reliable indicator of control failure). The project also found many of the chemical sachets to be slightly underweight and held discussions with the local supplier about this. Later extension training therefore concentrated on these details, which were crucial to success of the technique under local conditions.

The use of rapid research methods

Slow and overly precise research methods can reduce research productivity. Rapid, field-based technical methods of analysis have many benefits including lower cost, greater speed, greater potential for increased sampling (especially important in small-scale farming systems, given their immense variability), and the greater participation of farmers and field staff in the analysis and interpretation of results. Rapid data analysis is equally important: there is no point doing a rapid survey, for example, if it then takes ten times longer to analyse the data than it did to do the fieldwork.

The LGB project speeded up work through:

- *Rapid surveys and methods of survey analysis.* Full details are given in Compton *et al.* (1995). In brief, the project: (i) formulated specific, practical survey objectives. For example, the question 'What are average crop losses from LGB?', which would need an extensive random survey to answer properly, was reframed as 'Who has a problem with LGB?', 'What is the nature of that problem?', 'Where should the project direct its resources?'; (ii) used a range of rapid survey techniques to meet these objectives, including making use of secondary data when available, identifying key informants, conducting informal surveys and case studies and calling larger meetings of farmers; (iii) used rapid and flexible techniques of data analysis and presentation, in particular mapping. Computer-based analysis, which is very time-consuming, was used only for longer-term project studies such as the three-year study of losses and decision-making study (Magrath *et al.,* 1996).

- *Rapid field-based methods of sample analysis.* Rapid assessment methods for losses and insect numbers were employed next to the farmer's store after sampling the maize cobs. In brief, these involved dehusking the cobs one by one, tapping each on a white tray, counting the insects which fell onto the tray, and scoring the level of insect damage to each cob on a standard visual scale. Mean weight loss, mean value loss (more interesting to the farmer), and mean insect numbers per cob for the sample can then be determined from a simple calculation which is completed on the spot. (Compton and Sherington, unpublished a,b). These methods had many advantages over laboratory-based methods, the most important being speed and the ability to obtain final results in the field.

  SPEED: Given limited research resources, there is always a trade-off between the speed of processing samples and the number which can be processed. Rapid methods thus enable increased sampling, which in turn makes possible wider coverage and/or reduced sampling error. In large surveys, the use of a rapid method may also reduce the very real risk of data fabrication by bored enumerators, because using a rapid method takes no more time than inventing the answers (Poate and Daplyn 1993). Surprisingly, extensive calibration of the rapid methods used by the project against laboratory-based methods showed very little loss of accuracy and precision. Those errors in the estimation of losses from farm stores are more likely to be due to sampling problems than the visual scale *per se* (Compton and Sherington unpublished a,b).

  ON-THE-SPOT RESULTS: Obtaining results in the field has several practical benefits. The need for transport and handling of samples is reduced, and with this the risk of sample spoilage, misidentification and other laboratory errors goes down. Interesting and anomalous results can be double-checked and discussed with the farmer before leaving. Samples (in our case, maize cobs) can be handed back intact straight after assessment, avoiding the problem of how to compensate farmers for samples removed to the laboratory. Finally, and most importantly, farmers can follow and understand the whole process of analysis, which contributes to the participatory nature of the work (see Magrath *et al.,* in this issue).

- *Development of rapid proxy methods for client evaluation.* Client participation in the evaluation of research results can be time-consuming and costly (Magrath *et al,* ibid), so one way of speeding up and cutting costs is to develop rapid proxy methods for researcher evaluation according to farmer and trader criteria. Such methods will not replace all client participation, but means that scarce resources can be channelled to involving clients where their opinions are most needed, rather than having them routinely evaluate every trial. Some of the methods developed by the project for rapid evaluation are summarised in Box 8.
- *Framing research questions to provide critical data needed for decision-making,* as discussed in section 4, also helped to focus and speed research.
- *Re-examining the research programme every month, as a team,* at the planning meeting (see section 6), rather than once a year. This made it possible to reschedule studies or to add additional studies to make the best use of staff or make opportunistic use of materials (such as insect-infested maize or wood) available from work which was coming to an end. The rapid analysis and feedback from each study (discussed below under 'quarterly reports') was essential to this process.
- *Simultaneous operation of surveys, on-farm studies, trials and extension activities.* Frequently, research projects of short duration (the LGB project was initially planned for 2 years and later extended to 3.5 years) have no time to produce extension recommendations, let alone get feedback on them. This is because it is often felt necessary to refine research findings before they are 'handed on' to extension. During the earlier phases of the project, the aim was to generate working hypotheses, which were refined as the project proceeded, rather than to produce definitive, publishable results. The initial survey was complete within three months of starting the project, while trials started within two months. Farmers and extension staff were informed of possible solutions to the LGB problem as these emerged. This allowed time for problems at the extension stage to be fed back into the research programme during the lifetime of the project. Such an approach does, however, entail some risks and may not be feasible for all projects, particularly those of a more exploratory or open-ended nature. The danger of commencing trials simply to be seen to be doing something should certainly be guarded against.

Box 8. Two examples of rapid proxy methods for client evaluation developed by the project

Objective	Client-evaluation method	Rapid proxy method (researchers)
Evaluate trial treatments for effect on insect damage	Farmer groups dehusk maize, classify cobs into damage classes, rank or score treatments (Motte *et al.*, 1996; Magrath *et al.*, 1996)	Researchers score treatments on the basis of visual damage scales based on farmer classification (Compton and Sherington, forthcoming)
Value maize from trials for cost-benefit analysis	Cobs from each farmer damage class are shelled together and the resulting grain samples are presented to maize traders for valuation (Compton and Magrath, 1995)	Researchers shell maize in standard damage classes based on farmer classification. Damage-price equations developed from work with maize traders are then used to value grain samples (Compton *et al.*, forthcoming). Work is in progress to calibrate visual scales to estimate cash value (Compton, Magrath and Ofosu, unpublished data)

6 Important aspects of managing applied research: project organisation

Important organisational features of the LGB project included: a 'critical mass' of researchers organised in an interdisciplinary team with an anti-hierarchical ethos; the selection of experienced staff; extensive training for the whole project team; monthly meetings and quarterly reports used as management tools; good choice of host institution; flexible funding arrangements; and good administration.

A critical mass of researchers

A prime factor in the success of projects as a format for research is that they bring together a group of researchers who work together for a single goal and often in a single location. It is common for researchers in developing countries to be isolated and overstretched, which drastically diminishes their productivity. Prior to the LGB project, this was the case with post-harvest maize research in Ghana. A handful of post-harvest researchers was scattered through three universities and three research institutes, mostly working on separate and unrelated studies. Moreover, researchers everywhere in the world famously suffer from competitiveness and unwillingness to share ideas, a tendency which is encouraged by physical isolation.

The LGB project research team had 20-25 staff members, of whom eight were university-trained.[7] The majority were regular staff of the Ministry of Food and Agriculture. The project also had several National Service Personnel (secondary school leavers on one year pre-university work experience placements) and some casual laboratory staff (mostly unemployed secondary school leavers) at peak times of year. The administrative flexibility to take on students and other staff at short notice was very important to research success, as was the integration of all such staff as fully participating members of the project team.

The existence of a large group of researchers made the project team a natural centre for short-term training placements, for example for post-harvest officers from other regions, for university students studying post-harvest subjects, and for researchers from neighbouring countries. Taking on short-term trainees can be an overwhelming burden for a small research group, but a large group has a large number of activities which can easily absorb visitors.

An interdisciplinary team

Including socio-economic and extension specialists in an applied research team is likely to be important to the success of the research. However, the process of integrating this expertise and building a cohesive interdisciplinary research team is equally important. Many technical projects now recruit socio-economists, in particular, with the idea of keeping the technical workers in touch with farmers' opinions. However, the socio-economist cannot function alone as the 'human face' of a technocratic team, as testified by several critical accounts (e.g. Maxwell, 1984; Horton, 1984). It is necessary that all team members have a common vision of the work which includes interest in a farmer-participatory approach.

There are two phases in building an interdisciplinary team: project preparation and project implementation. During the project preparation phase, two important steps are the recruitment of staff who are sympathetic to interdisciplinary work and the definition of shared research objectives. This is often not well-recognised, as was the case with the LGB Project. Although the project was fortunate to have several staff members who were sympathetic to and experienced in interdisciplinary work, such experience was not an explicit criterion in staff recruitment, and not all staff were initially so inclined. Moreover, the original project document defined two separate research programmes: the 'socio-economic programme' and the 'entomology research programme', although there were some indications that these should work together. The donor did take an interest in strengthening interdisciplinary work and arranged a special briefing of expatriate staff to discuss this issue before the project started. However, most of the practical work of building an interdisciplinary team took place during the implementation phase of the project, and since this is a very common situation the lessons learned may be useful to other projects.

Key factors which contributed to building an interdisciplinary team were:

- the redefining of research objectives by and for the research team as a whole (not split by discipline) after the project began;
- the use of interdisciplinary teams on each project study, with different individuals responsible for each study;[8]
- mixing teams on different studies, giving everyone the chance to work with everyone else;
- frequent discussion of project objectives and results, both informally and in plenary monthly meetings (see below);
- in-service training in which the whole team was involved (see below).
- promoting disciplinary transparency, such that all team members would be aware of the objectives and methods of every study, and these would be open to debate. Everyone had a chance to undertake ail field tasks, whether or not these would have been considered normal for their particular discipline. 'Blinding with science' (or with any other discipline) was discouraged.
- finally, the wearing of project T-shirts (initially developed as extension materials) as an unofficial uniform by many members of the research team also fostered a team identity and helped to identify new project staff to farmers on field visits. In retrospect, an official project uniform (such as a T-shirt or hat) might have been a good investment.

Anti-hierarchical ethos

Whatever one's own preferred management style, it must be recognised that the strict, hierarchical way of working which is typical of many conventional research setups can be counterproductive in applied agricultural research. There are several reasons for this. First, so-called 'junior' technical staff often have knowledge which is not available to 'senior' university-trained staff. If they do not feel that they are respected and valued members of the research team, they may not communicate this information to others in the project or use it to improve project work. For example, agricultural technical staff often communicate better with farmers than city-bred university graduates and may receive more honest feedback about ideas advanced by the project. Also, junior technical staff are often less mobile than senior staff and may therefore be aware of previous agricultural development work in the project area; their knowledge can be valuable to prevent the project reinventing the wheel. (As an example, one research project unwittingly set up an experiment which was virtually identical to that done by a previous project a few miles away: one of the technicians had actually worked on the previous experiment but did not think that anyone was interested enough in his opinion to mention the matter.) Second, the success of trials and fieldwork depends on all staff understanding the reasons behind their activities and feeling responsible for the success of the work. Third, the call for participation with farmers looks hypocritical if there is no equivalent respect for all project staff.

The LGB Project aimed to devolve research and extension responsibilities among staff as much as possible. For example, MoFA Technical Officers and District Post-Harvest Officers were encouraged to make substantial inputs into the design and implementation of studies and trials and to question objectives and methods. All staff were encouraged to take on responsibility for some part of the work, depending on their individual talents, "which ranged from laboratory management to acting. All staff were also involved in manual field work (such as shelling maize or carrying baskets of cobs), especially at peak times of year. This helped to win the confidence and enthusiasm of technical staff, who had previous experience of senior staff disappearing into a cool office to do something 'more important' when any hard labour was to be done. It was important to maintain this atmosphere as new staff joined the project. One interview technique devised by the technical staff - which deterred at least two applicants - was to ask interviewees to join other staff in field labour.

The willingness of several senior individuals on the project to share ideas with all staff, to discuss and question methods, and to participate in field labour was a critical factor in the success of the anti-hierarchical approach. Their positive attitude meant that any other person who attempted to pull rank experienced social pressure against this behaviour. This underlines the importance of exploring senior staff attitudes to such issues during recruitment.

Experienced staff

Obvious though it may seem, it is worth mentioning the benefits of having experienced staff on agricultural research projects. It is not uncommon to find research projects which are run by Ph.D. students or by inexperienced people fresh from university, partly in the interests of economy. Intelligence and dedication, even when combined with an interest in farmers' views and in a participatory approach, are no substitute for field experience. This shows up in the tendency to reinvent the wheel mentioned earlier, and in numerous small but costly experimental errors. Farmers, too, are more likely to take a participatory dialogue on a farming subject seriously when the researcher knows something about farming and about the subject: goodwill is a necessary, but not sufficient, condition for productive dialogue.

The LGB project was fortunate to be staffed by people with substantial experience in post-harvest grains, marketing, extension and participatory work with farmers. The senior entomologist, who was seconded to the project from the Ghana Crops Research Institute, had over 20 years of post-harvest experience. The expatriate staff were seconded from the Natural Resources Institute (NRI), an UK-based centre for post-harvest work which had previously managed four other field projects targeting the Larger Grain Borer (see e.g. Farrell *et al.*, in press). The team received technical back-up from NRI and was able to build on its experience. This 'institutional memory', which is lacking in many one-off projects, was very important.

In-service training

There are three main reasons why training is an important component of agricultural research projects. First, team-building requires that all team members share a common vision. This can be imparted by training. Second, if projects are to be sustainable, team members who stay on after the end of the project must be fully equipped and trained to continue the work. Third, if research is to be implemented effectively, *all* research staff must have a clear understanding of research objectives and methods. Many small, on-the-spot decisions have to be made during trials and field studies which will affect the quality of the data obtained. If study supervisors do not feel able to delegate these decisions without risking major errors, they will have to oversee every single activity personally and this will significantly lower the productivity of the project.

Virtually all projects include some element of staff training, but this is often individualised (e.g. short courses or degree courses away from the work site) and limited to senior staff members. Even if the content of such training is very relevant to the project work, which is not always the case (for example with some overseas courses), a returning trainee may find it difficult to make full use of the new ideas gained to improve the project, unless s/he is an enthusiastic and articulate enough advocate to bring others round to the new way of thinking. Moreover, when individuals are sent away for long periods of training they may miss critical moments in the project team's own development.

In the LGB Project, many in-service training sessions were held for all project staff. In most cases, other staff of the MoFA also participated. Subjects covered included: participatory methods, statistics, experimental design, data analysis, report-writing, computing, laboratory methods, and field research methods for individual studies. Most of these sessions were given by project staff with experience of the particular subject involved.

Training methods were informal, dominated by group exercises and discussions, and the subject matter was tailored to project needs. In two cases outside experts were engaged to give short courses. A major advantage of this was the prestige which being able to draw on international expertise brought to the course, especially when it wished to attract and persuade senior Ministry staff of the value of a new approach, as was the case with the 'farmer participation' course. On the other hand, the disadvantages were the cost and the difficulty of tailoring the courses to local needs; both the courses given by outside experts were later supplemented by sessions given by project staff.

Plenary training sessions offered a good general forum for discussion and team-building, as well as helping to make sure that everyone shared an understanding of subjects such as basic interviewing techniques and the purpose and correct use of blocking in replicated trials. Individual staff career development plans were not ignored, however. The project helped individuals to gain specific skills and qualifications which could help them in their future career, including degrees, computing skills and practical certificates such as driver's licences. This was an important factor in retaining staff enthusiasm for the hard work demanded by the project. In the final year of the project a consultant was taken on with the remit of discussing future plans with all staff individually and making detailed proposals for the continuation of work after the project (Sekou, 1995).

Monthly plenary meetings

It is easy for a complex research project to run into communication problems. Study and trial organisers often compete for laboratory staff, transport and facilities, and resentment can arise over small issues. Regular, formal meetings are essential to prevent this.

All LGB project research staff and collaborators (20-30 people) met once a month for about three hours. District staff had a financial incentive to attend these meetings, as travel and subsistence payments for the month were made on the same day. National project management was also represented at most meetings.

The monthly meeting had three main sessions: report-back of the previous month's work; work plan for the coming two months; and administration. In the report-back session, which took more than half the meeting, *all* staff were asked to report on progress, by study. This provided some unspoken peer pressure for achievement of work goals, and also brought any misunderstandings out into the open. Staff were encouraged to report any interesting field observations they had made during the month and to discuss them in the meeting (these-xould be, for example, farmers' ideas or problems with the methods or equipment used in the study). Often, such a discussion would result in an immediate plan for follow-up action to check or test the observation.

In the planning session, a large calendar for the coming two months was put on a whiteboard at the front of the room and filled in gradually as study organisers called out their plans and personnel needs, and staff called in other commitments such as leave and meetings. This not only made everyone aware of all planned project activities (at times up to 15 studies and multi-site trials were running simultaneously), but it also made transparent the process of competing for staff and facilities at peak times, and forced the project to prioritise openly. Finally, in the administration session, all staff had an opportunity to air grievances or resolve problems openly, or to contribute to administrative decision-making. Recurring discussions included such subjects as: 'Is the mileage allowance enough to cover motorbike costs?'; 'How can we prevent overuse of the photocopier?'; 'Should we take on some casual staff this month?' The meetings thus helped to foster team spirit as well as improving communication.

Quarterly research reports

In theory the results of one research study are always a vital input into planning the next one. However, a classic problem in agricultural research is that the agricultural year rushes swiftly on from seed time to harvest, and often data analysis takes a back seat, especially when the experimental programme is ambitious. It is surprising how often scientists reply, when asked for their trial results, that they have not yet looked at the data. Yet frequently the main results may be obvious just from a visual inspection: for example, treatment A does not seem to work, and treatment B looks much better than the rest. If statistical analysis is needed to see if treatment C really is better than treatment D, this may mean that the results are not really sufficiently striking to be of interest to small-scale farmers. Given the variability of small-scale agriculture, approximate results from a large variety of environments (preferably on-farm) often give a better picture of a treatment's likely performance than detailed statistical analysis of one or two trials.

In the LGB project, the quarterly reports required by the donor agency developed into an important tool of research management. Quarterly progress reports were collected from each study organiser, and results were insisted upon even where these were only rough impressions (this was made clear, of course, in the reports). This improved project productivity and helped with planning subsequent studies. Regular, detailed reporting also provided an opportunity to verify that each study organiser was on top of his/her subject and had fully thought out the objectives, methods and analysis, thus maintaining good research quality.

Supportive institutional setting

The location, attitudes and managerial culture of the host institution are critical to the success of any research project. Institutions which are physically distant from farmers and their problems, which prioritise concerns such as the production of academic papers, or which have internal managerial problems are unlikely to be suitable hosts for a participatory, field-based project.

A further problem can arise if a project is based at an inappropriate level within the host institution. Projects frequently base themselves at the national headquarters of the host institution, usually in the capital city. This is rarely ideal, because headquarters staff are frequently overloaded with other activities and visitors, the capital city is usually some distance from the main farming areas, and city life provides many counter-attractions to project work. On the other hand, projects which have no national representation are likely to run into political or organisational problems originating at national level.

The LGB project's national management was based in the MoFA offices in the capital city, while the research team was based in a regional office of MoFA, opposite the regional agricultural extension offices. Most agricultural research in Ghana is based in research institutes under the Council of Science and Industrial Research rather than in the Ministry itself, although some MoFA departments carry out adaptive trials. However, there were many advantages to being based in the MoFA and the arrangement worked very well for the LGB project. The Ministry's extensive network of staff in rural areas helped the project make rapid contact with farmers and traders, and research-extension linkages were very strong due to the physical proximity of the extension department.[9] However, the future of adaptive research in the Ministry is currently under debate and it is not clear if the type of research developed under the LGB project will continue.[10] Since long-term institutional changes affecting research are frequent in nearly all countries, this is perhaps an argument for investing in short-term research projects with a clear focus and time-limit (such as the LGB project), as long as the nature of the research problem makes this possible.

Flexible funding arrangements

Funding arrangements can influence project efficiency and morale. This section discusses several funding-related issues, including the question of who pays recurrent project costs, the amounts of those costs, and administrative flexibility for fund-holding.

In projects which receive finance both from a national government and from an international donor agency, the question of who pays recurrent costs such as travel, subsistence and fuel is often a touchy one. Commonly, the national funding agency has cash flow problems and finds it difficult to make such payments on time, while the donor agency refuses to pay them on the grounds that this will make the project work unsustainable. Meanwhile work may grind to a halt, as most staff cannot advance payments out of their own pockets. Although sustainability of the work is undoubtedly an important issue, it is the contention of this paper that it must be addressed at an early stage, during project planning. Once the decision has been taken to finance an intensive, relatively expensive project (for example, one which provides vehicles and expatriate staff), it is uneconomic to risk the outcome of the project by refusing to pay recurrent costs. The alternative solution, of course, is a low-budget, long-term research project using existing personnel in research institutions — this is normally more sustainable, but carries the risk that it will not be able to mobilise a critical mass of researchers to accomplish the research objectives, or that unexpected institutional changes will threaten the research set-up (see above).

The levels of such recurrent payments constitute another issue which can affect long-term research success. It is argued here that subsistence and other such payments made by projects should be roughly in line with local rates, even if they are paid by foreign donors. Certain aid donors are known for making very high subsistence payments. In part this may be because rates are a difficult moral point for many expatriates on international salaries, who feel uncomfortable about the differences between their salaries and those of locally-paid staff, and tend to compensate by boosting the rates of project payments. However, if project rates rise significantly above local rates, there can be several adverse effects: it may sour the relationship between project staff and others in the host institution who do not receive such payments; it may attract senior staff of the host institution (often not well-paid themselves), who then use their rank to supplant people who are actually involved with the fieldwork (this is particularly common at internationally-funded meetings and conferences, which often carry heavy subsistence payments); and it tends to skew the work unduly towards the types of activities which are eligible for payment. For example, if attending meetings carries special financial benefits while laboratory work does not, no-one will be very enthusiastic about doing laboratory work.

Finally, it is important for projects to have the administrative flexibility to manage their own budgets according to local needs. For example, it is beneficial to be able to make overtime or day-out subsistence payments when needed; some projects/donors only permit the payment of overnight subsistence, leading staff to invent reasons for overnight stays, or to compete for overnight trips while important work nearer to base is disfavoured. Problems over the use of project vehicles are also common. Many institutions/donors have a standard vehicle policy and insurance terms which cover urban and rural projects alike. In rural areas, in particular, numerous social obligations arise which may conflict with the policy, such as the need to give lifts to farmers when travelling from village to village (in remote areas, the project vehicle may be the only vehicle which has passed that week), or to help staff members with pressing family needs such as funerals of very close relatives. Project failure to comply with such obligations can affect the outcome of research when farmers become unwilling to collaborate or staff morale drops. Administrators of rural projects must thus maintain a difficult balance between minimising expenditure and other risks connected with using project vehicles, and keeping the project on a good footing with collaborators and staff. Centralised regulations restricting vehicle use to that expected in an urban environment can make this task very difficult, although guidelines are of course essential.

The LGB project was very fortunate to have, during most of its lifetime, a flexible local budget from the donor agency which enabled the project to advance money to cover recurrent costs (mostly travel and subsistence) much of which was later repaid by the MoFA as funds became available. The budget also permitted the payment of some overtime to Ministry staff, and other payments such as gratuities to traders who helped with the research (see Magrath *et al.*, in this paper). Such payments were critical to the high productivity of project research. All payments were in line with local rates and staff were generally accepting of these and willing to work very hard, although the rates formed an ever-interesting subject of discussion at project meetings!

Good central administration

The quality of central administration can make or break a project. It can be very demoralising if the arrival of key equipment is delayed or if overlybureaucratic rules stifle initiative. Over-centralised and inefficient procedures can drastically reduce productivity. For example, some international organisations require all procurement to be done through a malfunctioning central system, delaying the arrival of vital equipment. (One expatriate on a two-year project said that his project vehicle arrived "just in time to transport the drinks for my leaving party"!)

The national and international administration of the LGB Project was very efficient, particularly in managing procurement and maintenance of project equipment (see Box 9). There was also a long lead time for the project (not wholly intentional), which meant that imported equipment such as vehicles and laboratory supplies had arrived before work began. In addition, the project budget allowed for local procurement of materials and recruitment of local consultants, students and casual staff, avoiding some of the problems described above.

7 Important aspects of managing applied research: liaison with other organisations

For research projects, open communication and good linkages both with other departments within the host institution and elsewhere within the agricultural technology system are essential. These help prevent duplication of work, avoid contradictory messages being given to farmers and improve the chances that project work will be sustained in future.

The LGB project was partially successful in its liaison efforts. The project worked closely with several other departments of the Ministry, especially the agricultural extension services. Other stakeholders such as farmers, political officials, NGOs, schools, agricultural training centres and other post-harvest projects were kept informed and involved through yearly project workshops, other meetings, radio and TV programmes, contributions to newsletters and wide circulation of project reports. The project also hosted many visitors, including farmer groups and short-term trainees. Close contact was maintained with post-harvest researchers from neighbouring countries and LGB researchers around the world, to avoid duplication of research. Access to email, which came only six months before the end of the project, made a drastic improvement in international communication.

Nevertheless, in retrospect, even more effort could have been put into liaison and this could usefully have been spelled out as a specific project objective. On several occasions, project staff were surprised to discover other institutions or NGOs carrying out research which had previously been done by the project, or promoting technical options which had already been tested and found wanting. The original budget did not include adequate provision for liaison activities and resources had to be squeezed out of budgets for other activities. Finally, there was no formal linkage to 'upstream' (long-term, more speculative, better-resourced) research on LGB, which is currently carried out by a number of institutions including NRI (UK), the International Institute of Tropical Agriculture (IITA) and universities in several countries. Such linkages could run in two directions: uptake by upstream researchers of ideas generated by field projects, and review by field projects of proposals from upstream researchers. The LGB project generated a number of ideas for upstream research, but there is currently no formal mechanism for collecting these (together with those from other field projects) and reviewing them. Similarly, upstream research proposals are mainly generated and judged by the same institutions which implement the proposals (funding institutions rarely comment on details, although these may be critical to the success of the proposal), and there is rarely any formal procedure for 'peer review' by field projects. LGB project team members did have some opportunities both to propose research topics and to make comments on proposed upstream research projects on

Box 9. Motorbike maintenance

Motorbikes provided for project research work often have a short life-span and/or require heavy maintenance costs. Two common problems are careless bikers who fail to do basic routine maintenance and 'project mechanics' in a semi-monopoly position who charge over the odds for their work. Giving bikers a personal stake both in keeping the bike in good condition and in saving on maintenance costs goes a long way towards solving these problems.

The system developed by the LGB project was successful in keeping the 12 project motorbikes on the road during the project period (and to this day) at reasonable cost. After selecting individuals who needed motorbikes for project-related work, contracts were drawn up for the motorbikes to be sold to each individual, based on monthly payments to be completed before the end of the project. A fuel allowance calculated according to a specified rate per mile was paid monthly on presentation of mileage sheets. Claimed mileages were-checked by the organisers of each research study involved, before being passed to administration for payment. (Payments were only made on approved project mileage, although bikers were also free to use their bikes for personal transport.) At the same time, a maintenance 'hard-running allowance', also based on mileage (for most of the project period this matched the fuel allowance), was paid into a special bank account. A record of each biker's holdings in this account was maintained, and individual bikers could draw on the funds they had accumulated to buy spare parts and pay for maintenance. This provided an incentive for bikers to seek out the lowest-cost maintenance to make best use of 'their' maintenance money. A reliable local mechanic was normally used, but riders were free to go elsewhere or bargain over rates if they felt he was overcharging. At the end of the project, any funds remaining to each biker's credit were used to buy spare parts for his machine. Meanwhile, the repayments on bike purchase were also paid into a special bank account, and at the end of the project these were made available to finance fuel costs for continuing research work.

LGB, but these were largely accomplished through personal contacts rather than any formal system. However, developing formal upstream-downstream linkages may be difficult in many cases given the multiplicity of institutions involved and the (often covert) competition between researchers from different institutions.

8 Summary: lessons to be learnt

Drawing on the experience of the Ghana/UK LGB project, this paper argues that simultaneous attention to selecting the right objectives and approach to the work, finding appropriate research methods, managing project administration effectively and investing in liaison with other organisations is necessary if applied research projects are to be successful. However, it must be acknowledged that the LGB project had some unusual features which might mean its experience would not be easy to replicate. It was a closely focused project, concentrating on the storage of a single crop after harvest, and to some degree on a single pest (LGB), in a single (although diverse) region of Ghana. Because the main target pest was new and highly destructive, farmers were very interested in the project outcome. It might not have been so easy to motivate the research team, or to secure such willing participation from farmers, if the research issue had been less well-defined, visible and immediate in its consequences (although there are many other such farming issues, especially in plant protection).

Even with these advantages, the positive features of the project described in the paper did not all arise by design. Some foundations for success were laid during project preparation (e.g. choice of a host institution with excellent contacts with farmers and extension), but some were due to good fortune (e.g. the genuine interest shared by staff in interdisciplinary, on-farm work). Moreover, the LGB project also had a number of weak points, of which the most serious is the question now raised as to whether the host institution will be able to carry out adaptive research in future (although some research is continuing at present).

In spite of these caveats, it is hoped that some aspects of the LGB project's experience may be useful in setting up new, applied agricultural research projects. In particular, it is suggested that:

- The project document should have clear overall goals, yet be flexible in detail, encouraging innovation by the team on the ground.
- The relative priority given to practical results for farmers and to publications should be clearly spelled out and budgeted accordingly. Frequent contact with farmers and extension staff is desirable to give researchers a sense of urgency.
- The project team should include staff with scientific, practical farming, socio-economic and extension expertise.
- The majority of research goals and activities should not be separated by discipline
- Staff recruitment should specify the need for on-farm experience and also experience (or at least proof of interest) in interdisciplinary team work. Back-up support and advice in specific technical areas should be made available.
- A suitable host institution with compatible goals and institutional culture should be sought. A regional research base with a national administration was a successful combination in the LGB project.
- Ample provision should be made for in-service training for the whole research team, which should be seen as a team-building exercise as well as a chance for individuals to gain specific skills. Training in participatory work, interview techniques and research skills (such as experimental design, computing, data analysis and report-writing) is likely to be useful.
- Provision should be made in the budget for liaison activities such as workshops and meetings, and investment in improved communications, such as email. Contact with other researchers, in particular, is invaluable to prevent duplication of effort.
- Administrative delays in setting up projects are common, and the time should be used to best advantage, especially if equipment is to be imported. Team members should be encouraged to communicate with each other and with other researchers in the same field in advance of the project's official start date. Ideally, there would be a pre-project workshop to facilitate this.

Finally, farmer-participation is a very popular buzz-word among international donor agencies at the moment. But agricultural problems cannot be 'participated' out of existence. Increased attention to farmer participation, although welcome, should not make technology-development projects lose sight of overall goals. Moreover, where a participatory approach is adopted, it is important to make sure that this is integrated into all activities and used by all members of the research team, rather than being grafted on as an independent activity undertaken only at certain times or by certain team members (typically the socio-economists). It is also important to look critically at the specific research questions asked and the technical methods used to make sure that these are all compatible with a farmer-participatory approach. In many technical disciplines, work is still needed to develop rapid, field-based methods of sample analysis which are compatible with rapid, participatory field studies.

Endnotes

1. The project was managed in Ghana by the, Post-Harvest Development Unit of MoFA and in the UK

by what was then the Natural Resources Institute of ODA.

2. The other villages in which LGB had declined were mainly denoted as ones in which 'less LGB appeared in 1996'. In a few cases, the decline was attributed (without evidence) to the biological control agent which had been released against LGB.
3. Sources: LGB Research Team Quarterly Report 8 (ed. J Compton) (n = 414 villages) and unpublished survey data, LGB Project FLS Survey, 1996 (n= 389 villages). 'Don't knows' (but not 'nones') were excluded, as were the three most southern districts.
4. For example, LGB was discussed in the Ghana parliament following farmer complaints about damage, an 'honour' rarely accorded to other pest insects. Senior members of the government had good reason to sympathise: at least one had experienced severe losses to LGB in his own grain store. LGB also provoked the collapse of an NGO-sponsored village credit project by destroying the grain stored cooperatively as collateral.
5. Farming families in the project area usually have one or two maize stores with the median size of a store being about 500 kg of cobs. In the most common store type ('ewe barn'), maize is stacked on a platform in orderly rows in a cylindrical stack, with no exterior supporting walls. It is difficult to subdivide such a stack for experimental purposes: in research station trials, stacks are occasionally divided with a complex arrangement of chicken-wire and wood, but this is expensive and would be impractical for farmers. An experiment, such as the use of a chemical which is not effective against LGB, thus normally involves the entire maize store and failure can cost farmers dearly. We visited one farmer who had tried four different practices to save his maize from LGB; none worked and he had to purchase extra maize from the market to feed his family.
6. Over the project period, the extension service as a whole moved towards introducing extension based on a dialogue with farmers, which was simultaneously being promoted by a number of other institutions in Ghana.
7. One was on secondment from the Crops Research Institute, two were British expatriates and two to three were research students from national universities and polytechnics.
8. The term 'project study' refers to a coherent group of project research activities with a single objective. This could be a field or laboratory study or group of trials.
9. An earlier plan to base the research team in an agricultural research station rather than in the regional Ministry offices would have made the logistics of on-station trials easier, but would probably have reduced the links to farmers and extension staff.
10. The Post-Harvest Development Unit, in which the project was based, was moved during the second year of the project from the Crops Department of MoFA to the Agricultural Engineering Services Department, which has less history of adaptive research work.

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Cost-benefit analysis of client participation in agricultural research: A case study from Ghana

Priscilla Magrath, Julia Compton, Anthony Ofosu, and Felix Motte

Participatory approaches to research are becoming popular in aid projects and in some national and international research institutes. But while research projects themselves are often subject to rigorous financial and technical appraisals, research methods tend to escape any kind of economic analysis. Although participatory approaches are often adopted for practical reasons, to increase the effectiveness and productivity of research, attempts to estimate net benefits of client participation are rare. One reason for this may lie in the difficulties of applying conventional cost-benefit analysis (CBA) techniques when the benefits of participation are often hard to measure and may be spread over many years. Ideally, one would want to compare a range of projects with similar goals, but varying levels of client participation. In the absence of comparative data from other projects, this paper explores the possibility of assessing the incremental costs and benefits of client participation in research within a single project, the Ghana/UK Larger Grain Borer project. This project included a range of research activities with varying types of client participation. The CBA involves comparing the costs, level of participation and contribution to achieving research goals of each research activity. Overall costs and benefits of client participation are then estimated.

The analysis is useful in highlighting the relationship between choice of research method and achievement of stated research goals. In a world of shrinking research budgets, it is hoped that it will stimulate debate concerning the cost-effectiveness of participatory methods, compared with conventional, research institute-based methods, achievement of wider project benefits, in this case a reduction in farm storage losses. This problem could be addressed through improved monitoring of benefits from individual projects, and through comparative analysis of data from several projects with similar goals.

1 Introduction

Much has been written in general terms about the benefits of client participation in agricultural research (Chambers, 1992; IIED, various), but it is rare to see an economic analysis of the costs and benefits of participatory research as compared to other approaches. Instead, the decision to use participatory methods is usually based on ideological belief or practical reasoning. Ideological reasons for using participatory methods include the feeling that conventional research methods are extractive and therefore unethical, and the belief in the potential for participation to lead to political empowerment. Where this is the case, participation may become an end in itself. Practical reasons for using the methods include the belief that the quality of research will be improved if local knowledge and ideas are incorporated, and that adoption rates of technologies will be higher if the technologies match local requirements.

Cost-benefit analysis (CBA) seems to have been ignored, both as a technique for deciding which research approach to adopt, and in the evaluation of participatory approaches. One reason for this probably lies in the difficulty of applying conventional CBA approaches to participatory research projects, as this paper will explore. There are, however, two main reasons for conducting CBA of participatory approaches. First, estimating overall net benefits from client participation can help research institutions decide whether or not to adopt participatory approaches in their work. Second, it can help researchers to select the most cost-effective method - amongst the many participatory methods on offer - for achieving the stated goals of the research.

Cost benefit analysis for project planning can be broken down into a number of steps: defining the goal or desired outcome of the activity; identifying alternative means of achieving this goal; enumerating the relevant costs and benefits; and measuring and comparing these costs and benefits in order to select the best alternative.

The first problem encountered in a CBA of different approaches to agricultural research is that 'conventional' institute-based research and farmer participatory research may not have the same objectives. The adoption of a participatory approach can lead to changes in the attitudes and goals of researchers, and an accompanying shift in emphasis from the generation of technology to the solving of clients' problems, or to enhancing farmers' ability to tackle their own problems. Even where shared objectives can be defined (for example, to maximise adoption rates), institute-based and participatory projects are unlikely to agree on the definition of all benefits. For example, increased farmer experimentation, or the formation of farmer extension groups might be seen as an output/benefit of a participatory project, but may not be valued or even noticed by an institute-based research project. Since proponents of the two types of research develop their own criteria for assessing success, they naturally continue to view their own research as successful on its own terms.

Even where this problem does not occur and the two 'camps' do reach agreement on the definition of outputs/benefits, these may be hard to quantify. This difficulty is accentuated if benefits are spread over many years. For example, increased farmer awareness of the problem, higher adoption rates for solutions, or greater competence of extension staff to deal with the problem may take several years to secure. Research projects often finish before such benefits become evident.

This paper proposes one way to get around some of these problems. The alternative route which it adopts is to estimate the incremental costs and benefits of participatory activities within a single project, the Ghana/UK Larger Grain Borer Project, by comparing the actual project with a hypothetical alternative without the participatory work, but with the same goals. The Ghana/UK Larger Grain Borer (LGB) Project (hereafter the LGB project) is apt for such an analysis since a wide range of activities were undertaken within the project (including conventional research station-based trials, on-farm trials, and a range of complementary participatory activities) and components of the project can be quite readily disaggregated in the analysis.

The paper is organised as follows. The following section provides an introduction to the approach and activities of the LGB project, emphasising in particular the iterative technology development process and the variety of different activities undertaken which drew both farmers and traders into the research process. Section 3 provides a brief analysis of the types of participation within the project. In Section 4 a cost-benefit analysis is presented in three steps: (i) the relative costs of different research activities are examined; (ii) costs are then related to the level of client participation in each activity and their contribution to achieving research goals; and (iii) an assessment of overall costs and benefits of client participation is then made. Section 5 looks at the costs and benefits of participation from the point of view of the participants, farmers and traders. The final section provides a conclusion and some reflections on the use of participatory research methods.

2 The Larger Grain Borer project

The Larger Grain Borer project was initiated in Ghana in 1993, to assist farmers in combating a serious, new pest of stored maize and dried cassava chips, the Larger Grain Borer *(Prostephanus truncatus,* (Horn)) (see Cbmpton, this issue). LGB was seen as a threat to food security in Ghana, where maize is the most important grain crop and is produced by 70% of all farmers (GSS, 1995). The project included a national awareness and extension programme based in the capital city, Accra, and an adaptive research and extension programme based in the Volta Region, where the LGB problem was at its most serious when the project was designed. The analysis presented here is based on the Volta Region programme.

Project approach

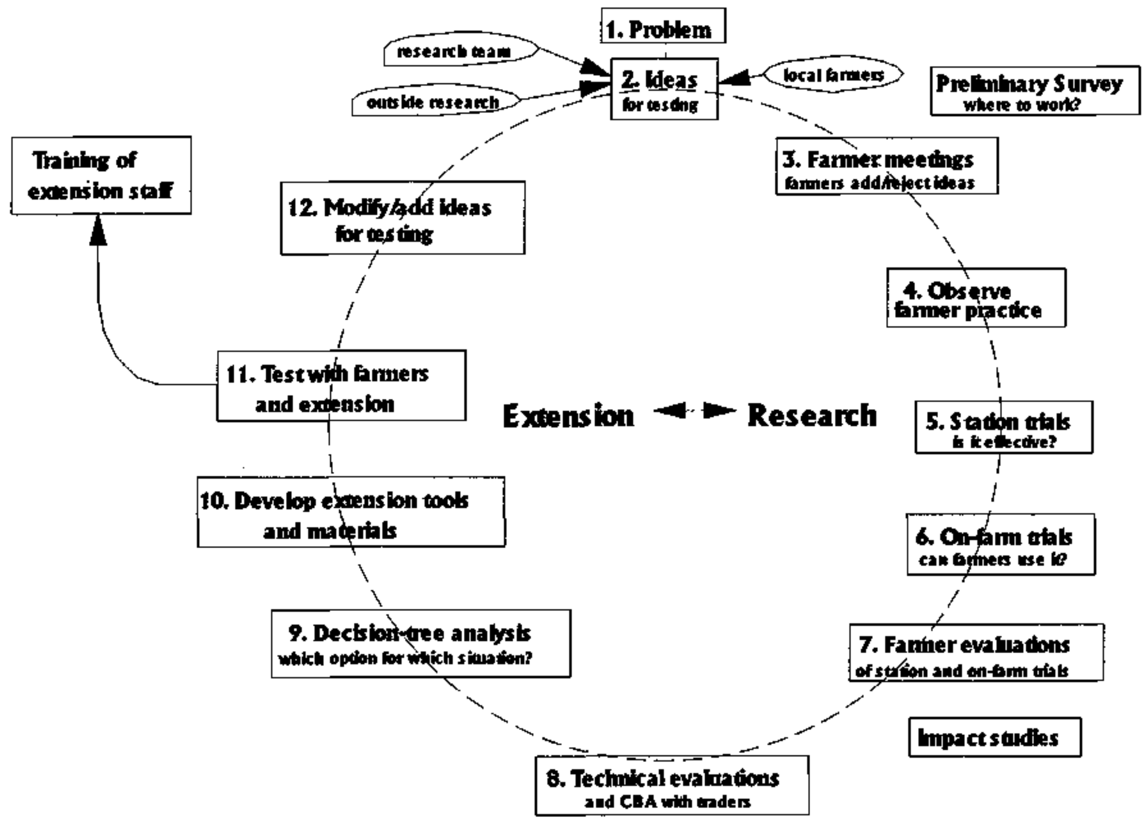
The objective of the LGB project, as laid down in the original project proposal, was 'to reduce post-harvest losses on the farm caused by insect infestation'. This was to be achieved through provision of 'cost-effective and socially acceptable methods of protecting produce against LGB'. Other activities were to: assess the social and economic impact of LGB; raise awareness; monitor the pest; and establish an extension and training programme.

Although knowledge of the local situation was clearly required if technologies were to be 'cost-effective and socially acceptable', the project could conceivably have been implemented with a low level of farmer participation, using, for example, socio-economic surveys coupled with technology development at the research centre. However, the research team aimed for a high level of client participation in the belief that this would increase its success in meeting farmers' needs and in generating high quality research results as quickly as possible. Other salient aspects of the project approach were that the research should be interdisciplinary, should develop close links with extension, and should follow a process approach whereby project objectives and activities would be modified in response to results from previous activities.

The activities undertaken by the project research team contributed to the satisfaction of three inter-related research goals: (i) assessing the social and economic impact of LGB; (ii) developing a range of methods for controlling the pest; and (iii) disseminating research results, mainly through the government extension system.[1] The relation between these activities is illustrated in Figure 1. The figure is intended to show how the project adopted an iterative approach to technology development, involving a cycle of experimentation and consultation.

Stage 1 of the cycle was the definition of the problem for research, in this case how to control storage losses from LGB. A rapid, preliminary survey was undertaken to assess the distribution and impact of the pest, and thereby to define priority work areas. The second stage involved the generation of ideas for testing. These came from previous research in other countries and from the research team, farmers, extension staff and others. They were refined through farmer meetings (stage 3) at which farmers were invited to describe their experiences with LGB and any control measures they had tried or heard of. Project ideas were then explained and participants were asked to rank their preferences for control methods, using local materials displayed on the ground. Stage 4, observation of farmer practice, took

Figure 1. The research-extension cycle



Used by Ghana/UK Larger Grain Borer Project. (After J Compton, 1995) place in tandem. An interdisciplinary team spent one week in each of seven villages during the maize harvest of 1993, observing, joining in, and discussing harvest and storage practices. The aim was to investigate how new control methods could build on and be integrated into current practice.

Testing of these ideas was done through formal station trials (stage 5) to assess effectiveness, and for the most promising treatments, through on-farm trials (stage 6). These allowed the team to assess popularity and practical problems of application under farmers' conditions. For the station trials, farmers from nearby villagges were invited to the station, and were presented with samples of maize from each trial treatment. They were asked to de-husk the maize, sort it as they would their own maize, and then rank and score the samples. In the on-farm trials volunteer farmers selected a treatment for their maize store, and applied it under project team supervision. Results of both on-farm and station trials were monitored by both farmers and the research team. One advantage of farmer evaluations was that results from them could be fed immediately into the next trial, whereas statistical analyses of data from researcher evaluations were not available until much later.

Maize traders were also involved in evaluating trial results (stage 8). Samples from each trial treatment were sorted into damage classes, then maize in each class was shelled. The maize traders were presented with the shelled maize samples and asked to price them, as they would maize in their local market on that day. The data was used in cost-benefit analyses of the trials (Magrath and Compton, 1995). In addition to control methods tested via station and on-farm trials, the project managed the release and monitoring of a biological control agent in conjunction with farmers (see Box 1).

Steps 9—11 involved working with the extension services (see Compton, this issue, for details). Decision-tree analysis was used to examine circumstances under which particular options for controlling LGB would be appropriate, as well as to identify gaps in the research (step 9) (Feakpi et al, 1994; Feakpi, 1996). Different ways of presenting this information, including decision trees, tables of options, and texts using short sentences, were tested with farmers and extension staff (steps 10-11) (Compton, Motte and Addo, unpublished data)). Step 12 involved the modification of practices to be incorporated into the following season's cycle, based on ideas generated during steps 1—11.

This approach to technology development can be contrasted with a typical, research institute-based approach, in which the focus is on technology development through formal trial programmes, with little input from the end users. The research process in this case tends to be linear, rather than cyclical, as illustrated in Figure 2. With less feedback from outside the research station there is less pressure for continuous modification, and researchers tend to come up with fixed 'packages' which are then handed over to the extension service to be recommended to farmers. This approach to research and extension remains more common than farmer participatory approaches, despite the fact that farmer uptake of the resultant packages tends to be low, and restricted to better-off farmers, since the packages fail to match the diversity of conditions and situations and the poor resource base of the majority of farmers in developing countries (Farrington, 1995; Compton *et al.,* 1995b; Compton, this issue.)

Assessing the social and economic impact of LGB

Researchers commonly assess the impact of new storage pests by attempting to answer the following question (often implicitly rather than explicitly formulated): 'what are average weight losses in farm stores before and after the arrival of the new pest?' The estimated increase in losses is then used as a justification for implementing research programmes to reduce losses.

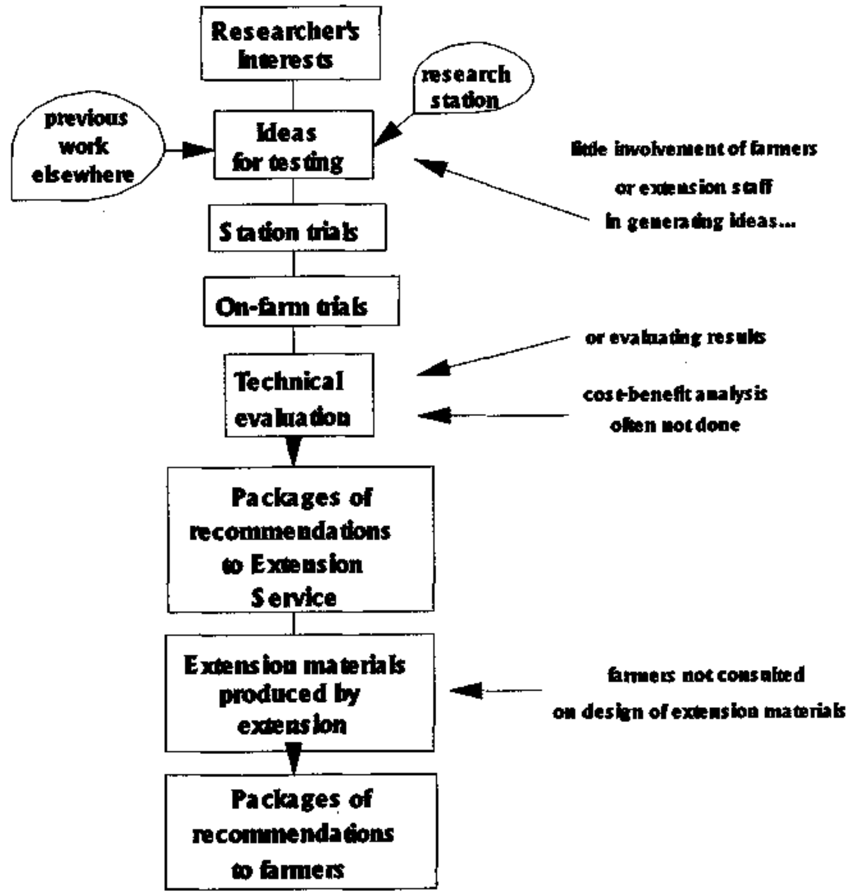
One problem with formulating the question in this way is that it can only really be answered through the implementation of an expensive large-scale random survey. More seriously, answering this question may not help in making policy decisions. For example, it is implicitly assumed that farmers passively accept losses from new pests rather than taking action to minimise them, which is what they in fact do (Motte *et al,* 1995). Furthermore, weight loss, the measure

Box 1. Farmer participation in classical biological control

The LGB project managed the release and monitoring of a biological control agent, *Teretriosoma nigrescens,* commonly referred to as Tn. This was a classical biocontrol programme, since Tn is a natural enemy of LGB from its place of origin (Central America).

Tn had been released in several other African countries, most recently in neighbouring Togo, though the Ghana LGB project undertook more detailed monitoring than had been done previously in Africa. The monitoring programme involved farmers as collaborators, which is relatively unusual for biological control programmes (Addo et al, 1995). Farmers were involved in: preliminary meetings to discuss the release, in which many farmer concerns were raised; setting insect traps to monitor levels of Tn and LGB (this job was done by extension staff or post-harvest officers in some villages); and monitoring of LGB and Tn levels in stores (20 farmers in each of 20 release and 20 non-release villages were involved). Benefits of farmer collaboration were that: (i) farmers' enquiries generated new research questions concerning the best time and place for Tn release to achieve maximum survival rates; (ii) farmers helped conserve insects by not using insecticides which kill Tn but not LGB; and (iii) farmers looked after monitoring traps, instead of destroying them.

Figure 2. A conventional research-extension set-up



most commonly used, often shows a poor relationship to loss in market value, which is the more relevant concern for policy decision-making. The whole question of the risk of pest attack is also not addressed by this question, although it is a very important parameter in decision-making about pest control.

Under the LGB project, the research problem was reformulated as follows: 'For whom is LGB a real problem? Is intervention needed on behalf of these farmers?' This question was addressed through a number of related studies including: the preliminary survey, mentioned above; a detailed *Study of Losses and Decision-Making;* on-farm cost-benefit analysis; two related market studies, which aimed to estimate the economic value of on-farm losses; and focus group meetings on the wider impact of LGB on the community. These studies are explained in more detail below. Results from them fed into the technology development and extension cycle at various points.

Study of Losses and Decision-Making

The objectives of this study were: to assess losses in farmer maize stores from LGB and other factors; to assess the economic impact of losses and farmer responses to LGB infestation; and to examine factors affecting the risk of LGB attack. Since these questions required detailed analysis of individual cases it was decided to work with a relatively small sample of farmers. About 10 volunteer farmers from each of five villages with a history of LGB infestation were invited to join the study. These farmers were visited on a monthly basis to discuss problems (based on a questionnaire) and to observe and make a rapid loss assessment of their stores.

Most sample maize stores consist of cob maize, neatly stacked in rows on a platform, with the base of the cob visible from the outside. One way of assessing losses is simply to observe the outer wall of cobs for signs of damage. In this survey, if the farmer had already started removing maize for the family's use, a second method was used, involving removal of a sample of 20 or 30 cobs from the store (the cobs were returned to the farmer after assessment) (Compton and Sherrington, forthcoming a,b). To counter any bias in the volunteer sample, a further 20 farmers from each of the same five villages were selected to participate in the study, using a semi-random method (based on a transect walk through the village). Since these farmers had not volunteered to participate in the study, only short visits were made to them during which stores were inspected for insect damage (but samples were not removed) and a more limited set of questions about decision-making was asked.

Cost-benefit analysis of farm storage

In the CBA of farm storage, the objective was to assess the damage level and market value of a small number of case study stores on the day upon which the stores were dismantled (farmers in contact with the project were asked to notify the team when they planned to take down their store). Research team members spent up to a full day with farmers. Questions asked included why the owner had decided to remove the maize from store that day (was insect infestation a factor?); whether the level of loss was acceptable, and how farmers sort and use good and damaged maize.

Market studies

The two market studies both aimed to estimate the relationship between insect damage and market price, in order to assess the financial losses to farmers of insect damage in their stores. In the market survey seven markets were visited and samples of good and damaged maize were bought from traders for laboratory analysis. In the trader panel study, groups of traders from four markets were presented with pre-prepared samples with different quality characteristics and were asked to assess their current market (Compton *et al.,* forthcoming c). Trader panels were organised, roughly one per quarter, from June 1993 to June 1994.

Focus group meetings on the impact of LGB

The aim of these meetings was to provide information on the wider social and economic impact of LGB in the community. Focus group meetings were held in the villages and markets included in the above studies. Farmers produced causal diagrams showing the implications for families and communities of serious LGB infestation. Traders produced calendars showing patterns of supply and demand and the incidence and impact of damaged maize in the markets.

3 The nature of participation in the project

'Participation' has become a label which brings credibility to those working to reduce poverty in developing countries. It has even been suggested that research proposals which do not include a reference to participation are less likely to secure funding (Richards, 1995). This may be one reason why the term tends to be used loosely and can refer to anything from people's presence at a meeting to their political empowerment through gaining real control of development processes. It is therefore important to define what we mean by participation.

The nature of participation within the LGB project was determined by the main objectives of the research team in adopting a participatory approach, ie. to focus on the problem, and to generate good results fast. This fits what Farrington and Nelson (1997) has described as a 'functional approach' to participation, which is more common in government programmes, as opposed to the 'empowerment approach', which tends to be more common with NGOs working for community development. The nature of participation also varied with the activity in question. Because of this it will be useful to draw on classifications or categories of participation developed by others, to avoid confusion. A number of schema have been developed (Okali *et al*, 1995, pl 20ff), including that developed by the World Bank Learning Group, which is useful for comparing specific activities, since it describes what each party participating in the activity does (Paul, 1986).[2]

Paul (1986) describes four stages which entail increasing levels of participation: information sharing, consultation, decision-making and initiating action. Table 1 uses a modified form of this schema to describe participation in LGB project research activities. Since every activity incorporated elements of information sharing, this category is not denoted. Instead, two levels of consultation are distinguished - a superficial level (single symbol), such as is achieved in short, one-off interviews, and in-depth consultation (double symbol), which could include intensive focus group meetings lasting a couple of hours, or repeated contact over a period of time, such as in the monthly *Study of Losses and Decision-Making,* or the monitoring of the biological control agent, Tn. Activities through which farmers influenced decision-making are shown by a triple symbol. Such influence was evident in: the selection of trial treatments; the design of trial methods; making recommendations to the extension service; and the design of extension materials (Feakpi et al, 1994, Feakpi, 1996). The degree of participation in research activities is discussed in more detail in Section 4.

An important feature of client participation in the project was that it began early and continued throughout the duration of the project. There was no period during which no participatory work was being done. This contrasts with other programmes which have involved clients only at certain stages in the project, such as at the beginning (diagnosis) and at the end (evaluation) (Farrington, 1995).

4 A Cost-Benefit Analysis of participation in the Larger Grain Borer Project

This section proposes a method for assessing the costs and benefits of participatory research, using the Larger Grain Borer project as an example. The CBA consists of three steps:

(i) comparing the relative costs of each research activity;
(ii) relating these costs to two factors: the contribution of each activity to achieving research goals and the level of participation in the activity;
(iii) grouping together all participatory activities, and assessing their overall impact on the costs and benefits of the research.

Relative costs of research activities

Table 2 shows the relative costs of the research activities undertaken along with their purpose and intended benefits. These are grouped according to the two main research goals: (i) assessing the social and economic impact of LGB; and (ii) developing a range of options for control of LGB. The third goal of disseminating research results is not included in the CBA.

In a cost-benefit analysis costs are generally broken down into: (i) investment costs, including site preparation (for example, office refurbishment) and capital costs (such as vehicles and equipment); and (ii) operating costs, which are incurred only once the project has started. Operating costs are in turn divided into fixed costs (such as staff salaries and project management costs) which are incurred regardless of activity levels, and variable costs (such as for materials used in trials), which increase directly with the level of activity (Irvin, 1978). Investment costs and fixed operating costs are not included in Table 2 since it is difficult to apportion their use between the various activities. However, vehicle costs are reflected in the data provided on distances travelled, and staff costs are reflected in the number of days' work involved.

The variable portion of operating costs are shown in the table as 'variable cash costs.' According to Table 2, station trials incurred the highest variable cash costs of all the activities. The cost of the maize, store construction and maize treatments came to almost 5.5 million cedis (£5,500), 60% of total cash costs for research activities. Station trials are not in themselves participatory, but in the project station trials were complemented by five activities involving client participation: (i) farmer meetings; (ii) observation of farmer practice to develop ideas for trials; (iii) on-farm trials for treatments which station trials had shown to be promising; (iv) farmer evaluation; (v) trader evaluations of station trials. These activities were relatively low cost, adding just over 1 million cedis, thereby increasing the costs of the experimental programme by 20%.

The research activity which incurred the second highest variable cash costs was the *Study of Losses and Decision-Making*, the main study of social and economic impact undertaken by the project. This cost 1.8 million cedis (£1,800), mainly accounted for by staff overnight subsistence payments. Other impact studies cost considerably less. Together, the preliminary survey, milling survey, cost-benefit analysis of on-farm storage, focus group meetings and two market studies added just over half a million cedis, increasing the costs of impact studies by 31%.

Table 1. Assessment of the level of participation, contribution to achieving research goals and relative costs of activities of the LGB project, Ghana

Activity	Frequency of contact	Number of villages/markets	Level of participation	Contribution to research goal	Investment (cash, time)
GOAL 1: Assessing the impact of LGB					
Preliminary survey • of farmers • of extension staff	 Single visits Once/year	 36 villages 100 staff 500 villages	 @ @@	 ** **	 $$ $
Losses studies • monthly • farmers' CBA • milling survey	 Monthly visits Single visits 4 visits	 5 villages 15 farmers 4 villages	 @@@ @@ @	**** *	 $$$$ $ $
Impact meetings • with farmers • with traders	 Single visits Single visits	 5 villages 4 markets	 @@ @@	* *	 $ $
Market studies • market survey • trader panels	 Weekly visits 5 visits	 7 markets 4 markets	 @ @@	*** *	 $$ $
GOAL 2a: Developing a range of methods for controlling the pest, generating ideas for testing					
Review of secondary literature	-	-	-	*	$
Meetings with other researchers	Irregular but frequent	Various	-	**	$
Exploratory farmer meetings	Single visits	10 villages	@@	*	$
Observations of farmer practice	Single visits	5 villages	@@	*	$$
Monthly farm visits: • Losses survey • On-farm trials	 Monthly Monthly	 5 villages 15 villages	 @@@ @@@	*** ***	$$$$ $$
Farmer visits to research station: • Farmer evaluations • Best farmer visits*	 Single visits Single visits	 10 villages Various	 @@@ @@	**	$
GOAL 2b: Developing a range of methods for controlling the pest: testing technologies					
Station trials	-	-	-	****	$$$$
Farmer evaluation of station trials	Single visits	10 villages	@@@	**	$$
Trader evaluation of station trial results	Single visits	4 markets	@@	*	$$
Rapid assessment method to evaluate station trials	-	-	-	*	$
On-farm trials		15 villages	@@@	**	$$
Tn release and monitoring	Monthly	40 villages	@	**	$$

[+] Best farmer awards are given at the annual Farmers' Day rallies, held in each district and region of Ghana. The project awarded study tours of the project, including station trials, as prizes. Best farmers were often those with greater access to resources. They sometimes had interesting ideas, based on their own experimentation and observations.

Key

@ = inform, superficial consultation
@@ = in-depth consultation
@@@ = clients contribute to project decision-making (not necessarily decision-making in the specific activity)

$ = < 100,000 cedis and < 100 days
$$ = > 100,000 < 0.5 million cedis and > 100 < 500 days
$$$ = > 0.5 million < 1 million cedis and > 500 < 1000 days
$$$$ = > 1 million cedis and > 500 days

NB: US$1 = 650 Ghanaian cedis

Table 2. Intended benefits and estimated costs of research activities of the Larger Grain Borer Project, Ghana

Activity (1)	Purpose	Intended benefits to project	Estimated costs of research activities						
			Description of cash costs	Variable cash costs 1993 cedis (2)	Cash costs as % of total	Project personnel days (3)	Personnel days as % total	Distance travelled (km) (4)	km travelled as % total km
GOAL: ASSESSING THE SOCIAL AND ECONOMIC IMPACT OF LGB									
Preliminary survey	Define priority work areas	Research focused on the problem	Subsistence	221,354	2.5%	128	3%	7,000	7%
Losses studies Survey of losses and decision-making	Understand on-farm losses and decision-making	Assess benefit of technologies; better recommendations; predict adoption	Subsistence; annual gift to farmers	1,794,351	20.0%	1,155	31%	32,900	35%
Cost-benefit analysis of farm storage	Estimate value losses in farm stores	Assess benefit of technologies	Sample bags	6,000	0.1%	30	1%	450	0%
Milling survey	Understand type/ quality of staple foods eaten	Assess impact of LGB on maize consumption	None	0	0.0%	20	1%	800	1%
Impact meetings Farmers and traders	Understand impact on family and community	Understanding the problem	Refreshments	20,739	0.2%	33	1%	1,820	2%
Market studies Market survey	Understand quality-price relationship	Assess economic value of losses	Sample bags; samples	84,951	0.9%	375	10%	11,180	12%
Trader panels	Understand quality-price relationship	Assess economic value of losses	Refreshments and payments	230,793	2.6%	140	4%	1,400	1%
GOAL: DEVELOPING A RANGE OF OPTIONS FOR CONTROL OF LGB									
Station trials (incl. technical evaluation)	Test efficacy of technologies	Better adoption of technologies	Maize store treatments	5,431,347	60.4%	730	19%	9,731	10%
Exploratory farmer meetings	Develop ideas for trials	Research more relevant to farmers	Refreshments	80,431	0.9%	37	1%	1,200	1%
Observe farmer practice	Fit technologies to local practice	Faster adoption	Subsistence	425,068	4.7%	74	2%	1,340	1%
Farmer evaluation of station trials	Undertake rapid assessment and test popularity	Future research more relevant	Refreshments* and payments	243,484	2.7%	66	2%	630	1%
Trader pricing for CBA of trials	Conduct CBA of trial treatments	Better recommendations	Refreshments and payments	177,894	2.0%	99	3%	549	1%
On-farm trials	Assess on-farm viability and popularity of treatments	Better recommendations	Treatments	176,274	2.0%	260	7%	16,000	17%
Biological control	Release and monitor biol. control agent	Reduce impact of LGB	Leaflets	100,000	1.1%	628	17%	10,000	11%
TOTAL FOR ALL RESEARCH ACTIVITIES				8,992,684	100.0%	3,775	100.0%	95,000	100.0%
TOTAL STATION TRIALS				5,431,347	60:4%	730	19.3%	9,731	10.2%
TOTAL PARTICIPATORY ACTIVITIES				3,561,337	39.6%	3,045	80.7%	85,269	89.8%

Notes

(1) Extension and training work is excluded.

(2) Costs are in Ghanaian cedis. £1 = 1,000 cedis, US$1 - 650 cedis, deflated to 1993 rates using the consumer price index for food for maize costs and that for non-food items for other costs.

(3) Personnel time excludes project management and administration.

(4) Activities aimed to cover all agro-ecological zones in which LGB was a problem.

Costs for these covered materials, such as sample bags, refreshments for participants, and payments for traders who priced maize and for farmers who evaluated station trials (a task involving de-husking and sorting sacks of project-owned trial maize).

Activities with the highest cash costs were not always the most time consuming. The *Study of Losses and Decision-Making* required the most time, using 1,155 staff days, or 31% of the total. Station trials used about two thirds of this, and biological control just over half. The market survey and on-farm trials were the next most time consuming activities.

Relative contribution to achieving research goals

Table 2 shows that the costs of different activities varied widely, with the cheapest costing less than 1% of the most expensive and using only about 3% of the time required for the most time consuming activity. Did the most expensive studies contribute most to achieving the research goals? What impact did the level of participation have on the cost-effectiveness of the activity? For answers to these questions we must refer back to Table 1.

In Table 1 cost-effectiveness is assessed in relation to the two research goals: (i) assessing the social and economic impact of LGB; and (ii) developing a range of options for control of LGB. This second goal is split into two stages. First, generating ideas for testing and second, testing itself. A system of symbols is used to grade each research activity in terms of: (i) level of participation; (ii) contribution to research goal; and (iii) investment required (combining both cash and staff time costs). Unlike costs, contribution to research goals and level of participation are neither quantifiable nor objectively verifiable, which means that the results and conclusions are open to debate. However, the exercise is useful as it makes relationships explicit, and offers them in a format which encourages debate about the relative cost-effectiveness of different research methods.

For the first goal, assessing the social and economic impact of LGB, it is suggested that the *Study of Losses and Decision-Making* made the greatest contribution, followed by the preliminary survey and market studies. Why was the losses study more successful? Monthly visits to farmers and their maize stores proved to have many advantages. Regular farm visits allowed the team to build personal relationships with each farmer, and much was learned through the resulting open discussions. Monthly visits were also crucial to understanding the storage process. Since stores can be constructed and dismantled at any time, much would be missed if visits were only occasional or random. Monthly visits also allowed the team to build up a picture of how farmers' storage decisions change in response both to what is happening in the store and to other factors, such as changes in market prices and the family situation. None of this would have been revealed from one-off meetings. Thus, although this survey was the most expensive project activity, it was nevertheless considered to have been cost-effective.

Studies involving monthly visits also generated most ideas for testing, for similar reasons to those outlined above. Many ideas came from incidental remarks made during discussions with farmers who knew the research team well. Conversely, one off meetings, such as the focus group meetings on LGB impact, and meetings to test ideas, contributed least to achieving research goals. This was because it proved very difficult to assess the value of information from such one-off meetings. First, it is hard to assess whether the gathered group is representative of the wider community. Second, information given can be hard to interpret. Tools developed to tackle this problem often compound the problem of interpretation, since the tool is unfamiliar to participants (IIED, various). 'Results' in the form of diagrams often give a false sense of truth, and are sensitive to the way in which the exercise was explained (Magrath *et al.*, 1996b). Thus, in the experience of this team, results from such rapid participatory appraisals need to be backed up by observation, or to be fed into other, longer term activities. They,are more useful early in research programme, since they can raise issues which can later be pursued in more depth using other methods.

Many of these points can be illustrated through a comparison of results from the monthly *Study of Losses and Decision-Making* and the one-off focus group meetings to discuss LGB impact. Both studies aimed to increase understanding of the social and economic impact of LGB, but each used different methods and generated different types of result.

According to the focus group meetings, losses from LGB led to: (i) loss in income leading to failure to pay school fees; (ii) hunger; (iii) shortage of maize seed next season; (iv) a tendency to move away from maize cultivation; and (v) social disgrace, as farmers failed to fulfil social obligations (see Magrath *et al.*, 1996a for more details). The impression from these meetings was that LGB had had a very big social and economic impact. But how could we tell whether people were exaggerating, or what proportion of farmers were really affected in the manner suggested?

According to the *Study of Losses and Decision-Making*, 72% of case study farmers, who were selected from five LGB infested villages, had experienced LGB attacks in a year of high LGB incidence (the first year of the study). These farmers lost between 15% and 45% of the market value of their maize, representing up to 5% of average household incomes (see Box 2). About 20% of case study farmers had had to buy maize because LGB had damaged their household stocks. Others substituted cassava for maize in their diet.

Box 2. How big are the losses caused by LGB?

According to the *Study of Losses and Decision-Making,* 47% of the case study stores visited over four storage seasons from 1993-5 had LGB. These farmers suffered losses consistently higher than those whose stores had only indigenous pests. Results from 96 case study farmers showed that the most common local pest, the maize weevil, gave rise to losses in the market value of the maize of between 5% and 10%, while value losses from LGB ranged from 15% to 45%. The resulting level of financial loss would be equivalent to about 5% of average total household expenditure

These estimates, however, are likely to understate the full financial impact of LGB since they do not account for the tinning of the pest attack. Value losses were measured by comparing the current market value of the damaged maize with the current value of equivalent samples of good quality maize. However, since the seasonal variation in maize prices in Ghana is very high, with pre-harvest prices as much as three times their post-harvest low in some years, the financial loss to farmers depends crucially on **when** LGB enters the store, as illustrated in the following example.

Alfred noticed that the damage level in his major season store was higher than usual. Having stacked the maize in September 1993, he decided to take the store down in January 1994, after only 4 months of storage. Like many farmers in Papase, a maize surplus area in the forest zone, he had originally planned to keep the maize for sale in the lean season (June-July).

The LGB project team estimated value losses to be 30% at this time, because of the high levels of both LCB and weevils. This meant that Alfred would receive only 70% of the current price for good maize, (6,500 cedis), if he sold the maize immediately. But prices then increased, reaching their peak in July at 15,000 cedis per 100kg bag. Alfred's income in January was, then, only 35% (70% x 50%) of the income he could have earned from selling at the peak price, as he had planned. Although he would have incurred further storage costs by storing until July, the estimate of 30% value loss underestimated the full financial impact of LCB damage.

About half the case study farmers who had LGB in their stores dismantled the store earlier than planned, and many of these subsequently sold the maize to avoid further damage.

Source: Magrath et al., 1996.

The monthly survey helped place results from the focus group meetings into perspective. It appeared that these meetings were exaggerating impact, or suggesting effects which applied to a small proportion of farmers. This may have been because of the way the exercise was explained to participants or due to the failure on the part of researchers to probe further and to assess the incidence of the suggested impacts.[3] However, on the positive side, the meetings did raise issues not covered explicitly in the monthly study, such as the shift out of maize production, the shortage of seed, and the risk of social disgrace if maize stocks were destroyed. These could then be explored through other studies.

The focus group meetings were always intended to be complementary to the *Study of Losses and Decision-Making,* with each providing a cross-check against the other (a form of 'triangulation'). However, the conclusion is that the meetings on their own could contribute little to the research goal, because of doubts over the validity of results. Only in combination with the long term monthly survey did the results prove useful.

What about the relationship between levels of participation and the contribution of each activity to meeting research goals? Focus group meetings on LGB impact and meetings to test ideas for control appeared very participatory, with everyone contributing enthusiastically to the discussion. However, the long-term activities, such as the monthly losses study and the on-farm trials, actually provided more scope for farmers to influence project decision-making, in terms of, for example, providing ideas for trial treatments (losses survey), or suggestions for modifying treatment application methods (on-farm trials). Monthly visits allowed time for farmers to develop their ideas and to gain confidence in discussing them with the research team. However, it should be pointed out that participants were never given the scope to design or manage research activities directly as in other farmer participatory research projects. Rather, their ideas and experiences fed into the research team's planning process.

In conclusion it can be said that long-term studies, although more expensive, not only contributed more to achieving research goals, but also provided greater scope for more meaningful participation in the project than rapid participatory appraisals. For the first goal (assessing LGB impact), activities with higher levels of participation tended to contribute more to achieving research goals. They also generated more ideas for control methods. However, when it came to the third goal of testing technologies for LGB control, the station trials, which did not involve clients directly, contributed most. Despite the wealth of information gleaned from on-farm trials and observation of farmer practices, none of the recommendations made by the project team could have been made with confidence had the station trials not taken place. It is important to note, however, that this observation may be specific to the LGB project; station trials will not always provide an appropriate means for testing technologies, especially where on-farm conditions cannot be replicated at the research station.

Overall costs of participatory research

We have seen that most research activities under the project involved farmers or traders to some extent, but that the level of participation and also the cost-effectiveness of these activities varied widely. However, for comparison with other projects which may involve very little client participation, it is useful to group all activities involving farmers and traders together, and to examine the overall impact of client participation on the costs and benefits of research. In order to do this, project activities must be split into station trials (no client participation) and 'other participatory activities'; the bottom line of Table 2 shows the relative costs of each of these, split into components. While the cash costs of station trials accounted for more than 60% of total cash costs, staff time spent on 'other participatory activities' was four times that used in the station trials, while distances travelled were nine times greater.

Not all costs are detailed in Table 2. A programme involving only station trials is likely to incur lower transport costs, since there would be little or no field work. However, to counterbalance this, equipment costs are likely to be higher. Laboratory-based analytical methods often require more expensive equipment than rapid, field based participatory techniques. Rapid field-based loss assessment in the LGB project required only a set of standard photographs illustrating the visual scale, a white tray on which to count insects, a standard form, a clipboard and a pencil. The method does, however, rely on previous calibration of the visual scale against more conventional techniques (Compton and Sherrington, 1996 a, b). The method also reduces the costs of verifying data, since this can be done on the spot, together with the store owner. When laboratory based methods are used, faulty data either have to be rejected or require further follow up visits at additional cost (see Compton, this issue). Project management and administration is, on the other hand, likely to be more complex and time-consuming for participatory projects, because of the increase in the number and types of institutions involved. Training costs may also be higher if, as with this project, all staff are trained in a wide range of skills, including not only analytical and laboratory methods, but also communication skills, interviewing techniques and simple presentation of research results.

Overall benefits of participation in the Larger Grain Borer project

In the opinion of the research team, client participation was crucial to achieving project objectives, and greatly increased the productivity of research. As mentioned in a companion paper (Compton, this issue), by the end of the project, the team was able to recommend a range of different options for controlling LGB in farm stores. Farmer input was instrumental in the development of 9 of these. Farmer participants also contributed directly to the release and monitoring of the biological control agent, Tn, and in the development of extension materials covering all control measures. Both farmers and traders contributed to the assessment of on-farm storage losses, and their social and economic impact, and to assessing cost-effectiveness of recommended treatments.

From the point of view of researchers on the team, interaction with farmers and traders made a concrete contribution to the development of popular and cost-effective technologies in the following ways:

(i) New ideas for possible control methods were suggested by farmers. For example, some farmers were found to be covering their maize stack with plastic sheeting to provide a barrier against insect attack. This was tried in station trials and subsequently included in a recommendation to farmers.

(ii) Ideas for testing were evaluated by farmers (for example, one idea for LGB control, the use of a local week, acheampong, was dropped after farmers rejected it as too poisonous). This can save costs in testing technologies which will not be popular (although there is a risk that potentially popular ideas will be rejected because a few farmers who happen to have contact with the project do not like them).

(iii) Farmers evaluated station trial set-ups, to ensure that conditions matched those on farms as closely as possible. This is a crucial contribution, since resources will be wasted if trial conditions are so different from the farm as to render results useless (de Villiers, 1996);.

(iv) Observation of the environment in farmers' stores led to an improved understanding of LGB infestation and its relationship to farmer behaviour. For example, the importance of carry-over infestation (whereby newly stored maize rapidly becomes infested with LGB which has remained nearby in storage structures or other materials), became clear from observation of the same storage platforms, in the same locations over several seasons. It would have been hard to examine this phenomena through trials based at a research station.

(iv) Assessment of losses was done in a more meaningful way. Understanding maize losses from the farmer's point of view helps determine the importance of the problem, and how keen farmers are to take action. Also, farmers' methods of sorting and valuing maize can be incorporated into cost-benefit analyses of technologies being tested, providing a better guide to cost-effectiveness and popularity than standard loss assessment techniques.

(v) Continuous interaction kept the team aware of the urgency of finding solutions to the LGB problem (see Compton, this issue).

While the specific benefits will vary with the research programme, the above points are likely to be fairly general to problem-oriented agricultural research projects.

Box 3. Model to estimate the relationship between adoption rates and reduction in losses (savings)

Assumptions

Scenario	Scenario 1: High risk of LGB	Scenario 2: Low risk of LGB
Probability of LGB in Volta Region	50%	33%
If LGB, % maize crop affected	40%	30%
Value loss from LGB infestation	30%	15%
Average maize production in Volta Region, 1992-94 (tons)	56,290	56,290
Maize price (cedis/ton)	100,000	100,000
Treatment cost as % maize value	8%	8%

Estimates

Average proportion of annual production affected	20%	10%
Value loss if no action taken	6%	1.5%
Savings if 1% of farmers adopt control measures	0.06%	0.015%
Savings net of treatment costs	0.055%	0.014%
Cash savings for % adoption (cedis)	3,107,208	769,034

This said, the ultimate aim of the project was not to conduct research as an end in itself, but to assist farmers in reducing losses from LGB in their maize stores. This is, therefore, a standard by which the project might be judged. Measuring the project's contribution to reducing losses is, however, complicated for a number of reasons. First, some farmers may take action to control LGB with no input from the project. According to the *Study of Losses and Decision-Making,* 45% of case study farmers had made changes to their storage practices in an attempt to control LGB. Some were influenced by their interaction with the project, while others were experimenting with their own ideas, often existing practices used against indigenous pests, most of which were ineffective (see Compton, this issue).[4] A second reason why the project's contribution to limiting losses is difficult to measure is that the incidence of LGB may fall for reasons not related to farmer behaviour, such as climatic factors.

If, though, the project did lead to an increase in adoption rates of measures to control LGB, how much maize might have been saved?

Information from project surveys and other sources can be used to model the relationship between adoption rates and financial losses. Box 3 shows one possible model for doing this. For simplicity, the model is for Volta Region only, since this is where the research work was concentrated. The project also had a national component, and a similar exercise in impact assessment at the national level has been published elsewhere (Magrath, 1996).

Two scenarios are illustrated: one which assumes 'high' risk of loss, the other low' risk. In the high risk model it is assumed that LGB attacks Volta Region every two years and that, when it attacks, 40% of stored maize is at risk. Thus, over a period of two years, 20% (50% times 40%) of the maize crop is at risk. Estimates from project surveys suggest that if no action is taken, maize attacked by LGB is likely to lose about 30% of its financial value. This means that, with no action, the maize crop suffers a 6% value loss (30% loss for the 20% of the crop at risk). However, farmers with experience of LGB are likely to take action. Let us assume that LGB attack is equally distributed among small and large stores. Then the 20% of the maize crop affected belongs to 20% of the farmers. Every 1% of affected farmers taking effective action reduces overall maize value losses by 0.06% (6% times 1%). The average cost of controlling LGB (using one or more of the project recommendations) can be estimated as about 8% of the maize value. So savings net of treatment costs would be a little less, around 0.055%.

Average maize production for Volta Region from 1992-4 was 56,290 tons, which was worth 5,629 million cedis at average 1993 prices. Thus, a 1% increase in farmer adoption rates would save 3.1 million cedis (0.055% of 5,629 million) per year. Total project costs for the Volta Region component were about £740,000 or 740 million cedis. If the project increased adoption rates by 20%, then this would pay back the project costs in 12 years. An adoption rate of 40% would pay back in 6 years.

Using the lower estimates (LGB attacks every three years, 30% of the mai2e crop is at risk each attack, and losses for an LGB infested store with no action are 15%) savings would be only three quarter of a million cedis per year, giving a 24 year pay back period if adoption rates increase by 40%.

What then is the likely increase in adoption rates due to project activity, and what was the contribution of the participatory approach? Post-harvest officers and extension staff were asked to make estimates of adoption rates with and without the LGB project activities for all regions of Ghana (Magrath, 1996). They estimated that, in the absence of participatory LGB project activities, 20% of farmers in Volta Region who were at high risk from LGB would adopt LGB control measures. In the presence of the project, adoption rates would increase to 30% after one year and 60% after four years. Thus, by the year 2,000, the project would have increased adoption rates by 40% over the 'no project' alternative. If the assumptions of the model described above are accepted, then the resulting reduction in losses would cover project costs in 6-24 years (depending on which LGB risk scenario is taken).

Although a direct comparison is not possible, the research team believes that current and future adoption rates would be considerably lower if the project had not involved farmers, traders and extension staff in a participatory approach. About 4,000 farmers and traders, representing 1.3% of all households in the region, had some contact with the project. Perhaps because LGB was considered by farmers to be a serious problem, information about methods of control tended to spread fast. About a quarter of case study farmers in the *Study of Losses and Decision-Making* were using project recommended control measures by the second year of the study, even though the team aimed to observe, rather than change farmer practice through this study.

Other farmers mentioned learning of control methods from extension staff, who were trained regularly by the project as new experimental results became available. Post-harvest officers working in regions of Ghana in which LGB was a problem but the research programme was not active observed lower rates of adoption of LGB control measures.[5] They believed that adoption rates would increase if similar participatory research activities were undertaken. However, continuous monitoring of actual adoption rates would be necessary to confirm the assertion that project activities have had a sustained impact. In addition, comparison with projects which are less, and more participatory is needed to confirm that rates of adoption are higher when client participation in research is high.

Finally, it must be mentioned that involving clients in research also has its disadvantages from the point of view of agricultural researchers. A well documented problem, also experienced in this project, is the tension between allowing participants greater control over the research process, and obtaining data which is amenable to conventional methods of analysis. The LGB project on-farm trials disappointed some members of the research team because of their failure to generate results which could be analysed statistically, even though other useful results were produced (Magrath *et al*, 1996b). Another problem is the difficulty in interpreting results of participatory activities such as diagrams produced in farmer meetings (as mentioned above, diagrams produced by farmers in focus group meetings on LGB impact proved somewhat misleading). Third, farmer participatory research may limit thinking to ideas which fit the current farming system. For example, the LGB project focused research on storage systems prevalent in the Volta Region of Ghana. One possible problem with this is that results have limited applicability outside the project zone. In Ghana, further research will be needed in other areas in which store types and practices are different. Another possible problem is that ideas from outside might be more effective in solving local problems in some cases. One post-harvest example is the metal bin, an imported storage technology which has proved popular in Latin America (Jonathan Coulter, NRI, UK personal communication).

5 Costs and benefits of participation to participants

Costs to participants

From the point of view of the project, involving farmers and traders introduced savings as well as costs. Participating farmers and traders provided valuable resources to the research programme, not only in terms of their knowledge and experience (which are difficult to value in money terms) but also in terms of time and material resources. These contributions reduced project costs but represent significant investments on the part of participants. In a social cost-benefit analysis the opportunity cost to farmers and traders of their participation would need to be estimated.

An attempt is made to illustrate these costs in Table 3. The on-farm trials and the *Study of Losses and Decision-Making* were able to make use of farmers' maize stores without payment. The value of maize included in these studies is estimated at about 8.6 million cedis (£8,600 or US$13,231). This is almost as much as the project's estimated total variable costs (for both participatory and non-participatory work) of 9 million cedis (see Table 2). However, although the project benefited from the maize (and would have had

Table 3. Estimated costs of participation to farmers and traders

Activity	Purpose	Participants	Benefits to participants	Value of maize in study (1)	Number of farmers or traders	Farmer/trader days	days as % of total
GOAL: ASSESSING THE SOCIAL AND ECONOMIC IMPACT OF LGB							
Preliminary survey	Define priority work areas	Farmers	Increased awareness of LGB and potential to control it		1,440	360	9%
Losses Studies Survey of losses and decision-making	Understand on-farm losses and decision-making	Farmers	Storage advice Annual gift Learn research results	3,327,218	590	708	17%
Cost-benefit analysis of farm storage	Estimate value losses in farm stores	Farmers	Storage advice	225,000	15	15	0.4%
Impact Meetings Farmers and traders	Understand impact on family and community	Farmers Traders	Exchange ideas		240	120	3%
Market studies Market survey	Understand quality-price relationship	Traders	Storage advice		140	728	18%
Trader panels	Understand quality-price relationship	Traders	Storage advice		225	113	3%
GOAL: DEVELOPING A RANGE OF OPTIONS FOR CONTROL OF LGB							
Station trials (including tech. evaluation)	Test efficacy of technologies	Farmers			0	0	0%
Exploratory meetings	Develop ideas for trials	Farmers	Exchange ideas Storage advice		300	150	4%
Observe farmer practice	Fit technologies to local practice	Farmers			60	30	1%
Farmer evaluation of station trials	Undertake rapid assessment and test popularity	Traders	Learn research results Exchange ideas		185	93	2%
Trader pricing for CBA of trials	Conduct CBA of trial treatments	Farmers			120	60	1%
On-farm trials	On-farm viability and popularity of treatments	Farmers	Storage advice Maize treatment	1,037,194	145	242	6%
Biological control with Tn	Release and monitor biol. control agent	Farmers	Storage advice	4,000,000	800	1,440	35%
TOTAL				8,589,413	4,260	4,058	1 00%

Notes

(1) Estimated average store size, for Loss Study: case study stores 150 kg; transect stores 100 kg; on-farm trials 150 kg
Current price deflated using FOOD component of CP - see note (2), Table 2.
Shelled maize estimated at 70% of volume of cob maize.

to purchase a large proportion of it to get the same benefits from laboratory work), farmers themselves did not lose the maize. In fact, in most cases, farmers' use of the maize was not greatly affected by the study, which means that the opportunity cost to farmers was considerably lower than the total maize value.

It is estimated that farmers and traders contributed over 4,000 days of their time to LGB project participation over the three year project period. If this time is valued at the minimum wage rate it represents a cost of 6 million cedis (£6,000 or US$9,230). In most cases farmers and traders "were not paid for their participation but contributed because they felt they would gain from it (cases in which they were paid for their work comprise less than 10% of this total - see below).

Benefits of participation in research to farmers and traders

The research team benefited from farmer and trader involvement in the research. The general population at risk from LGB also benefited from the new knowledge and techniques generated. But what about those who participated directly in the research, giving up their time and other resources? As with the costs, the benefits to participants would need to be included in a social cost-benefit analysis. Box 4 shows the benefits which might be expected.

About 2,000 farmers and traders were directly involved in project research activities, and many more attended one-off village meetings which dealt with LGB control. Most activities included an evaluation of the exercise by participants. For example, during the two year losses study, a general meeting was held at the end of each year, in each study village, at which farmers aired their views about their involvement in the study and the team presented research findings. In general, the response from both farmers and traders was enthusiastic.

However, in some cases involving farmers and traders in research tended to raise expectations. For activities which required farmers to contribute time on a regular basis rewards were expected. There is some debate among practitioners of participatory approaches about whether remuneration is appropriate, especially if the participants are supposed to be the main beneficiaries of the exercise (PLA Notes 22, p.6). Certainly, farmers' and traders' assessments of benefits from participation are likely to vary, but the benefits to the project were very clear. As a consequence the project felt that remuneration was appropriate for some activities. Where farmers or traders provided labour and skills (for example, shelling or pricing maize samples) they were paid at local wage rates. Where there was a long-term involvement, as in the *Study of Losses and Decision-Making*, token gifts were given at the end of each year. Farmers participating in on-farm trials received free treatments for their maize storage.

> Box 4. Benefits of participation to farmers and traders
>
> - Earlier access than non-participants to researchers' knowledge and to the results of the experimental programme. Those who participated in some activities (the survey of losses, and the on-farm trials) received regular monthly advice on their maize stores.
> - The opportunity to influence the research according to their needs.
> - Their knowledge and opinions were valued, giving them increased confidence. This was particularly true for women farmers who have less contact with extension staff and other outsiders.
> - Exchange of ideas, and learning from other farmers and traders, both within the village and from other villages.

A major problem with any remuneration, however small, by a project with external funding, is that it is often not possible for government departments to sustain it after the end of the project. There may therefore be greater justification for making payments to participants if the primary objective is to generate research results during the project lifetime, as was the case with the LGB project. Although it was hoped that participatory approaches would be sustained within the MoFA post-project, it was always understood that their form would change, in order to fit current resources and practice. However, another reason for providing remuneration, especially when participants are expected to contribute substantial amounts of time, is to ensure that poorer people are not excluded from participation because they are less able to afford the time.

Despite the attempts by the project to compensate farmers for their time and effort (both materially and in terms of advice and information), some farmers were still disappointed. Farmers' expectations of rewards are often based on previous experience with outsiders. They have learnt to expect advice and free inputs and it can take time to introduce the idea of an exchange of knowledge in a joint research activity.

Other disadvantages faced by participating farmers were that they could not always obtain inputs for recommended practices which they had heard about;[6] and survey and trial work involved the removal of maize from their stores, to which some farmers objected.[7]

Sustainability of benefits

The overall sum of benefits to farmers from the project research depends in part on the sustainability of beneficial project impact. It is hoped that the benefits of the project will be sustained through: improved storage pest control practices implemented by farmers and traders; implementation of more effective research and extension practices by staff trained under the project; and the adoption of research methods pioneered by the project by other projects and organisations. Some of the researchers on the team who had no previous experience of participatory approaches, aim to incorporate it into their future work. According to one:

> *'Here in Ghana, researchers tend to spend 100% of their time at the research station. They are interested in producing publications, and they forget who their real clients are. If they were to spend 50% of their time with farmers, listening to them, they would do a much better job.'*

However, further support to research and extension is required both to sustain the achievements of the LGB project in Volta Region and to extend the benefits to other areas of Ghana. This is already happening. The Post-harvest Development Unit (PHDU) of the Ghanaian Ministry of Food and Agriculture is placing a high priority on LGB research and control, and extra personnel have recently been moved to high risk LGB areas outside Volta Region. It is hoped that this work will continue, and will be supported by external funding where this is requested.

6 Conclusion

Whereas rapid rural appraisal was initially developed with the explicit objective of making research more cost-effective, this focus on cost-effectiveness seems to have been neglected in the 'participatory' movement. Indeed there has been a tendency to accept any research activity as long as it can be termed 'participatory'. However, it is the experience of this project that participation alone is not sufficient to ensure that research will be productive and useful to clients. Participatory activities, as all research activities, should be assessed critically in terms of their contribution to achieving these goals. Even when participation is seen as an end in itself, with the main goal being empowerment of participants, it is still desirable to find more effective, and lower cost ways of achieving this goal.

This paper has attempted to illustrate how a cost-benefit analysis of participatory research might be conducted. The CBA involved three steps. First, project activities were disaggregated, and their costs were compared. Second, these costs were examined in relation to the contribution of each associated activity to one or more research goals and the level of participation which the associated activity entailed. Finally, the costs of all activities involving clients were summed, and their impact on overall costs and benefits was assessed. It should be pointed out that the LGB project did not plan to carry out a CBA of participatory research from the start and this should be borne in mind when assessing the results of the analysis. Had it done so, costs data might have been collected in a more systematic manner.

However, it is not costs but benefits which are the most difficult to assess. Improving estimates of benefits requires not only better monitoring over the long term but also comparison with other more and less participatory projects. An interesting finding of the CBA was that activities typical of participatory appraisal work, such as farmer focus group meetings, turned out to contribute less to research goals than some other activities. Long-term activities involving repeated visits to the same farmers contributed most to achieving the research goals of assessing social and economic impact of LGB, and generating ideas for trials. Furthermore, individual farmers involved in these activities were able to influence certain project decisions, such as trial set-up and technologies tested in the trials, because of their frequent contact and exchange of ideas with the research team. But the greatest contribution to research goals was not always made by the most participatory activity. The station trials, for example, were found to make the greater contribution to the goal of testing technologies.

It was estimated that participatory activities collectively increased research programme costs by *66%* and accounted for 80% of researchers' time. Since CBA of research methods is not generally done, and standard methods are not yet available, it is difficult to judge whether these costs are high or low. However, a number of features of this project tended to increase the relative costs of participation.

First, social and economic impact studies played a prominent role in the research programme. This reflected the lack of relevant secondary information available to the project and the researchers' commitment to understanding the nature and extent of the LGB problem as experienced by local farmers so that recommendations made would be relevant, popular and cost-effective. Impact studies also supported the development of new technical methods, based on farmer practice, in particular a method for assessing losses in market value of maize damaged by insects. Impact studies comprised 71% of the costs of participatory work, and 26% of total operating costs for the research programme. The emphasis on methodology development (see Compton, this issue) reflects the fact that, despite the proliferation of participatory methods, in general the application of these methods in post-harvest work has so far been limited.

Another factor which increased costs was the desire to cover all relevant agroecological zones in the field work. Visits to the most distant areas required overnight stays, and therefore, subsistence payments to staff. 63% of the costs of participatory •work were for staff overnight subsistence. Clearly, other projects working in smaller areas may be able to reduce this cost.

Benefits of client participation in general included: the generation of new ideas for trials; a better understanding of interactions between insect and farmer behaviour (easily missed in more 'technical' projects); better judgement of which technologies would be popular, and why; and maintaining a sense of urgency to solve the problem as experienced by farmers. Longer term benefits in terms of reduced on-farm losses are difficult to assess at this stage, although indications are that loss-reducing technologies were adopted earlier and are spreading more rapidly than would have been the case had this been a non-participatory, research station-based project. This is, though, difficult to confirm in the absence of data from comparable projects.

Although this paper does not claim to provide a comprehensive guide for CBA of participatory projects, it does strive to show that such analysis is both possible and profitable and should, therefore, be more widely adopted. If more work were to be put into this area, analysis would become more sophisticated and research as a whole would be expected to become more cost effective. Though some participatory techniques might be criticised in particular circumstances, overall participatory research would be likely to be more defensible (as it would be backed by hard data) . This would be an important step forward.

Endnotes

1. Project activities are described in more detail in Boxall and Compton (1996) and in project quarterly reports.
2. ODA uses a slightly modified version of this schema in its Stakeholder Analysis (ODA, 1995). Another schema by Biggs (1989) is designed for evaluating an institution or project as a whole and describes the quality of the relationship between researcher and client.
3. This might have been difficult for sensitive issues such as hunger and social disgrace.
4. In this survey, the intention was to observe and understand farmer practices, rather than to influence them directly. However, interaction with the research team kept the survey farmers in touch with the results of project experimental work.
5. An LGB awareness and extension programme was implemented at the national level, but a more limited range of technical options for LGB was available in the other regions; research is still needed in these areas.
6. Government policy was that input distribution should be via the private sector and it was difficult for the project to become directly involved.
7. Some farmers believed that 'touching the barn' by removing maize led to infestation. Sampling was therefore usually done once the farmer had already started removing maize.

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