CROP PROTECTION PROGRAMME

Economic evaluation and international implementation of community-based forecasting of armyworm

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FINAL TECHNICAL REPORT

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Executive Summary

All project outputs have been achieved. Five villages in Machakos District, Kenya have been empowered to carry out their own community-based forecasting of armyworm. Essential to move CBF successfully to a new country, the use of participatory methods was important in understanding differences in village administration between Kenya and Tanzania. Forecasting accuracy was high (about 80%) and potential for simplification exists, particularly in relation to whether it is necessary to take into account rain gauge as well as moth catch data. The original CBF pilot villages in Kilosa District, Tanzania have continued to run their forecasting operation largely unaided for a further three years since inception. Each year they were visited once and provided with pheromone lures for the moth trap.

The largest costs for CBF are incurred during start-up. That the training is quite intensive and participatory, increases these costs but it can be argued that without this type of initial input, empowerment and ownership and hence sustainability would be jeopardised. Running costs in contrast are extremely low, again contributing to potential sustainability. Even including start-up costs, the yield saved through forecasting need only be (at the most) 1.6 – 4.3% for CBF to be economically worthwhile. In terms of penetration of the technology, this corresponds to less than 6.5% of farmers. A far greater proportion than that received and responded to the village forecasts. On economic grounds therefore, it is not at all surprising that the uptake of CBF has been so strong.

The uptake of CBF was also thought to be successful because it fulfils a real need using an appropriate technology. The armyworm problem is important and widespread and farmers are aware of it and want to do something about it. The CBF approach uses village level technology and farmers have seen that it does work. The way in which CBF has been introduced and implemented has been highly participatory and the project team believed that this was an essential element of its success. Engagement of the community and the village authorities and offering aspects of the decision making to the villager's themselves has led in the pilot studies to ownership of CBF by the village. This is evidenced by the fact that pilot villages have continued to run CBF. In addition, local initiatives have arisen associated with CBF, e.g. a sprayer rental scheme and a contract sprayer group. As a sign of institutional investment, in some cases both village and district authorities have allocated some funding to allow CBF to continue. The next logical step for CBF is to continue the scale-up process. Pilots have now been carried out in Kenya and Tanzania as well as an initial pilot in Ethiopia. The number of villages reached has so far been a small proportion of the number which might benefit so the next challenge must be to test potential scale up approaches to devise effective ways to present greater numbers of villages the opportunity to develop CBF.

Background

The initiative of community-based forecasting represents a significant paradigm shift in migrant pest forecasting. The prevailing view was that migrant pests, by their nature, are international and therefore their forecasting can only be tackled by centralised organisations. The last project demonstrated that forecasting at a village level can be both feasible and complementary to the national service. Indeed the national service in Tanzania has taken a strong lead in setting up and running the community forecasting pilot studies. Community-based forecasting, though clearly lacking the bigger perspective of the national operation, has key advantages. A greater sense of ownership of the process has increased the likelihood that farmers will act on forecasts. The major constraint that the national forecast usually failed to reach the people who needed it has been overcome by putting forecast generation in the hands of the people who use it. In the first community forecasting pilot, the Tanzanian government supplied insecticide spraying equipment for the participating villages and they agreed to pay the local costs for a second pilot. These are encouraging signs for further uptake of the approach.

Farmers, District Agricultural Officers, chemical suppliers, extension officers, a pesticide registration officer and district agricultural managers were involved in developing the ideas which underpin the community-based forecasting approach. An initial socioeconomic survey assessed whether farmers were interested in carrying out their own armyworm forecasting and in what way they are willing to respond to forecasts, either local or national. Participatory methods where used in the pilot studies and during the first year, traps were successfully operated and forecasts made by all the participating villages. A forecasting pack in both Kiswahili and English was produced to accompany training. This included basic information about armyworms and how they can be forecast, instructions on how to operate the pheromone trap, the rain gauge, and how to record and interpret the data to make the forecast. In the five pilot study villages forecasting accuracy has so far been good and one key outcome was that farmers tended to become aware of armyworm infestations in their fields at an earlier stage. The use of a community based forecast to alert farmers to the need for crop monitoring offers considerable promise as both feasible and cost effective.

Following a three year Department for International Development Crop Protection Program (DFID CPP) -funded project in which Community-based forecasting (CBF) of armyworm was developed and implemented in Tanzania, this one year follow-on project moved CBF to a new country, Kenya with a pilot study taking place in Machakos district. The project also assessed the technical performance of CBF and its sustainability from the pilot studies carried out so far in Tanzania. With a view to future scale up of CBF to reach more villages, a more general economic analysis was performed and the key elements identified that have made CBF a success so far. In addition to DFID funding, USAID also funded a one year CBF project which funded a second pilot in Tanzania as well as involving DLCO-EA personnel from Ethiopia. Using these funds, DLCO-EA with the Ethiopian MoARD last year carried out their own CBF pilot. Enabling a valuable sharing of information between delegates from Tanzania, Kenya and Ethiopia, DFID funded the attendance of representatives from DLCO-EA and MoARD to a project workshop held in Nairobi in September 2005.

Njuki, J., Kimani, M. & Mushobozi, W. (2002) Pilot Community Forecasting of Armyworm in Kilosa District: Field Days. CAB International, Africa Regional Centre.

Njuki, J., Kimani, M. & Mushobozi, W. (2003) Evaluation of Community Based Armyworm Forecasting in Kilosa District. CAB International, Africa Regional Centre.

Day, R. (2003) Community Based Armyworm Forecasting in Tanzania. Paper presented at a workshop on Agricultural Technology and Poverty, Makerere, University, Uganda, 26-27 November 2003. (Organised by Danish Institute of International Studies and Makerere).

Project Purpose

<u>'Strategies developed to improve forecasting and reduce the impact of migrant pests in semi-arid cropping systems, for benefit of poor people'</u>

The constraints the project sought to address related to the production of cereals, staple crops in east Africa but with yields that are highly variable due to the unpredictability of climate and pest attack. This variability is a key constraint to rural development, causing periodic crisis and hardship for rural communities. Improved forecasting of sporadic but serious crop pests is at the heart of the approach to reduce this variability. The losses due to armyworm, *Spodoptera exempta*, are virtually zero in some years and immense in others (Scott 1991). A reduction in the impact of armyworm attack, hinges around the timely supply and use of effective agro-chemicals (which are also safe and environmentally benign). Forecasting is directed toward improving the supply, targeting and timing of pesticide use.

The nationally-generated armyworm forecast rarely reaches the farmers and community-based forecasting solves the problem by empowering the villages to carry out their own forecasting. This project extends implementation of the technology to a new country, Kenya.

The main target institutions are the village communities whose crops suffer armyworm attack as well as the armyworm control services in Kenya and Tanzania. The latter includes the central forecasting operation and the regional and district agricultural offices. The policy implications of the work in particular are also relevant to the Ministries of Agriculture and at international agencies involved in funding and organising armyworm control (DLCO-EA, RLCO-SA).

Scott, P.J. (1991) A general review of the evidence on the economic importance of the African Armyworm (with specific reference to the eastern Africa region). Desert Locust Control Organisation for Eastern Africa, Technical Report no. 100. DLCO-EA, Nairobi, Kenya. 46 pp.

Research Activities & Outputs

1. CBF study performed in northern Machakos District, Kenya, a high armyworm risk locality. Brief baseline survey, discussions in the villages, training days, monitoring and evaluation

The pilot community based armyworm forecasting was implemented in Mwala Division of Machakos district. The district with an estimated 99,170 farm families has 159,500 Ha under Crop Production and 445,600 Ha is range land. Maize, Sorghum and millets which are vulnerable to armyworm attacks are also the most commonly grown cereal crops in the district. The district is classified among the primary outbreak areas where the initial outbreaks of the season are normally recorded before spreading to other areas of the country if not controlled. Mwala division was chosen for this pilot phase as it is among the most high risk armyworm out break areas in the district. Five sub-locations in the division were selected namely: (i) Wetaa, (ii) Mithini, (iii) Kibau, (iv) Mithanga, (v) Kyamutwii. The activities undertaken are tabulated below (Table 1).

Table 1. Summary of activities undertaken during the Machakos pilot

Activity	**Timing**	**Remarks**
(a) Baseline survey	1st – 4th March 2005	• Individual interviews and group discussion approach were used.
(b) Sub-location meetings	7th – 11th March 2005	• A total of 236 participants from the 5 sub-locations attended the meetings. • Two farmer forecasters elected from each sub-location for further training. • Communication methods to communicate forecast warnings discussed and agreed on.
(c)Training workshop	14th – 15th March 2004	• Attended by 20 participants as follows: o Nine farmers elected during sub-location meetings. o Five assistant chiefs (one per sub-location). o Five locational extension officers. o One divisional extension officer. • At the end of the workshop each sub-location was issued with a forecasting pack. • The trap and rain gauge were installed on 18/3/05 and data collection started on 19/3/05. • The first forecast was issued on 25/3/05.
(d) Official	29th April	• Organized to publicize CBAF.

Project Launching	2005	• Officiated by Assistant Minister for Agriculture (representative). • Trainees were presented with certificates.
(e) Mid-season Evaluation	3rd – 7th May 2005	• Group discussion approach used. • Discussions with farmer forecasters.
(f) End of season evaluation	11th – 15th July 2005	• Individual interviews. • Group discussions.

Implementation involved the following partners: Plant Protection Services Sub-division and CABI, District Agricultural Office Machakos, Divisional Agricultural Extension Office Mwala, Location Agricultural Extension Offices, Sub-location administration office (Assistant Chiefs)' Farmer forecasters and the Local communities.

A baseline survey (Annex 1) was carried out with the specific objectives to assess farmer perceptions about armyworms, examine the farmer decision making behaviour in relation to armyworms and to determine the yield losses due to armyworms. Focus group discussions were carried out as part of this process (Annex 2).

Farmer perceptions about armyworms. Farmers aware of armyworms, but had divergent views about what causes armyworms or when they appear with only 24% being aware that that the caterpillars follow the arrival of the adult moths. 45% of the farmers did not know what causes armyworms whilst some thought armyworms were associated with heavy rainfall and storms (7%) following a prolonged drought (11%). Armyworms were regarded as the most serous pest because they could cause total crop loss.

The farmer decision making behaviour in relation to armyworms. The main armyworm control method was use of pesticides but 41% of the farmers never controlled during the last outbreak. Reasons for failure to control were: limited financial resources, lack of information, lack of access to pesticides and lack of sprayers (43%). Armyworms attacked mainly maize (83%). Government pesticides were supplied but they were limited in quantity and occasionally arrived late. Most farmers were not aware of the government forecasting service. Only 13% received a warning during the last outbreak (2004). Control methods used: use of own pesticides (36%), use of government pesticides (12%), removal by hand (11%), no control at all (41%).

Mid-season (Annex 3) and end of season (Annex 4) monitoring and evaluation was carried out with the objectives: to asses farmer perceptions and knowledge of community forecasting, determine the performance of the forecasters, assess the forecasting information flow among the stakeholders, assess the role and participation of the different stakeholders, examine the methods and effectiveness of control, identify improvements that could be made during future scale-up.

Performance of the forecasters. The forecasters described their forecasting activities correctly to the fellow farmers. The forecasters were recording correctly and making the forecasts correctly and this was done every week starting 19/3/2005. Forecasters were maintaining the forecasting equipment correctly. Farmers reported that they saw forecasters performing forecasting duties and having been given forecast information.

Forecasters issued forecasts consistent with the forecast rules provided during the training. No armyworm outbreaks were reported during the season and only negative forecasts were issued. The negative forecasts were therefore consistent with the lack of outbreaks and the farmers reported that they trusted the forecasts. Farmers reported that they were now aware that armyworms could be forecasted, 92% of the farmers as opposed to the initial 51% reporting that armyworms could be forecasted. Farmers reported the activities of community forecasting to include: trapping moths, forecasting of armyworms, outbreak announcement and monitoring traps. In the event of a positive forecast in the future, farmers reported that they could take different actions. This remains to be tested as no positive forecasts were issued and no outbreaks were reported. Potential actions reported by farmers were: monitoring the fields, going to look for / purchase pesticides, visiting the extension office for advice, controlling whenever there was an outbreak.

Forecast dissemination with the village is an essential part of the training and the implementation. Sources of information in the sub-locations (in no particular order) were reported to be: Schools, Churches, Assistant chiefs, Extension officers, Village elders, Market places, Forecasters, Special village groups (Myethia) (Table 2).

Table 2. Flow of forecasting information among the stakeholders

Sources of Information	Number of farmers
Assistant chiefs	35
Sub-location extension officer	34
Sub-location forecaster	51
Mosques	1
Churches	34
Schools	29

Some corrections and modifications of procedures were suggested by the farmers: hold regular meetings to create awareness, increase the number of forecasters possibly for each sub-location, provide transport and some honorarium to the forecasters enhance information flow from the sub-location to the district level, provide information on appropriate pesticides and safe use of pesticides, encourage community initiatives for collective control improve access to pesticides and sprayers, e.g. hire schemes, hold farmer trainings in different areas, provide motivation the forecasters, and scale up CBF to other sub-locations.

Additional activity carried out with DISS funding. Delegates to attend workshop and present the findings from their CBF activities in Ethiopia and to allow representatives form Kenya, Tanzania & Ethiopia to share experiences with CBF

Overview of community–based forecasting initiative in Ethiopia (DLCO-EA)

The work in Ethiopia was initiated following the Nairobi meeting at CABI, Aug 2004, held in connection with a USAID funded input to the CBF initiative. The Ethiopian effort was USAID-funded and following the 2004 workshop discussions were held with PPD officials. Site selection for the Ethiopian pilot was made on the basis of the expected severity of the armyworm infestation, accessibility and the presence of a DA. The districts selected were Konso in southwestern Ethiopia, and Fedis in eastern Ethiopia. Five PAs selected in each district. The Criteria for selection of farmers were: ability to read and write, willingness, and selection by the peasant association.

Socio – economic surveys were carried out as follows:

Fedis: 17 – 22 November

Konso: 13 – 17 December, 2004

Farmers were divided into 2 groups for interview (group interview) and the no. of farmers interviewed was Fedis 59 & Konso 104.

Farmers' perceptions about armyworm. All consider armyworm as the major pest and many believe armyworm causes heavy damage/loss. The major crops affected are: teff, finger millet, maize and sorghum. Farmers had a variety of views on the occurrence of armyworm: many said comes with wind driven rain, some said comes from God in the sky, some also said comes from adjacent grassland and about 1% said it comes from moths.

Farmers' decision making practices. Most farmers like to control armyworm, but could not get insecticides on time. As a result, they use traditional methods such as digging a furrow, wood ash, removing weeds from sorghum and maize fields, mulching with dry grass, etc. All farmers reported that they do not start control operations on time. Farmers know the presence of armyworm from: neighbours, DAs, and some detect by themselves

During the CBF training in the villages, 35 farmers and DAs were trained and the topics covered were: biology and identification, crops attacked and damaged, control methods, operation of pheromone traps, forecasting methods, and methods of disseminating warning. A field exercise involved pheromone trap site selection, trap installation and trap catch removing and recording. Video film and sample of armyworm were used as training aids and materials were provided:

Pheromone trap and a capsule

Forecasting manuals (Amharic)

Daily record sheets

A certificate presentation was carried out at the end of the training.

African Armyworm Forecasting and Control in Ethiopia – A Closer Look (Kassahun Bedada, National Armyworm Coordinator)

The African armyworm, Spodoptera exempta (Walk.) (Lepidoptera: Noctuidae), is an economically important, outbreak seasonal pest of pastures and cereal crops in Ethiopia. Crop farmers and pastoralists have been suffering due to armyworm infestation for many years. The area infested over the last 20 years has ranged from 10,000 to over 350,000 ha per year and from 1963 – 67 the total estimated loss due to armyworm infestation was 25,000 tons of cereals (Table 3).

Table 3. Some major armyworm infestation records in Ethiopia

Year	Total area infested
1986 crop season	92,396 ha
1994 crop season	366,414 ha
1996 crop season	246,186 ha
1997 crop season	78,437 ha
1999 crop season	92,449 ha
2004 crop season	11,160 ha

Although the level of infestation varies from year to year and from region to region, armyworm infestation is reported approximately every other year in Ethiopia.

Armyworm Forecasting & Control in Ethiopia is run by the government. The CPD distribute pheromone lure & traps and gives financial support. This is now implemented through the use of pheromone trap net works (about 100 pheromone traps) distributed in strategic locations in different Regions. However, most of these traps are broken or spoiled otherwise and no reliable records are expected from them.

To control armyworm, the Government provides pesticides, either bought or secured from donors. It provides spraying equipments and protective materials to be used by farmers through the regional agricultural bureaus. It also gives financial support used to undertake control operation and during armyworm invasion the national armyworm coordinator, the crop protection experts in the Regional Offices & Plant Health Clinics coordinate control operations in different Regions. The woreda (= District) agricultural offices & the DA stations supervise and assist farmers in control operations.

In Ethiopia armyworm forecasting operations need large improvements so as to deliver timely information and warnings to farmer communities. The problems encountered in the foregoing forecasting operations are: i. the reports do not reach on time, ii. there is no suitable menu-driven data management system that could help to predict armyworm outbreak by using the simulated models for armyworm invasion. It is well known that forecasting could provide sufficient time to plan effective control strategy. So, beside improving the national armyworm forecasting service CBF can play a significant role to obtain data & disseminate information.

Short term forecasts: could they assist to tackle armyworm invasion? In 2004 DLCO-EA initiated community based armyworm forecasting in Ethiopia. Collaborating with the Regional Agricultural Bureaus and consulting historical data, 2 woredas - Konso woreda on southern part and Fedis woreda on the eastern part of the country - were selected. The main criterion for selection of woredas were: frequency of outbreak in the area, extent of damage in the area, and familiarity of the farmers to the pest.

To initiate CBF the sequence of activities was:
I. Information collection & analysis

1. Questionnaire preparation
2. Meeting with farmers community
3. Selecting farmers
4. Decision making

II. Implementation Process
Manual preparation. A manual composed of the biology, identification, damage & control practices including forecasting rules was prepared by CPD and DLCO-EA. The manual was to include colour pictures of the different development stages of the pest so as it can also serve as a reference material.
2. Trainings

On February 21-23 in Konso, and
On March 26-28 in Fedis woreda,

3. Performance of trained farmers

- Starting from Sunday March 27/05 the farmers in Konso have begun recording daily moth catches

- The incoming reports were remarkably good that they included the No. of rainy days and reasons when there was catches

From the other woreda – Fedis – beginning from April 10 only 5 week reports were dispatched and the reports were not as good as that of Konso (southern part). Due to several reasons evaluation of trained farmers is not undertaken in Fedis woreda.

Evaluation of forecasting trials. It is proposed that evaluation of the trials to asses their strength and weakness should be made in a two stage process. In Ethiopia training of selected farmers was not made on time and this also caused a delay in the evaluations. Only the end-of-season evaluation was undertaken in Konso by CPD on July 2005

Lessons learned and achievements. The selected farmers were willing, attentive and eager to undertake the work in both woredas. Especially in Konso (Southern part) the farmers have showed that community based forecasting of armyworm can successfully be applied by farmers. In some villages at Konso many farmers have come to hope that with daily monitoring of armyworm moths by the selected farmers no armyworm infestation would occur in their surroundings. [Clearly, there is some confusion here about the powers of forecasting]. In general the method followed to train farmers and the beginning of forecasting immediately is found suitable to undertake CBF in Ethiopia.

Problems

- Trained farmers were working individually not in pairs.
- Recording of catches were not properly made in some of the PA's & also permanent records are not available in some PA's.
- There were an unverified high number of moth catch reports.
- There was a shortage of stationary.
- Conveying the message of forecasting was poor
- Trained farmers are found to expect some incentives

A number of problems also exist from a government perspective. The plan to undertake (scale out/ scale up) CBF trail in 2005/2006 looks most unlikely due to budget constraints. Despite this, there is a fertile ground to wide scale implementation of CBF in the country. Regional agricultural offices, Plant Health Clinics, Woreda experts, DA's and many farmers become aware of the initiative. Although, some mistakes were done when presenting budget request to officials the CPD is convinced that the trial would bear fruit if implemented properly and it would do its best in the future.

2. Forecasts from Machakos, Kilosa, Moshi and Hai analysed to determine accuracy and explore simplification possibilities

Four broad topics were considered: Were the forecasting rules followed by the farmer forecasters? Did the forecasting rules predict outbreaks correctly? Was the farmer forecaster better than the rules in predicting outbreaks & why? Can the rules be changed to improve and simplify the forecast?

The data from the pilot villages were grouped as follows (Table 4). The 0405 season experienced no outbreaks as was omitted from the analysis.

Table 4. Community-based forecasting evaluation results grouped in six data-sets

Data-set	Occurrence of outbreaks
Kilosa 0102	Outbreaks
Kilosa 0203	Outbreaks
Kilosa 0304	Outbreaks
Kilosa 0405	None
Moshi & Hai 0304	Outbreaks
Machakos 0405	None

Were the forecasting rules followed by the farmer forecasters?

In the majority of cases the farmer forecasters appeared to follow the forecasting rules given during the training. When they do not adhere to the rules, two types of difference can occur: Farmer positive, Rule negative, and Farmer negative, Rule positive (Table 5).

Table 5. Agreement between Farmer-forecast & forecasting rules as given (Number & % of total forecasts)

	Kil 0102	Kil 0203	Kil 0304	M&H 0304	Overall
Same	31 89%	60 86%	84 95%	64 94%	239 92%
Farmer +ve Rule -ve	3 9%	4 6%	0	2 3%	9 3%
Farmer –ve Rule +ve	1 3%	6 9%	4 5%	2 3%	13 5%

Possible reasons were identified were discrepancies existed between the forecast according to the rules and the forecasts as issued by the farmers. The possible reasons should be regarded as pointers to what may be causing the farmers to deviate from the rules. Theses might inform discussions in future participatory evaluations.

Events associated with ‘Farmer +ve Rule –ve’

- One or more recent outbreaks had occurred (8 cases)
- Moths increased from 0 to 33 (but no rain & no previous outbreaks) (1 case)

Events associated with ‘Farmer –ve Rule +ve’

- Didn’t follow ‘previous week rule’ (7 cases)
- Farmer made an incorrect +ve forecast the previous week (1 case)
- Drop in moth catch from 195 to 35 (1 case)
- More than 4 weeks elapsed since last outbreaks (4)

Do the forecasting rules predict outbreaks correctly?

The average percentage of forecasts correct according to the forecasting rules was 80% (Table 6).

Table 6. Agreement between forecasting rules and occurrence of reported outbreaks (number and percentage)

Kil 0102	Kil 0203	Kil 0304	M&H 0304	Overall
32	51	79	47	209
91%	73%	90%	69%	80%

In considering those cases where the forecasting rules failed to predict outbreaks correctly, it is instructive to distinguish two types of error (Table 7). Positive forecasts proved more error-prone than negative forecasts, arguably the more desirable situation as incorrect negative forecasts are likely to have worse consequences.

Table 7. Number of cases of incorrect forecasting rules, either where the forecast was positive but no outbreak was reported or the forecast was negative but an outbreak was reported

Forecast	Kil 0102	Kil 0203	Kil 0304	M&H 0304	Overall
Positive (% of those positive)	0	15 50%	9 26%	19 66%	43 36%
Negative (% of those negative)	3 27%	4 10%	0	2 5%	9 6%

Events associated with incorrect negative forecasts

- Moth and/or rain thresholds not met but a succession of outbreaks over several weeks continued (7 cases)
- Outbreaks occurred and moth threshold but not rain threshold, met (2 cases)

Events associated with incorrect rule positives

- Longer delay (> 2weeks) before outbreaks started (7 cases)
- Thresholds exceeded later in season when earlier succession of outbreaks had long ceased (4 cases)
- Forecast +ve due to ‘previous week rule’ but outbreaks did not continue (1 case)
- Thresholds still exceeded but outbreaks had stopped (2 cases)

Comparison of farmer-forecasts and outbreaks

In the majority of cases the forecasts issued by the farmers were correct in the sense that outbreaks tended to occur or not occur following positive and negative forecasts, respectively. Where the farmer issued a positive forecast and no outbreak was reported, this is described as a false positive. Conversely, where the farmer issued a negative forecast and an outbreak was reported this is described as a false negative (Table 8).

Table 8. The outcome of the forecasts issued by the farmers

	Kil 0102	Kil 0203	Kil 0304	M&H 0304	Over-all
Correct (% of all)	34 97%	59 84%	81 92%	51 75%	225 86%
Farmer incorrect positives (% of those positive)	0	10 36%	6 19%	17 59%	33 29%
Farmer incorrect negatives (% of those negative)	1 11%	1 2%	1 2%	0	3 2%

It was instructive to compare the forecast that would have been issued had the forecasting rules been followed with the forecast that was actually issued by the farmers (Table 9).

Table 9. Comparison of Forecasts made by the farmers and forecasts:

a. Number of correct forecasts (% of total forecasts)

Forecast	Kil 0102	Kil 0203	Kil 0304	M&H 0304	Overall
Farmer	34 97%	59 84%	81 92%	51 75%	225 86%
Rules	32 91%	51 73%	79 90%	47 69%	209 80%

b. Number of incorrect negative forecasts (and percentage incorrect, of the total number of negative forecasts)

Forecast	Kil 0102	Kil 0203	Kil 0304	M&H 0304	Overall
Farmer	1 11%	1 2%	1 2%	0	3 2%
Rules	3 27%	4 0%	0	2 5%	9 6%

c. Number of incorrect positive forecasts (and percentage incorrect, of the total number of positive forecasts)

Forecast	Kil 0102	Kil 0203	Kil 0304	M&H 0304	Overall
Farmer	0	10 36%	6 19%	17 59%	33 29%
Rules	0	15 50%	9 26%	19 66%	43 36%

Although it is not known precisely why the farmers failed to follow the forecasting rules in a minority cases, useful pointers were obtained for further investigation. It is possible to some extent to identify the circumstances when the farmers did better than the rules (i.e. made a correct forecast when had they followed the forecasting rules, the forecast would have been wrong). These are listed below but of course do not necessarily imply that the prevailing situation caused the farmers to make a forecast contrary to the forecasting rules

- Recent outbreaks had occurred (6 cases)
- Moths above threshold but no rain (2 cases
- Didn't follow previous week rule (4 cases)
- Hadn't been outbreaks for more than one month (4 cases)
- Farmer issued a false positive last week, so predicted negative (2 cases)

Similarly when the farmer did worse than the rules (i.e. made an incorrect forecast but had they followed the rules the forecast would have been correct)

- Recent outbreaks had occurred (1 case)
- Didn't follow previous week rule (2 cases)

Potential for future alteration of the forecasting rules

Although there has probably been insufficient data collected to take the relatively large step of altering the forecasting rules given to the farmers, it was useful to investigate three specific alterations: No 'previous week rule', No rain threshold, and Different moth threshold.

Previous week rule. The previous week rule refers to the condition in the forecasting rules whereby if a forecast was positive last week because the moth and rainfall thresholds were exceeded, then the forecast is also positive in the current week (even if the thresholds are not exceeded this week). This rule appears to have caused some confusion for the farmer forecasters so it is helpful to examine whether it is really necessary.

Whilst the total percentage of correct forecasts was the same whether or not the rule was used (Table 10), there was an import effect on the relative occurrence of false positives and false negatives.

Table 10. Percentages of forecasts correct and incorrect with and without the ‘previous week rule’.

	Previous week rule	Kil 0102	Kil 0203	Kil 0304	M&H 0304	Total
Total correct	With	91	73	90	69	80
% of total	Without	80	74	89	76	80
Incorrect pos.	With	0	50	26	66	36
% of positives	Without	0	48	17	59	31
Incorrect neg.	With	27	10	0	5	6
% of negatives	Without	47	16	9	7	14

Without the previous week rule it was more likely that the forecast would issue an incorrect negative, i.e. say that there would be no outbreak when outbreaks did in fact occur. Incorrect negatives forecast are arguably the worse of the two types of error.

No rainfall threshold. The current forecasting rules incorporate thresholds for both moth catch (30 per week) and rainfall (at least 1 day in the week with at least 5 mm rain). We examined whether the rainfall dimension of the forecasting rule was necessary. Overall there was a slight reduction the percentage of correct forecasts; however, the percentage of incorrect negative forecasts was actually reduced (Table 11).

Table 11. Percentage of correct and incorrect forecasts with and without the rainfall threshold condition.

	Rainfall threshold	Kil 0102	Kil 0203	Kil 0304	M&H 0304	Total
Total correct	With	91	73	90	69	80
% of total	Without	94	66	85	68	77
Incorrect pos.	With	0	50	26	66	36
% of positives	Without	0	56	33	65	42
Incorrect neg.	With	27	10	0	5	6
% of negatives	Without	20	3	0	0	2

The moth catch threshold. The moth catch threshold given to the farmers was a ‘total of 30 or more moths per week’. The number of correct forecasts obtained using the standard threshold of 30 moths per week is shown for comparison with that using the optimum threshold (Table 12). The optimum threshold was calculated in hindsight for each of the four data sets as that which gave most correct forecasts. The results were variable but in general a somewhat higher threshold than 30 gave more correct forecasts, at least in three out of the four data sets

Table 12. Moth catch thresholds which resulted in the greatest number of correct forecasts

	Kil 0102	Kil 0203	Kil 0304	M&H 0304	Total / aver-age
No. correct (threshold ≥ 30)	32	51	79	47	209
Altered threshold to maximise correct forecasts	≥1	≥73	≥85	≥199	≥90
No. correct	33	55	83	54	225
% improvement	3%	8%	5%	15%	8%

Main Conclusions

The main conclusions from these analyses fall under four headings:
1. The accuracy of the forecast
2. Situations in which the forecasting rules failed
3. Why the farmer forecasters might be doing better than the forecasting rules
4. Considerations for forecast modification

Accuracy of the forecast

- The forecasting rules proved very accurate, averaging 80% accuracy.

- In evaluating this accuracy, however, it is necessary to consider the prior probability of a correct forecast (see Holt et al. Annex 5)

- Incorrect positive forecasts ('crying wolf') were more common that incorrect negative forecasts (missed outbreaks). It is probably less problematical for the errors to be skewed in this way rather than to have a higher proportion of missed outbreaks.

Situations in which the forecasting rules failed

- Outbreaks continued but catches dropped & therefore thresholds not met

- Thresholds were exceeded but outbreaks took longer to get going

- Thresholds were exceed but outbreaks had been & gone, one or more armyworm generations previously

Why farmer forecasters might be doing better than the forecasting rules

- Farmers use knowledge of occurrence / non-occurrence of prior or current outbreaks to inform their forecast

- Farmers may or may not follow the ‘previous week rule’ perhaps depending what other information they have

- Farmers appear sometimes make a forecast based just on moths

- Farmers appear sometimes alter a forecast if they made a wrong forecast last week

Considerations for forecast modification

- Dropping the previous week rule led to fewer false positives but more false negatives. The previous week condition should probably be retained though the degree to which it improves the forecast is small given the confusion it appears to cause.

- Dropping the rainfall condition led to more false positives but fewer false negatives. If future data follow the same pattern, it may be beneficial to greatly simplify the forecasting procedure (as well as training and implementation) by removing the rainfall condition

- A higher moth threshold led to a slightly improved forecast. Again, more data are required before making moth threshold adjustments. The appropriate moth threshold in any case is known to be trap-specific and individual traps can be calibrated as more data accrues

A paper describing aspects of this work has been accepted subject to minor revision in Annals of Applied Biology: ‘A simple Bayesian network to interpret the accuracy of armyworm outbreak forecasts’ by J Holt, W Mushobozi, R K Day, J D Knight, M Kimani, J Njuki and R Musebe (Annex 5).

3. Monitoring and evaluation will be carried out in the original CBF pilot villages in Kilosa. To learn lessons to continued implementation in the villages that have already been trained and for scale-up to others

Following the initial community-based forecasting pilot carried out in 5 villages in Kilosa district during the 2001/2002 armyworm season, there are now 20 villages in 4 Districts implementing CBF of armyworm. Evaluations have shown that the different stakeholders have all acknowledged benefits in a variety of ways. For example, the Tanzania Government has provided resources for the approach to be used in districts not covered by this project.

The main objective of this project activity was to learn lessons for the continued implementation of CBF in villages once the approach has been introduced, and for scale-up to other villages. Since it was initiated in the 01/02 armyworm season, CBF has been continued in all five pilot villages, in Kilosa with only a small external input from the National Coordinator to provide pheromone lures and carry out evaluation visits.

The initial villages in which CBF was piloted provided the opportunity to examine how sustainable the approach is, and what can be learned in this regard for extending the approach more widely. An evaluation was carried out in which all 5 villages were invited in June 2005. The following activities were conducted.

- Interview questionnaires with 50 individual farmers.
- Focus group discussions with farmers
- Discussions with the farmer forecasters
- Discussions with village extension officers
- Discussions with village government representatives
- Discussions with district authorities

The results and findings are summarised under 7 questions. The full report is in Annex 6.

- Do the stakeholders still perceive benefits of CBF?
- Are the farmer forecasters still performing their role effectively?
- How is forecast information flowing?
- What roles are the other stakeholders playing?
- What improvements would stakeholders still like to see?
- How have farmers' control practices and perceptions changed?
- Are there indicators that the approach is sustainable?

Do the stakeholders still perceive benefits of CBF?

All the stakeholders with whom discussions were held continue to see CBF as beneficial. At the village level (farmers, extensionists, village government) benefits include:

- Earlier control of armyworm, through monitoring and preparation for control.
- Reduced crop damage.
- Empowerment of the community, through a sense of ownership and improved understanding of the armyworm problem.

At the district level benefits include:

- Improved links between District Agricultural Office staff and village governments and extension officers.
- More time to respond to requests for assistance in control.
- Use of rainfall data for other purposes.

Are the farmer forecasters still performing their role effectively?

Forecasting was still being undertaken in all five villages by the original forecasters. One of the 10 forecasters originally trained had left the village and not been replaced. In the 2004/2005 season all forecasts were correctly issued as negative, while in the 2003/2004 season the farmers' adherence to the defined forecasting rules was as in Table 13.

Table 13. Forecaster adherence to forecast rules, Kilosa District, 2003/2004 season. Table shows number of forecasts falling into each category across all 5 villages.

		Correct Forecast	
		Positive	Negative
Farmer forecast	Positive	37	0
	Negative	4	47

Thus overall 95% of the forecasts were issued according to the rules. The 5% of 'errors' were all negative forecasts issued when a forecast should have been issued based on the 'previous week' rule, which it is known causes some confusion (and may be of marginal value, see Output 2). As well as issuing forecasts regularly and throughout the armyworm season, they were also maintaining the equipment well, and there was every indication that they were performing their role as effectively as in the first season when they were trained.

How is forecast information flowing?

Information is disseminated in different ways in different villages. Villages agreed at the establishment of CBF that dissemination of forecasts would not be the responsibility of the forecasters, but the forecasters would inform the village government and extension officer who would communicate to other farmers. However, at the end of the first season the forecasters were reported to be the primary source of information and this was still the case in the re-evaluation. Other farmers were in both evaluations the 2nd most frequent source of forecast information, but the role of the extension officer seems to have declined. Overall 52% of farmers who experienced an outbreak in 2003/2004 received a warning, so information is flowing, but not as effectively as it could.

What roles are the other stakeholders playing?

A key role of other stakeholders (extensionist, village government, other farmers) in the village is communication of forecasts, and as noted above this is occurring though not as effectively as required. The village governments also manage the 5 sprayers provided by central government at the start of the project. This is continuing, with some villages charging a modest fee for hire of the sprayers.

The District office sees its role as providing extension and other staff to backstop and support CBF, including the provision of insecticides and sprayers where possible. They are also responsible for training on the safe use of pesticides. Their role in communication is to represent farmers' interests at the district development committee, and to communicate information to the national coordinator.

What improvements would stakeholders still like to see?

Stakeholders expressed a range of suggestions for improvement of CBF, which fall into 4 areas:

- Improved information flow. Stakeholders are aware this is an important issue, and made suggestions for improved information flow in general, as well as in the specific instance of outbreak warnings.
- Improved control capacity. Forecasts are only valuable if farmers can respond, which includes controlling outbreaks once detected. Suggestions made for improving access to control methods include greater provision by government (District), providing more sprayers for hire, provision of control materials on credit, development of alternative control methods, and facilitation of community initiatives.
- Support for forecasters. Suggestions here included the provision of an honorarium to forecasters, provision of clothing/footware and provision of refresher courses and other courses to enable forecasters to give additional advice.
- Scaling up. There were frequent suggestions for scaling up to other villages, from all the stakeholder groups.

How have farmers' perceptions and control practices changed?

Table 14 shows some key parameters and how they have changed during the implementation of CBF. The first two columns of data were collected in the previous project, while the last column of data was collected during the current project.

Table 14. Changes in farmer perceptions and control of armyworm

Parameter	Before CBF	After 1 season	After 3 seasons
Know that outbreaks can be forecast	32%	71%	70%
Received warning of outbreak	26%	81%	52%
Controlled most recent outbreak	32%	81%	82%
Sprayed instars I-III	52%	83%	73%
Replanted after outbreak	58%	13%	36%

Farmer awareness of forecasting has been maintained, though it might have been expected to rise. However, there will always be a small proportion unaware, and 100% awareness is not necessary for the approach to be effective or sustainable (see Output 4). The proportion of farmers receiving a warning at their most recent outbreak has fallen. It is still better than before CBF, but this reflects the shortcomings in communication identified by the communities themselves, rather than inaccuracy of the forecasts. The proportion of farmers controlling the most recent outbreak remains high compared to before CBF, perhaps due to the fact that appropriate preparations at a village and district level can be made without all the farmers knowing of the forecast. Chemical application is still targeting younger instars that before CBF, though there is a suggestion that outbreaks may be being sprayed slightly later than after 1 season of CBF. This would explain why the proportion replanting has risen (though still not to pre-CBF levels), as replanting is necessary where control has been inadequate.

Are there indicators that the approach is sustainable?

This question can be addressed at two levels. First we can examine whether the approach is still operating as originally implemented, and delivering the benefits that stakeholders clearly expressed after the first season's trial. The preceding sections show clearly in all villages that CBF is indeed still functioning after two seasons with no external support other than provision of the pheromone trap. This is a very clear indication of sustainability. The stakeholders all continue to say the approach is valuable, and the data indicate that it is still delivering benefits, even if there are signs of a need to improve the dissemination of forecasts within the village.

The second level at which sustainability can be assessed is to look for indicators that the approach is not simply being used exactly as introduced, but that it has been genuinely appropriated. We briefly discuss a few such indicators.

Local investment. If the approach is valued by communities, we would expect them to be willing to invest in it. In Mvumi village the village government is providing a small honorarium to the forecasters, and also pays the village announcers who disseminate armyworm forecasts (and other notices).

Several village governments have also conducted public meetings to raise awareness of the approach.

Community initiatives. In several villages initiatives related to CBF have been observed which were not introduced under the project but have originated within the community. There are cases of groups of farmers making contributions and pooling their resources in order to purchase pesticides, presumably as with CBF control becomes more worthwhile. Other groups have made plans for purchasing sprayers for renting out to fellow farmers.

Demand for the approach. No systematic attempt has been made to assess demand for implementing CBF on a wider scale, but there are strong indications that the demand is there. At national level CBF has been included within the migrant pest control budget, and the Kilosa district authority has expressed support for scaling up and out. There are also cases of enquiries from NGOs who wish to implement the approach in the agricultural communities they are working with.

These indicators of sustainability are of particular significance as armyworm control has historically been led by government, promoting the widespread attitude that it is the government's problem to solve. The experience in Kilosa suggests that while that attitude has not entirely disappeared, CBF is empowering farmers to tackle the problem themselves, in a way that is appropriate and sustainable.

4. Economic analysis carried out of the value of CBF. Economic model developed to provide a tool for policy-makers to appraise future support for the approach and its applicability to new situations

The economic analysis was conducted using data collected from a variety of the trial sites in the different countries. However the majority of the information was derived from the surveys conducted in Tanzania and from literature relating to crop production in that country. Data collected and recorded for the villages in Kenya and other locations was less detailed but did provide valuable information on the occurrence of outbreaks.

The economic analysis was done on the assumption that the further dissemination of CBF will be done using a reduced level of inputs in terms of visiting villages. During the project itself time was spent in the village conducting socio-economic surveys to collect background information. The collection of this information will not be necessary for the implementation of the technique elsewhere so the cost of this activity will not be included.

Estimation of costs of CBF implementation

The first step was to estimate the cost of the preliminary visit to the village to explain the programme and then the subsequent training workshop. This was a relatively straight forward exercise as inputs to the training workshops were recorded as part of the programme. The tables below (Table 15 and Table 16) give the costs incurred by the preliminary visit and in running a training workshop for 20 villagers i.e. 10 villages. The costs were incurred in Kenyan shillings and then converted to dollars at the then current exchange rate of 75KSh to 1US$.

Table 15. Costs per village of preliminary meetings with villagers

ITEM	UNIT CONSIDERED	NO. OF UNITS USED	COST PER UNIT KSh	TOTAL COST KSh	Total cost US$
Trainers related costs. a) Preparation and presentation	Training hours Government approved rate.	2	2,500	5,000	67
b) Accommodation costs(2 trainers)	Days Each trainer 3 days	2	2,000	8,000	53
c) Driver	Days	2	1,200	2,400	32
d) Travel costs(Vehicle costs)	Distance (Km)	250	24	6,000	80
			Total costs	21400	**232**
			Total cost per village	2140	**23.2**

The only other cost to be incurred during the training programme was the provision of the pheromone trap and the lures necessary to run them. The traps and lures in this project were provided by the Tanzanian partner and were from existing stocks so no price was available. However, prices obtained from a UK supplier indicate that the cost of each trap is in the region of US$10. The traps are assumed to last 5 years before they need replacing. Lures need to be replaced at the star of the season and once during the course of the season the cost of these replacements is put at US$5 each (total US$10 per season) to include delivery to the village.

Table 16. Training workshop costs for 20 forecasters

	ITEM	UNIT CONSIDERED	NO. OF UNITS USED	COST PER UNIT KSh	TOTAL COST KSh	Total cost US$
1	Trainers related costs. a) Preparation and presentation	Training hours Government approved rate.	10	2,500	25,000	333
	b) Accommodation costs(2 trainers)	Days Each trainer 3 days	6	2,000	12,000	160
	c) Driver	Days	3	1,200	3,600	48
	d) Travel costs(Vehicle costs)	Distance (Km)	250	24	6,000	80
2	Trainee related costs. (No. of trainees – 20) a) Accommodation (Full board)	Each participant KSh.850 per day. Days	3	17,000	51,000	680
	b) Transport (fare reimbursement)	Number	20	600	12,000	160
	c) Out-of-pocket allowance	Number	20	600	12,000	160
3	Training materials					
	i) Flipcharts	Number (No.)	2	750	1,500	20
	ii) Note books	No.	25	80	2,000	27
	iii) Pens	No.	30	10	300	4
	iv) Photocopying paper	Ream	2	500	1,000	13
	v) Pencils	No.	25	25	625	8
	vi) Erasers	No.	25	15	375	5
	vii) Markers (Assorted)	No.	10	75	750	10
	viii) Rain gauge	No.	1	2500	2,500	33
4	Facilities (Hire of training hall)	Days	3	500	1,500	20
	TOTAL (expenditure for one workshop training 20 people)				**132150**	**1762**
	Cost per village (2 people)				**13215**	**176**

Recurrent costs to the CBF programme are the annual cost of lures and the time and effort required of the 2 nominated and trained villagers in the running and servicing of the trap. The costs of the trap and lures have been detailed above and the opportunity cost to the forecasters has been estimated at US$0.30 per day for the 6 month armyworm season. This is based on an input of 1 hour per day to cover the average time spent servicing the trap, allowing for travelling to and from the trap, counting the moths and processing the information at the end of each week to produce the forecast and to "publish" the information within the village. This gives an approximate cost of US$25 for the entire season. This assumes that the forecasters are indeed suffering some opportunity cost. Feedback from the forecasters and other villagers indicated that in some villages they both felt that the forecasters should be paid for their time. Indeed, in one village, a decision to pay the forecasters some money was made. It therefore does not seem unreasonable to cost this into the analysis. The total annual recurrent cost is therefore US$35. Traps are assumed to last fro 5 years and are replaced on that basis and rainfall gauges are assumed to have a lifespan of 10 years and therefore the cost of replacement is included at these intervals.

Value of the CBF

In order for the CBF to have value the benefits accruing from its deployment should exceed the costs of its implementation. It is possible to calculate the yield saving that is required to cover the cost of the CBF programme by doing some simple calculations using the price of maize as an example.

For the programme to break even a yield saving equivalent to the cost of implementation and running the programme must be achieved. To cover the cost of the initial meetings and training the yield saving must be equal to the combined cost of these activities which is US$199.2 (i.e. US$176 plus US$23.2). In addition to this the recurrent costs will also have to be met which is an additional US$35 which means the yield savings must be approximately US$235 assuming all the costs are to be recouped in the first year of operation. Using an average price of maize of TSh 125/kg (US$0.11/kg) then the yield saving required per village is of the order of 2140kg. For the villages surveyed the area cultivated and growing cereals ranged from 49 to 176 acres (20 to 74 ha). If the saving is distributed over the entire area of the village the improved yield per ha required ranges from 118kg/ha to 29kh/ha. In subsequent years the savings only need to cover the recurrent costs which only total US$35 per year or 318kg of maize. This is equivalent to only 18kg/ha to 4kg/ha. Of course it would be more realistic to spread the costs and benefits over a number of years and not expect all costs to be recouped in the first year. It has thus been established that relatively moderate improvements in yields will recoup the cost of the implementation programme.

Projected returns from CBF implementation

In order to determine the likely return on the investment made in the implementation of CBF a model incorporating Monte Carlo simulation was developed. The factors that were included in the model were as follows. All values in TSh were converted to US$ at the current exchange rate of 1155 TSh/1 US$

The type of seed planted
The type of seed can be selected between improved hybrid varieties and local farm saved seed. The price of hybrid seed was set at 1909 TSh/kg and local seed at 204 TSh/kg. The use of local seed was also assumed to reduce overall yields by 20% compared to hybrid seed.

Type of year
The type of year can be varied between “good” or “bad” the result of this is that final yields are set at either 2513kg/ha or 948kg/ha for good and bad years respectively

Discount rate
To make the estimate of the payback more realistic the model was run over 25 years and the Net Present Value of the costs and benefits calculated over that period. The discount rate can be changed but was set at 5% for the most part. The impact of changing the discount rate was explored.

Level and probability of outbreak
The model could use one of three outbreak levels low (15% of crop destroyed), medium (60% of crop destroyed) or high (70% of crop destroyed). The impact of attack level was assessed by having a discrete probability density function (pdf) for the likelihood of an outbreak occurring i.e. a one in ten chance of an outbreak occurring in any one year and then another discrete pdf for the level of the outbreak with low level outbreaks occurring 60% of the time, medium level outbreaks 30% of the time and high level outbreaks occurring the remaining 10% of the time.

Other inputs
Other inputs to the model included the following
Price of maize – set at a value of 125TSh/kg
Price of fertilizer – set at 221 TSh/kg
Price of labour – set at 17,000TSh/acre per season
Price of insecticide – set at 8543 TSh/litre

Seed rates and application rates were used to calculate the cost of establishing and growing a crop of maize. Control was assumed to occur in those years when there was an outbreak and the costs and benefits calculated.

The final variable in the model was the improvement in control that had been achieved by the intervention of the project. This was expressed as a percentage increase in the number of people controlling the armyworm and was derived from the figures obtained from the initial socio-economic survey data and the evaluation report from the field trials. The initial survey report indicated that 45% of farmers did not control armyworm for a variety of reasons which included those in the following table. The evaluation report indicated that the improvement in armyworm control was significant with the level of control reaching approximately 85% an increase of 30% from before the introduction of CBF.

Reason for not controlling (%) was given as:

Financial inability	38.3
Did not know what to do	16.1
Too late to control	10.7
Believed in self control	8.1
Waiting for government supplies	7.4
Unavailability of pesticides	4.7
No valid reason	4.7

From the preliminary socio-economic survey the largest improvement that may reasonably have been expected would be the sum of those who did not previously know what to do and those that were too late controlling which would only be about a 12% increase in control (although there are a number of others who gave no valid reason). Given this level of improvement the model shows that the cost of the CBF programme is easily met by the improvements in yields that could be expected.

The model was run for a number of different conservative scenarios. A conservative approach was used since if the cost benefits were positive under these conditions the benefits would be even greater under more favourable for conditions. For this reason the scenario chosen was as follows. The type of year was set as bad i.e. low yields would be obtained, and the seed used was local seed with a 20% yield penalty against hybrid seed. Pesticide use was assumed to be only 50% efficient which reflects poor use and timing. The outcomes are shown in Table 17.

Table 17. Net present value (US$) for 25 year period of CBF implementation under a variety of scenarios

Increase in farmers controlling armyworm (%)		1%	2%	4%	8%	16%	32%
5% discount rate outbreak I year in 10							
Area CBF implemented on	Overall yield						
49 acres	bad	-577	-541	-469	-322	-54	520
98 acres	bad	-470	-320	-46	553	1684	3905
49 acres	good	-520	-423	-231	146	893	2442
98 acres	good	-232	139	910	2414	5397	11191
10% discount rate outbreak 1 year in 10							
49 acres	bad	-432	-414	-372	-293	-132	192
10% discount rate outbreak 2 years in 10							
49 acres	bad	-534	-456	-301	12	645	1896

It is also assumed that 50% of the crop area destroyed is re-sown although this does not include labour so represents a very small proportion of the overall cost and as such the model is not very sensitive to any changes. The probability of an outbreak was set to 0.1 with the size of the outbreak being determined by the pdf defined above. The cost of the CBF training was spread over the area farmed within in a village. In this case the area chosen (49acres) was to see if the CBF was economically viable for the smallest area that was farmed in the pilot programme. The model was run 10,000 times to produce pdf of the Net Present Value. The table shows the outcomes from the model for a range of scenarios (Values are the 50th percentile values from the Monte Carlo simulation of the net present value for 25 year period in US$). As can be seen the outcomes are most affected by the frequency of the outbreak, whether it is a good or bad year overall for crop yields and the area over which the forecasting activities apply. For the smallest area the increase in control or technology penetration that is required in a bad year with a 5% discount rate and an outbreak only every 1 in 10 years is approximately 17.5% to break even. An outbreak frequency of 1 year in 5 brings the technology penetration requirement down to 6.5% in order to recoup the costs of the training. These targets appear to have been surpassed by the recorded increase in the percentage of farmers undertaking control as a result of the CBF programme. This analysis is based on the data collected in Tanzania but it is highly probable that when data is available for the other countries the results will be similar.

The model highlights that, in theory, even with outbreak frequency as low as 1 year in 10 there is benefit in undertaking the CBF, however, it is not at all clear whether the communities will continue to run the trapping system in the absence of armyworm outbreaks although villages have been recorded as continuing with the programme even with an absence of outbreaks, most notably during the 04/05 season. It would be a useful exercise to ascertain the frequency of outbreaks in armyworm affected countries and the associated crop production economics to see where it would be sensible to implement the CBF approach.

5. An evaluation will be carried out to establish the important factors which contribute to the successful implementation and sustainability of CBF

Key success factors

This activity took the form of a project workshop session followed by discussion and consolidation to produce the report. The question considered during the workshop was “What are the key things that make CBF a success? Can we simplify the scale-up process yet retain the important elements of success”. A full report of the workshop including this activity is given in Annex 7.

Brainstorming the question of what are the key things that make CBF a success, workshop participants wrote two to three ideas each on cards. The cards were then displayed and ordered by the group into what appeared to be two natural categories: the nature of CBF itself (what is CBF) and the way CBF is implemented (How CBF is done)

What is community-based forecasting?

List of cards contributed by participants:

- Good science
- Demand driven
- Appropriate technology
- Applicable to a regional pest problem
- Helps the farmers to get control materials on time
- Relevant to farmers seeing armyworms as a problem
- Changes the farmers attitude in pest control
- Improves information dissemination
- It works (probably)
- Provides better forecasting than existing system

How community-based forecasting done?

List of cards contributed by participants:

- Approach of genuine empowerment
- By effective engagement of communities
- Planning before implementation of CBF
- Offer availability of equipment
- Introduced within the existing village structures, e.g. assistant chief must be ‘on-board’
- Decision must be approved (supported?) by the DA (DA’s) before announcement
- Targeting training
- Ownership – farmers given the chance to nominate one of their own as the forecaster
- Genuine participatory approach
- Institutional investment by government at all levels

- Community ownership

It was felt that in order to be taken up successfully that CBF must fulfil a real need and also be an appropriate technology to solve the problem – perhaps an obvious truth but important none the less. The set of 'What is CBF' cards make the point well. The armyworm problem is important and widespread and farmers are aware of it and want to do something about it. The CBF approach uses village level technology and has worked well so far, and importantly, farmers have seen that it does work.

The way in which CBF has been introduced to, and implemented in, the pilot villages has been highly participatory and the workshop group believed that this was an essential element of its success. Engagement of the community and the village authorities and offering aspects of the decision making to the villager's themselves has led in the pilot studies to ownership of CBF by the village. This is evidenced by the fact that pilot villages have continued to run CBF, in the case of the Kilosa pilot for a further three years following the initial training. In addition, local initiatives have arisen associated with CBF, e.g. a sprayer rental scheme and a contract sprayer group. As a sign of institutional investment, in some cases both village and district authorities have allocated some funding to allow CBF to continue.

Possible future directions

In the light of experience gained to date with CBF development and implementation, further discussion took place on possible future directions. The next logical step for CBF is to continue the scale-up process. Pilots have now been carried out in Kenya and Tanzania as well as an initial pilot in Ethiopia. The number of villages reached has so far been a small proportion of the number which might benefit so the next challenge must be to test potential scale up approaches to devise effective ways to present greater numbers of villages the opportunity to develop CBF.

The process of implementing CBF which we have used so far was revisited to consider the problem of scale-up such that the key elements listed above would not be lost. It was felt that the basic structure of the training should remain the same but that a number of activities could be combined or condensed. In addition, further institutionalisation of CBF was proposed by introducing a training of trainers (TOT) workshop (Item 2, below) for the district (or equivalent) coordinators, probably the district crop protection officer (or equivalent). The TOT would cover both training in participatory approaches and training in CBF. It is envisaged that the district coordinators would then act as the key trainers and return to their districts to carry out the farmer-forecaster training in selected villages. A feasible TOT group might comprise DA's from 10 districts plus a deputy, making 20 people in total.

The first contact with the village would take approximately two consecutive half days to introduce the topic, hold a group discussion, call a village meeting and elect the farmer-forecasters (Items 4 – 6 below). It is envisaged that the national forecasting coordinator would back up the DA trainer but clearly it would not be possible for the national person to attend all village level activities. The training workshop would proceed as before with 4 representatives from each participating village (farmer-forecaster and deputy, village extension officer, and village authority e.g. assistant chief) attending a residential course in the district. Mid and end of season monitoring, with the important ancillary function of offering encouragement, would take a short half day each. Were appropriate to raise the political profile of CBF, a 'launch' could be held in newly participating villages, although it was noted that the costs of such are often substantial.

Implementation, step by step

1. Planning meeting
2. TOT for District / Woreda co-ordinators
3. District planning meeting
4. Socio-economic survey & introduction to AW forecasting
5. Village meeting
6. Election of Farmer-Forecasters
7. Training WS
8. Forecasting tools pack
9. Forecasting (and data collection)
10. 'Launch' (when appropriate)
11. Mid-season monitoring
12. End-of-season evaluation
13. Review meeting

Two slightly different models for scale up were discussed. In the first, District coordinators would be exposed to the TOT workshop without prior hands-on experience of carrying out CBF training in the villages. The advantage of this is that a relatively large number of DA's can be trained at the outset. In the second model, training of the DA would post-experience. Whilst probably better, it would mean that the burden of initial introduction of CBF to every district would have to fall on a single national person, so making the whole process of scale-up rather slow. There is no reason why a single training model should be used, and indeed, trying both approaches would itself be very instructive.

Proposed methodology for the implementation of a scaled-up CBF programme

The scaling-up of the CBF methodology needs to address issues at three different levels; regional, national and local or district level. A key requirement for all of these is a planning meeting to decide the strategy at each of the levels.

<u>Planning meeting</u>
(REGIONAL LEVEL)

NATIONAL LEVEL
At the national level decisions will be needed on which districts will participate in the programme in any particular year, probably based on the risk of

armyworm in that district. The training of trainers will then be organised (see section on training of trainers).

DISTRICT LEVEL
At the district level the purpose of the planning meeting will be to select which villages will be used in the implementation of CBF.

Socio-economic survey and introduction to community based forecasting
Whilst the S-E survey was an integral part of the development programme it is not clear that is has value in the general implementation process. The actual data will not have value but it is possible that the process of collecting to helps to engage the community with the process. The S-E survey can be combined with the initial village meeting to explain the forecasting process and to explore the different existing channels of communication within the village. The two farmers to be trained will be elected at this meeting. The process will be divided into two half day sessions run on consecutive days allowing two villages to be addressed in two days but still allowing sufficient time for the villagers to think about who they might elect to be trained.

Training workshop
The two elected farmers, the assistant chief (or equivalent) and the village extension worker (or development agent) will be trained how to operate the trap and to produce the forecast. (The extension worker (development agent) has the potential to be trained up as a trainer in future years perhaps)

Training of Trainers
The training of individuals within villages cannot be undertaken using the approach used to date i.e. the use of CABI staff and high level persons within the country forecasting service. Even if only the high risk districts within each country are considered there would be approximately 150 districts (Tanzania 22, Kenya 25 and Ethiopia ~100) each containing up to 200 villages. To train all the villages would simply take too long. A suitable approach to this may be to “train trainers” whereby the number of trainers is multiplied during the training process itself.

Various models for the training of trainers were considered. A “traditional” model whereby the most enthusiastic student from one previous session is selected to train other farmers was felt to be less likely to succeed with this particular programme since there is the need to embrace both the philosophy of community based projects and the participatory approach with the technical dimension of the forecasting. It was therefore decided that training the District Crop Protection officer with his assistant in each district and then using them to do the training in the villages would be more successful since the technique was less likely to be “diluted” by the training trickling down through a number of layers of farmers. This does have the disadvantage that the roll-out of the technology will be relatively slow in the first instance although ways of speeding this up could be considered later depending on the success of this strategy.

Both Kenya and Tanzania are now in a position to begin testing out the institutionalisation of CBF in a first phase of scaling up. The pilot in Ethiopia ran into some problems and the next step there would be a better supported and organised pilot.

The need for sustainability indicators was raised as becoming more important as more villages become trained. The project workshop developed a list of sustainability indicators that might be used to assess whether CBF is becoming self sustaining within a village. These indicators apply at the village level but also in some cases to the district level and above:

- Internal investment
- Continued functioning of the system
- Value perceived
- Evolution of the system occurring
- Reproducing itself (i.e. new villages starting up CBF independently)
- Demand by non-participants
- Institutionalisation

Research Issues

Along side the CBF training and implementation a number of research issues were considered necessary.

1. Forecasting rules. With the data collected from the pilots conducted so far possibilities are emerging for modifications to improve the forecasting rules. These include the level of detail with which it is necessary to collect rainfall information, the moth number threshold, and the inclusion of additional information, notably the presence of outbreaks at the time the new forecast is made. There have been some indications that the farmers may adapt the rules rather than simply make mistakes in their interpretation. Evaluation could usefully be extended to gain a better understanding of whether the farmer-forecasters are indeed making deliberate modifications. A key part of forecast evaluation is accurate outbreak reporting. In the pilots carried out so far, outbreak reporting has been rather ad-hoc, and non-standardised making evaluation of the accuracy of forecasts somewhat open to interpretation.

2. Trap design. Rather than sources relatively expensive professionally produced pheromone traps, there are possibilities to produce simple traps from local materials such as plastic bottles or other containers commonly available in village shops. Whilst this would potentially make traps cheap and easy to make, they would become non-standardised, so making comparisons between traps less valid.

3. Impact & economics. As a body of data builds up during scale up the opportunity exists for more quantitative monitoring and evaluation

4. Currently each participating village has received a single trap. It may be that more than one trap per village would provide more accurate forecasts, or that several villages could effectively share the information from a single trap. Spatial corrections of trap data and outbreak reports might be used to investigate what are satisfactory trap densities for effective local forecasting.

Contribution of Outputs to developmental impact

Following the initial community-based forecasting pilot carried out in 5 villages in Kilosa district during the 2001/2002 armyworm season, there are now 20 villages in 4 Districts of Tanzania implementing CBF of armyworm. CBF has continued in all villages with only a small external input to provide pheromone lures and carry out evaluation visits. In addition 5 villages in Kenya started CBF last year. The number of farmers in a village is highly variable but is typically many hundred.

The Tanzania Government and/or donors have provided resources for the scaling up which has been carried out in Tanzania.

District authorities have benefited through institution-building and the links between community forecaster, village Government, extension staff & district office have been strengthened. Farmers and village authorities have expressed a sense of ownership of the CBF activity and a willingness both to continue it and to support it. Actions have changed as farmers report monitoring their crops for armyworm and taking early control with the effect that armyworm damage was reduced and this translated into higher yields.

Community-based forecasting has proved to an effective method for supporting poor farmers to control armyworm outbreaks, at least in those districts with a high risk of armyworm attack, were it has been piloted. The implementation activity itself has promoted a better partnership between scientists and farmers through a shared concern to solve the problem.

A high demand for CBF has been expressed by groups and individuals from villages and districts who have heard about the pilot schemes but have not so far participated. The need for scaling up is therefore very apparent. Scaling-up needs to be accompanied by on going research and development. As more results become available from the pilot studies, work is needed to revisit and refine the forecasting procedures. There is a major logistical and technical challenge to plan and implement the scaling up operation with is associated needs to train more stakeholders and partners.

Reduction in crop losses has led to higher yields and income from crops. There has been an improvement in peoples' livelihood and welfare due to increase marketed surplus and more food for subsistence purposes. Technical know how in the village has increased and forecasters have gained status through the training. All the original forecasters were still 'in post' except one who had obtained a job in Morogoro.

88% of the farmers in the participating villages now monitor their farms for armyworms. There has been an improvement in the success of control with successful control reported by 75% of the farmers that used control measure. Fewer farmers now replant crops due to this improvement in successful control. Village communication has increased and many villages have made efforts to develop and maintain CBF. In some cases a small token has been provided to the forecasters by the village government. The village government facilitates photocopying of the data forms and some village governments pay Tsh 500 to the village announcers. Some also conduct regular meetings to create awareness. Villagers provide security for the trap and regard both the forecasting and the information dissemination as a group responsibility.

The number of villages reached has so far been a small proportion of the number which might benefit so the next challenge must be to test potential scale up approaches to devise effective ways to present greater numbers of villages the opportunity to develop CBF.

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List of Annexes

Annex 1 Musebe R, Musavi F, Ndetu V. 2006. *Economic evaluation and international implementation of community-based forecasting of armyworm: Baseline socioeconomic conditions in the forecasting trial areas.* Nairobi: CAB International Africa Regional Centre.

Annex 3. Musebe R, Kimani M, Musavi F. 2006. *Economic evaluation and international implementation of community-based forecasting of armyworm: Monitoring report* Nairobi: CAB International Africa Regional Centre.

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Annex 5. Holt J, Mushobozi W, Day R K, Knight J D, Kimani M, Njuki J, Musebe R. A simple Bayesian network to interpret the accuracy of armyworm outbreak forecasts. Annals of Applied Biology, submitted.

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Biometricians Signature

The projects named biometrician must sign off the Final Technical Report before it is submitted to CPP. This can either be done by the projects named biometrician signing in the space provided below, or by a letter or email from the named biometrician accompanying the Final Technical Report submitted to CPP. (Please note that NR International reserves the right to retain the final quarter's payment pending NR International's receipt and approval of the Final Technical Report, duly signed by the project's biometrician)

I confirm that the biometric issues have been adequately addressed in the Final Technical Report:

Signature:
Name (typed):
Position:
Date: