Economic Analysis of the CATIE IPM/AF Programme in Nicaragua

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List of Abbreviations

CABI	Commonwealth Agricultural Bureau International
CARE	Cooperative for Assistance and Relief Everywhere
CATIE	Tropical Agricultural Research and Higher Education Center (Spanish acronym)
EIRR	Economic Internal Rate of Return
FAO	Food and Agricultural Organization
FAO-EU	Food and Agricultural Organization – European Union
FFS	Farmer Field School
FIRR	Financial Internal Rate of Return
ICO	International Coffee Organisation
INTA	National Agency for Agricultural Technology (Spanish acronym)
IPM/AF	Integrated Pest Management and Agroforestry
IRR	Internal Rate of Return
MAgFor	Ministry for Agriculture and Forestry
M & E	Monitoring and Evaluation
NPV	Net Present Value
NORAD	Norwegian Agency for Development Cooperation
PROMIPAC	Programme for Integrated Pest Management in Central America (Spanish acronym)
SADC	Swedish Agency for Development and Cooperation
SDC	Swiss Development Cooperation
T&V	Training and Visit type of Agricultural Extension
UoH	University of Hannover
WLS	Wider Learning Studies

Preface

This study of an IPM Programme in Nicaragua is an example showing the possibilities and limitations of conducting economic impact assessment of a technical cooperation development project in agriculture. The case is nevertheless special because ways and means are explored to carry out such analysis in the context of highly imperfect information. The study is a component of an integrated set of studies within the CABI/CATIE Wider Learning Framework. The CATIE IPM/AF Programme in Nicaragua was a long-term IPM programme funded by NORAD. The 15 year Programme followed a participatory technology development approach with the objective to improve decision-making processes among different levels of the agricultural service delivery system including farmers. This complexity posed considerable challenge for conducting a quantitative analysis to assess the Programme’s impact on economic welfare.

The approach taken in this study was novel in such a way that participatory principles were an integrated part of the analytical procedure. IPM stakeholders in were not only confronted with the results of the study but were actually challenged to improve the analysis through a systematic process of verifying the major assumptions that were initially used in the economic analysis. Hence, cost benefit analysis was used as tool of ex post impact assessment but also as a instrument of facilitating better communication between economists and IPM experts. By making the analytical procedure and the assumptions very transparent more attention for the methods used in economic analysis, raised interest in the study results, higher responsibility for the implications of the study and in the end also more ownership of the Programme itself was achieved.

It is hoped that this report will encourage more economic studies on IPM Programmes in developing countries in spite of the sparse data situation, which is common for many development projects not only in IPM. We submit that lack of data should not be used as an excuse for going on with “business as usual”.

Hildegard Garming

Hermann Waibel   Hannover, November 2005

Acknowledgements

At this place we would like to thank those persons who contributed to this study and made it possible. The first thank goes to the CATIE IPM/AF team in Managua and the Programme Director Dr. Falguni Guharay who hosted the researchers during their stay in Nicaragua and provided the infrastructure, all the information required and contributed in discussions with their valuable ideas in the course of the study. They carried the workload of organizing the stakeholder workshop in Managua. Their hospitality was very much enjoyed and is highly appreciated.

In Nicaragua there are a number of people who contributed to this study: We acknowledge the contribution of the farmers who provided data from their farms in the communities of Santa Cruz, Apapuerta, Las Americas, Niquinomo, Payacuca and La Concepción and the extension workers from INTA, AGRODERSA, Unicafé and ESTECA. Dr. Allan Hruska and Dr. Marianela Corriols facilitated data on pesticide-related health and advised us on that topic. Also we thank the participants of the stakeholder workshop for sharing their experience and contributing substantial information to improve the analysis.

We thank the CABI team: Julius Jackson, Azra Awan-Hamlyn and Catrin Meir for the organization of the WLS and Myriam Paredes who gave us valuable support during fieldwork.

In the University of Hannover this study was reviewed and edited by Rudolph Witt and Florian Heinrichs. We appreciate their valuable time and effort.

The authors

November 2005

Executive Summary

The CATIE[1] Regional Programme on Integrated Pest Management and Agroforestry, financed by NORAD[2], was initiated in 1989 in coffee and vegetable production in Nicaragua. The overall goal was to develop a national capacity in Integrated Pest Management (IPM) in order to facilitate the introduction of environmentally benign production technology in agriculture.

In this report the results of an economic study of the Programme are presented. The study is part of a range of different studies of the CATIE IPM/AF Programme[3] called the Wider Learning Studies (WLS) conducted in collaboration of Commonwealth Agricultural Bureau International (CABI) and the University of Hannover (UH). The objective of the study is the quantification of the Programme's impact. The methodology is based on a cost benefit framework including a Monte Carlo risk analysis approach. The IPM stakeholders in Nicaragua were involved in the evaluation process by contributing expert assessments in order to complement the available data.

The findings of this study are meant not only to inform about the Programme but also to provide information for the planning of future IPM activities in Nicaragua and neighbouring countries. Chapter 1 describes the general setting of the Programme in an international context. Parallels can be drawn to the concept of the Farmer Field Schools, which was widely applied in Asia and in several Latin American countries. The WLS concept of evaluation is outlined in chapter 2.

In chapter 3, the Programme's concept and its development phases are outlined. The Programme started out with a conventional technology development phase. However, soon it adopted participatory research and training methods. The third and last phase then can be labelled as the main field phase with large-scale farmer training. To develop a national capacity in IPM the Programme followed a multi-institutional intervention concept, involving farmer organisations, universities, governmental and non-governmental organisations as partners working in IPM.

[1] CATIE: Tropical Agricultural Research and Higher Education Center (Spanish acronym),

[2] NORAD: Norwegian Agency for Development Cooperation.

[3] referred to throughout this document as 'the Programme'

The methodology of the cost benefit analysis and the database are presented in chapter 4. The data availability in the case of the CATIE IPM/AF programme is sparse, especially because no baseline study was conducted that could be used to establish a counterfactual. Therefore various information sources were used. To cope with the resulting high uncertainty about the Programme impact in the data, risk analysis methods were used , which are described in chapter 4.

Chapter 5 presents the results of the financial analysis of the Programme. The quantitative assessment shows a positive net present value (NPV) and a financial internal rate of return (FIRR) of 19.1%. A scenario analysis shows that the major benefit share is attributable to yield increase in coffee. However, the economic success of the Programme also depends on the sustainability of the benefits in the future. A benefit flow that exceeds the Programme's intervention at least by 3 years is the critical time span to achieve financial viability. By means of a stochastic simulation model the probability distribution of the NPV was computed. Results showed that the probability of a positive NPV is about 90%. On the other hand, if benefits cannot be maintained for 5 years after the Programme's end, the probability of a negative NPV increases to 48%.

The initial calculations were subjected to stakeholder discussions in a workshop in Nicaragua. Equipped with the results of the WLS studies national experts reviewed and discussed the assumptions on which the calculations in the economic study were based. Simultaneous integration of the proposed changes into the model calculations provided a new set of results. They showed that the stakeholders had a more optimistic judgement of the Programme's impact.

In chapter 6 the assumptions of the financial analysis were modified to perform an economic cost benefit analysis of the Programme. External benefits from reduced pesticide use include improvements in the health status of farmers and consumers, as well as a reduction of the contamination of water.

In chapter 7 the findings of the study are summarized. It is concluded that the Programme's investment had paid off. The Programme benefited both the Nicaraguan farmers as the main target group and the Nicaraguan economy. The participatory nature of the study especially the transparent and open conduct of the risk analysis increased the validity of the results. Also the acceptance of the study rose and the decision makers became more interested in economic evaluation studies of IPM.

1 The Rationale of IPM Impact Assessment

IPM is a combination of crop management practises that emphasize the self-regulating forces in agro-ecosystems. IPM favours agronomic practises such as crop rotation and mechanical, cultural and biological control of pests instead of sole reliance on chemical inputs. Governments in developing countries and donor agencies support public programmes promoting IPM, expecting that several objectives can be achieved:

a) improve the productivity of agriculture through more effective targeting of pest control measures,
b) reduce human health hazards resulting from excessive pesticide use,
c) protect the environment by reducing the amount of pollution resulting from pesticides, and
d) stabilize agro-ecosystems and thus reduce the likelihood of severe pest outbreaks.

To date there are a few rigorous studies evaluating the impact of IPM at farm and national level. Hence there is a need to conduct more and better economic studies of IPM programmes in developing countries. Such studies especially have to address methodological issues of impact assessment, which are subjects of on-going discussions on the effectiveness and efficiency of agricultural extension in developing countries.

1.1 Recent Evidence on Economic Impact of IPM

Existing information on the impact of IPM programmes in developing countries is conflicting. On one hand, several evaluation reports of the Farmer Field School (FFS) approach promoted by FAO (FAO 1999, 2000, FAO/World Bank, 2000) and other development organisations claim positive effects on yields and farmer profits. In most cases these reports also show a decline in pesticide use of those farmers who participated in IPM programmes. These studies were mainly conducted in Asian countries including Sri Lanka (Tripp *et* *al.* 2005), Bangladesh and Vietnam (cited in Feder *et al.* 2004)[4]. Similar claims have been made for FFS-projects in Africa, e.g. in Ghana, Cote d'Ivoire and Burkina Faso (cited in van den Berg 2004). Unfortunately these reports were not published in scientific journals and thus are mostly "grey literature". Also, most previous studies did not apply econometric analysis but relied on simple comparisons of means of performance parameters. Feder *et al.* (2004) pointed out that such studies might overestimate the impact of IPM programmes. This will be the case, for example, if the placement of the programme is in different villages and if the selection of farmers to participate in the programme is not made at random. Contrary to evaluations of many FFS programmes, the study of Feder *et al.* (2004) on the impact of a World Bank supported IPM training programme in Indonesia, which followed the FFS methodology, found no differences between IPM and non-IPM farmers, neither in the level of pesticide use nor in yield. Instead, both trained and untrained farmers had even increased their use of pesticides over time, despite a general decline in yields.

As far as the effectiveness of IPM programmes is concerned, previous studies provide no consistent and reliable information. Hence, further quantitative studies of IPM programmes are needed. These should help to clarify the true potential of IPM, given the political, institutional and economic constraints that prevail in many developing countries where IPM programmes are implemented. Such studies are also needed to draw appropriate lessons on how to improve the design and the effectiveness of IPM programmes. In addition, conducting additional studies will help to avoid a polarisation of the debate, which could result in a decline in donor interest in IPM and a return to the promotion of single solutions in pest control such as genetically modified varieties. It also has to be considered that in the actual situation of changing market structures in the pesticides and crop protection industry with only few remaining global companies, the disappearance of public-funded IPM could cause severe disadvantages for farmers and pose additional environmental risks.

[4] Praneetvatakul and Waibel (2001) have initiated a study on a pilot scheme of FFS irrigated rice in six provinces in Thailand. Initial results indicate a reduction in pesticide use but are less conclusive about increases in profit.

1.2 Investment in Public Agricultural Extension and IPM Programmes

Public funds spending has to follow the principle of economic efficiency such that the investment has to be justified by the benefits that are generated by the programmes. This implies that empirical evidence on past performance of IPM programmes, provided through independent studies, is essential to draw conclusions about the future of "public-funded IPM".

Another factor, which makes the evaluation of large-scale IPM programmes an important issue is that in most cases such programmes are embedded in centrally administered extension systems. However agricultural extension programmes suffer from typical problems of government-run programmes, such as lack of accountability to the clients, poor coordination with the policy environment, lack of fiscal sustainability, and poor interaction with other stakeholders (Feder *et al*. 1999). Based on the scientific literature, the experience of agricultural extension systems over the past few decades has been mixed. Some studies estimate high rates of return to investment in extension (Birkhaeuser *et al*. 1991), or to farmer education (Jamison and Lau 1982; Lockheed *et al.* 1980). Yet, many observers document poor performance in the operation of extension and informal education systems, due to bureaucratic inefficiency, deficient programme design, and some generic weaknesses inherent in publicly-operated, staff-intensive information delivery systems (Feder *et al.,* 2001, Anderson and Feder 2004). Recent studies on the impact of national extension programmes, for example in Kenya, have observed highly unsatisfactory performances (Gautam and Anderson 1999). Consequently, the relevance of public agricultural extension services is increasingly being questioned.

The discussion to date centres around the fiscal burden of the existing public services on governments, and alternative ways to tap new sources of finance for agricultural extension. Thus liberalization and the part-privatization of agricultural extension services are seen as a potential solution to these problems. For example, Dinar and Keynan (1998) analysed the improvements of service performance in response to introducing cost recovery mechanisms in Central America. Also Anderson and Feder (2004) concluded from their review of agricultural extension service systems, that efficiency gains can be expected from decentralized delivery and incentive structures based on largely private extension.

On the other hand it has been argued by Fleischer *et al.* (2002), that even if agricultural extension is partially privatized, where more market-oriented and commercialized rural economies allow a stronger involvement of the private sector in information and knowledge systems, a set of well-defined agricultural extension functions should remain in the public domain. These functions are found in at least four areas:

1) The provision of information about non-market goods such as public health, and cultivation practises for protecting ground water quality and other environmental resources.
2) Balancing the information provided by the private sector, which may be biased towards promoting specific technologies primarily benefiting the input supply industry, and which can lead to the inefficient use of farm resources.
3) The provision of information to disadvantaged sectors of the rural economy, such as small-scale farmers, the rural poor (e.g. landless tenants) and women, who may not have sufficient access to information from private sources.
4) Incorporating elements of informal adult education into extension to meet the needs of large sectors of the rural population in developing countries who have not benefited from education and are not functionally literate.

It has been further pointed out that approaches to information transfer by public extension programmes are not effective because of the past neglect of human resource development. Therefore, stakeholders demand that clients play an active role in local institution building and community development (Roeling 1986). The tendency of many public officers dealing with the transmission of knowledge to conduct their assignment in a “top-down” manner has been identified as a major deficiency both by researchers and practitioners. The transfer of fixed technological packages comprising recommended practises is perceived as a less effective method for improving knowledge compared with more participatory extension approaches (Axxin 1988; Braun *et al.* 2000). Consequently, existing public extension agencies need to engage in a process of gradual change, which includes improving the relevance of their information delivery, and increasing the effectiveness with which they reach the rural population.

2 The CABI-CATIE Wider Learning Studies

The economic analysis of the CATIE IPM/AF Programme forms part of a broader framework of external monitoring and evaluation. In order to achieve in-depth qualitative assessment of the Programme's impact in Nicaragua, a "Wider Learning Studies" (WLS) consortium was established, involving collaboration between CATIE Nicaragua, the Commonwealth Agricultural Bureau International (CABI) in Great Britain and the University of Hannover (UH) in Germany.

The objective of the WLS was to understand the scope and the nature of changes induced by the Programme, as well as to learn from the experience of a sizeable and long-term IPM programme. Therefore, studies were initiated which aimed to complement the results of the internal monitoring and evaluation activities of the Programme, and to draw conclusions relevant to the organization and implementation of complex IPM programmes in developing countries. The economic viability of the Programme was seen as one among several performance indicators, which were required in order to assess the multi-institutional nature of the IPM interventions within the CATIE Programme.

To evaluate the economic impact of the Programme, a cost benefit analysis of the training component of the Programme was carried out. In cost benefit analyses it is usually assumed that the ultimate purpose of programme activities is to improve the welfare of the society. Such an analysis can be conducted at three impact levels and applying at least two criteria - namely feasibility and efficiency. The general questions for each impact level and criteria as summarized in Table 1 are used to structure the analysis.

Table 1: General Questions to Be Asked in Programme Evaluation

Criteria/Level	Target Group	Programme Organization	National Economy
Technical Feasibility	Is the target group able to participate in the programme?	Is the programme organization able to take over the programme after outside assistance ends?	Are the economic and institutional conditions favorable for the programme?
Economic Efficiency	What is the net benefit increase for the target group?	Can the programme organization cope with follow-up costs?	What is the contribution of the programme to national welfare?

A positive answer to the questions of feasibility is a pre-condition for conducting the cost benefit analysis. If the answer to this first set of questions is that the conditions on the levels of the target group, the organizational background and the policy environment clearly work against a programme's goals, then the results of any economic analysis are pre-determined and there would be no point in conducting the analysis. The technical feasibility can basically be assessed from the Programme concept, as outlined in chapter 3, where the general setting of the Programme is described.

As a first step for analysing the economic efficiency, the effects of the Programme's outputs need to be quantified in terms of net income changes at farm level. However, the impact is not limited to changes in economic parameters. Knowledge, decision-making capacity, and perceptions of crop and pest management were explicitly addressed in the Programme's interventions, and should be observable at farm level as well as at the level of other collaborating stakeholders. The concept of the WLS is to conduct a comprehensive impact evaluation, which includes the economic and sociological perspective, analysing the quantitative and qualitative changes from the different viewpoints of the four main target groups involved: farmers and farm families, extensionists, specialists (i.e. researchers and trainers of extensionists) and decision-makers (for further information see Paredes and Meir 2004).

Furthermore, evaluations always have to take into account the complexity of the programme under study, which is related to the nature of IPM. In the transfer of a complex knowledge-intensive technology like IPM there are aspects or risks that need to be considered. These risks refer to, for example, the significant challenge posed by the need to provide good quality participatory farmer training and to motivate farmers to attend the meetings regularly, or by the complexity of the organization of the training process.

The measurement of changes in economic performance at farm level due to Programme intervention is subject to an uncertainty that hampers economic impact assessment and has to be considered explicitly in the cost benefit analysis. Additional indicators for the plausibility and sustainability of the observed impacts can be obtained from the qualitative studies of the WLS framework, thus providing a better basis for assessment. The studies deal with different types of impact assessment, but are interlinked and considered complementary. In particular, the economic study benefited from the results of the sociological studies because these contributed to qualify the assumptions made in the cost benefit analysis.

This study presents a conventional cost benefit analysis of an IPM programme that is integrated into the framework of the Wider Learning Studies. Its initial results were tested against the findings of the sociological studies and subjected to the views of stakeholder groups in a workshop in Nicaragua. Workshop participants, including stakeholders from organizations involved in the Programme, experts from the universities and ministries of agriculture and health, reassessed the results of the study using their knowledge of the situation. This procedure is a way to deal with the imperfect conditions for obtaining the data required for a cost benefit analysis of a development project. This situation may be typical for project analysis in developing countries; it also applies to the case of the CATIE IPM Programme. Rather than relying on “objective data” from farmer interviews or farm models, the cost benefit analysis was incorporated into a participatory process, maximizing transparency and at the same time contributing to the stakeholders’ interests and commitment to the Programme and future IPM policies. The ultimate aim of this procedure was to increase the reliability of the results in the cost benefit analysis, and enhance the relevance of the study to practical decision-making.

At the same time this paper aims to contribute to solving some of the methodological questions of impact assessment of participatory approaches in agricultural extension.

3 Description of the CATIE IPM/AF Programme

3.1 History

The Programme was initiated in 1989 with funding from NORAD. During the 13 years of its implementation, the Programme has been organized in three different phases. The first phase, 1989-94, was jointly funded by NORAD and the Swedish Agency for Development Cooperation (SADC), while the following two phases were solely financed by NORAD.

The first phase initially concentrated on conventional technology development and classic transfer of technology approaches. It was designed as a *technology development* phase. IPM technology was generated in response to the most severe pest problems encountered in vegetable crops and coffee. In order to involve the stakeholders in IPM, and to ensure the applicability of the practises for farmers, a new approach to the transfer of technology was soon considered necessary and participatory working procedures were developed.

The second phase, from 1995-1998, could be called a *pilot implementation* phase. During this phase, the development of participatory training methods using hands-on approaches was prioritized, and the implementation at farm level was established (Braun *et al.* 2002). Scientists and institutional decision-makers were involved in the planning and coordination of research and training activities with the aim of achieving broader support for the idea of IPM at national, regional and local level. In this regard, the Programme initiated national as well as regional IPM committees for which funding and technical support was provided.

In the third phase, from 1999 to 2003, the Programme aimed at scaling up IPM training in Nicaragua. In collaboration with multiple counterpart organizations, participatory training of farmers was conducted on a large scale. With regard to the sustainability of impact, the Programme collaborated with national, regional and local institutions in order to strengthen their capacity in IPM, and to make their delivery service more effective. The target crops of the training were mainly coffee and vegetables, plantains and to a lesser extent food grains.

Figure 1 illustrates the average annual costs of the Programme in its different phases and the number of farmers trained. During the first 6 years of the development phase, costs remained low and increased significantly only in the main field phase, with the increasing intensity of fieldwork and farmer training in phase 3.

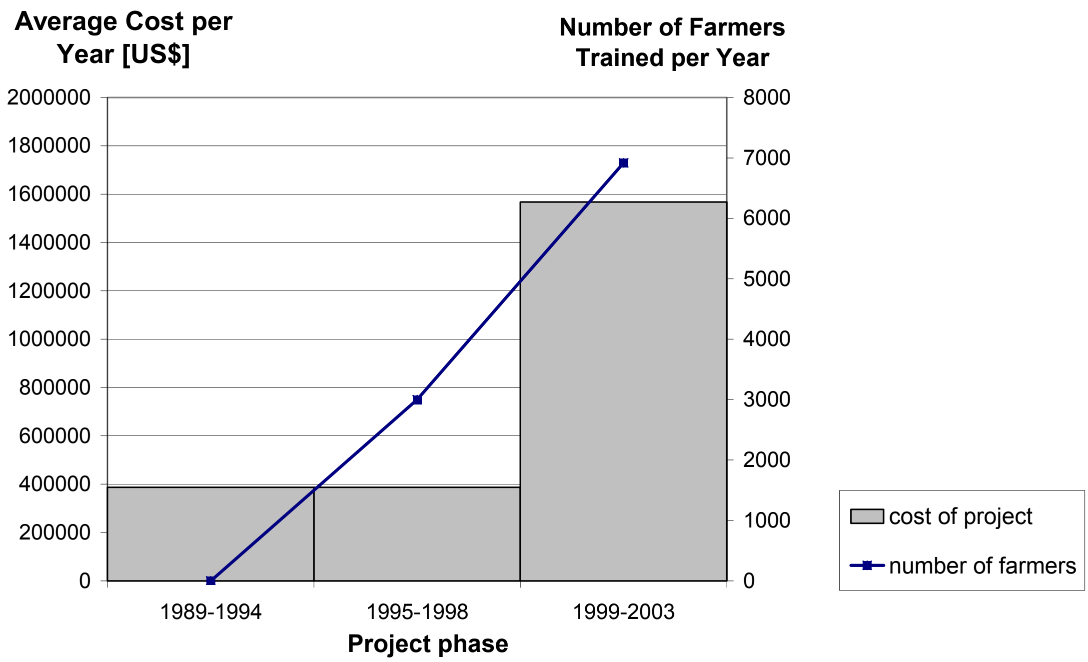

Figure 1: Programme Costs and Farmers trained, by Programme Phase

Source: own calculation based on data from Braun *et al.* (2002) and data provided by the Programme.

3.2 The Concept of the Programme

There are several possible starting points for an intervention of an IPM programme, as illustrated in Figure 2. In principle, an IPM programme can target the policy level aiming at building institutional capacity. Most frequently however it will target farmers in order to improve their crop management practises and to strengthen the innovative capacity. The CATIE Programme activities targeted both the farmers and the institutional level, in order to achieve the overall goal of building a national capacity in IPM. The specific objectives were:

1) to improve the crop management capacity of the farmers, and
2) to make the institutional and policy environment of agriculture in Nicaragua more conducive to IPM.

The main concept for the field phase of the Programme was to generate a better understanding of the agro ecosystem among farmers, and to strengthen their ability to better analyse how and when to apply pest control measures. Unlike in less complex extension approaches, where packages of (chemical or organic) pest management technology are being transferred to farmers, in the Programme the ideal of strengthening the decision-making capacity of farmers was promoted. The expectation was that as a result of this development in understanding and skills, farmers would be stimulated to experiment further and develop new IPM options by themselves. Also, it was expected that farmers would apply their IPM knowledge and experiences to other crops. Finally, through the group training process community action was expected to be encouraged, thereby contributing to better coordination of pest control measures at village level, i.e. a better response to the common property character of natural enemies or the common problem which pests represent.

In addition to interventions at farm level, the Programme also became involved at the level of regional and national organizations, and included collaboration with decision-makers, thus supporting institutional IPM capacity at these levels and facilitating policy interactions. The basic expectation was that all these interlinked issues would reinforce each other.

In the organization of the CATIE-initiated farmer training, two principles were combined: a small project approach and the timing of training according to vegetative stages of the crop. The usual procedure was that the extension workers carried out a participatory evaluation of the field situation, and designed a season-long training project with the participating farm households. In collaboration with the extension workers, farmers defined the goals to be achieved in the training cycle and planned the activities accordingly. The Programme’s support included financing of these small projects and organising the training of the extension workers. The Programme's concept was to guide the trainers through the crop cycle, to provide the required information related to their work with farmer groups, and to use their experiences from the ongoing fieldwork as feedback in the training.

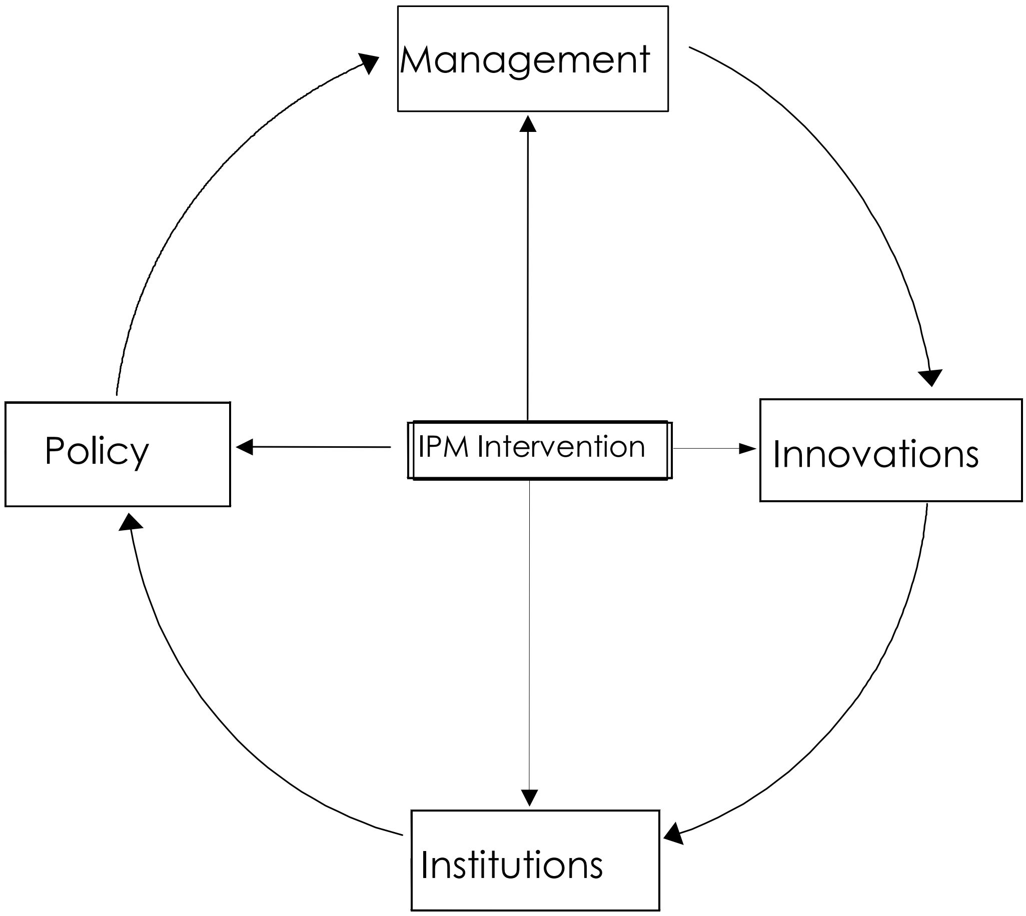

Figure 2: Possible Entry Points for IPM Interventions

Source: Fleischer *et al.* 1999

The methodology was based on the so-called “zig-zag” concept (CATIE, 2001). The term "zig-zag" referred to alternating meetings of specialists, training of the technical staff and farmer training, with feedback procedures at all levels, which took place during the entire cropping cycle, starting with pre-planting activities and continuing until harvest. It should be noted that this approach differs from the Farmer Field School concept which is promoted by the FAO and other organizations (Kenmore *et al.,* 1995), where farmers meet weekly on an experimentation plot, following a defined curriculum. In the CATIE Programme, the training of extension workers and farmers, as well as the IPM implementation at farmer level took place simultaneously in one cropping cycle with about 6-8 group meetings according to the crop. This allowed problems encountered during on-farm implementation to be included directly into the training of trainers.

While the Programme's field activities were closely related to the target crops, the work in the national and regional IPM committees aimed at involving specialists and decision-makers in the planning of complementary activities and coordination of the IPM research agenda. In summary, the Programme simultaneously intervened at farmer level and at the level of regional and national institutions thus implementing procedures to enhance the technical feasibility on all relevant levels.

4 Applying Cost Benefit Analysis to IPM Programmes: Some Conceptual Issues

The analysis of the costs and benefits of a complex development programme is facilitated by clarifying some basic questions with regard to IPM as a knowledge-intensive technology to be adopted by small farmers in developing countries. Assuming profit maximizing behaviour farmers will adopt IPM if it increases their net income. Thus in the crops where farmers apply IPM, ideally the yields should increase due to more effective pest control, crop prices should increase if there is a demand for crops with lower residue levels of pesticides in the markets, and production cost should decrease due to savings in pesticide expenditure. The latter has the additional benefit of reductions in occupational health problems and environmental contamination. Another benefit could be risk reduction. When farmers understand their field situation better, they can take action to avoid pest outbreaks or respond more effectively to such situations, and may therefore reduce fluctuations in income. In reality, however, things are not so straightforward.

There are a number of reasons why despite its economic benefits, IPM may not be readily adopted by farmers, and why pesticide-based plant protection may remain the dominant practise. Firstly, pesticides have been promoted for a long time and have even been subsidised directly, as well as indirectly, by public funding of pesticide-related research and extension systems. Secondly, the external costs associated with intensive pesticide use are generally not internalized into the farmer's budget, leading to a level of pesticide use that exceeds the social optimum. The intensive use of pesticides results in a decline in those mechanisms which naturally control pest outbreaks, and thus in a loss of alternative pest control options for the farmer and an increasing dependency on pesticides (Waibel *et al.,* 2003). These conditions have implications for the degree of uncertainty associated with the quantification of the impacts. The methodology proposed for this study addressed this challenge explicitly when making assumptions about costs and benefits, especially those regarding the long-term effects.

Figure 3 gives an overview of the costs and benefits of IPM programmes, that have to be considered in a comprehensive impact assessment.

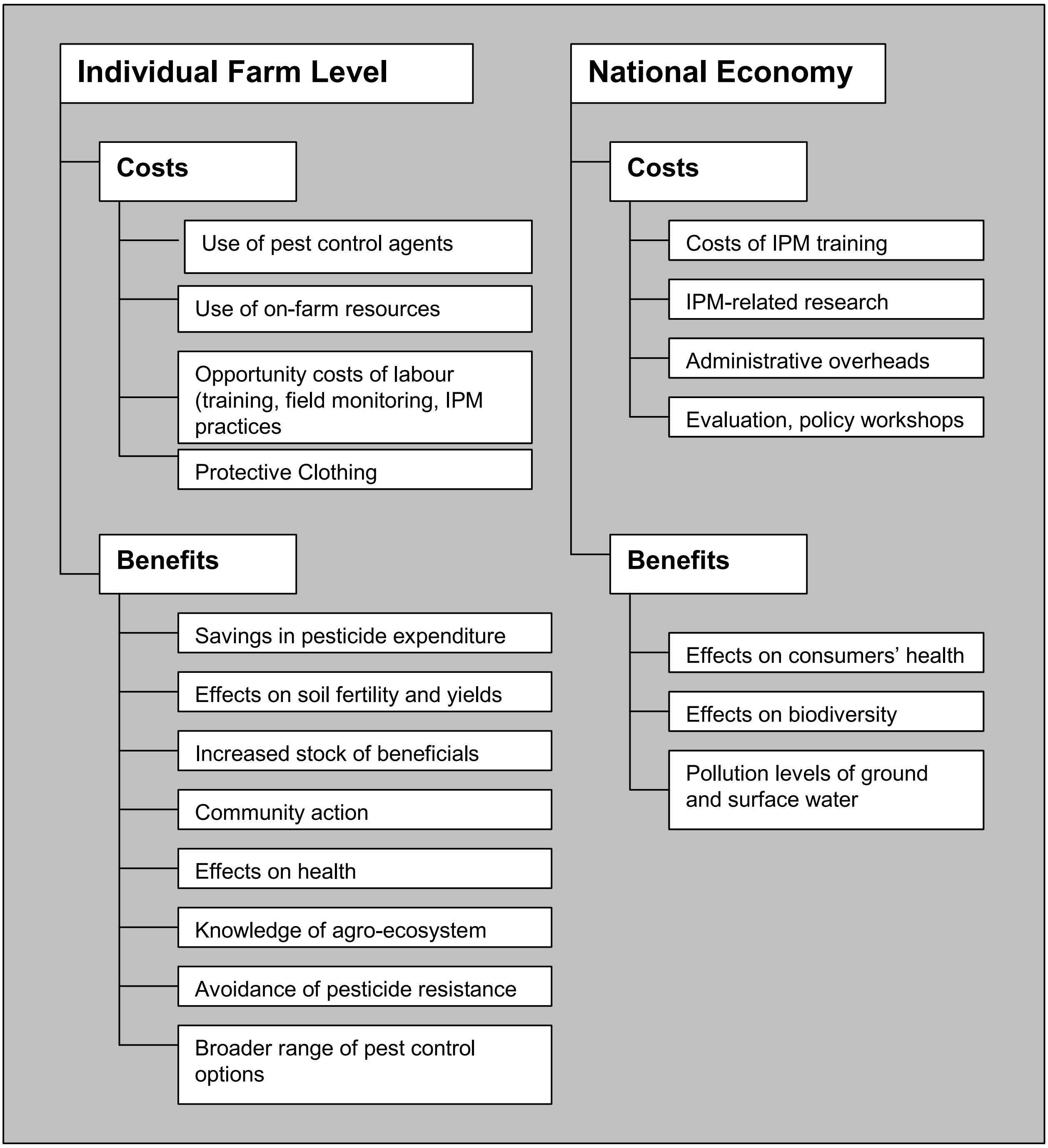

Figure 3: Costs and Benefits of IPM

Source: Fleischer *et al.* (1999)

The rationale to spend public funds on IPM-projects is based on the expectation that benefits will be generated in terms of increased agricultural productivity and reduced external costs of agriculture through a reduction in the level of pesticide use. This leads to the definition of the starting points for a cost benefit analysis: IPM must be viable at farm level, and the costs of the programme must be justified by equivalent benefits for society as a whole. Not all the costs and benefits of IPM are obvious and may not always be easily attributable to the programme impact (Figure 3). However to account for the total impact of IPM, the less easily measurable effects must also be considered.

In the following section, these effects are discussed in order to identify cost and benefit items. The counterfactual situation as the basis for the measurement of changes is then defined. The methodology of the quantitative estimation of costs and benefits as applied in this study is provided, and the data requirements for cost benefit analysis are characterized.

4.1 Defining Programme Costs

The costs encountered at farm level when changing from conventional to integrated pest management is the opportunity cost of time required to participate in the training and to search for additional information about IPM. Implementing IPM involves some other costs as well: the labour use on the farm may change due to an increase in crop monitoring activities, application of labour-intensive cultivation practises and the preparation of organic control agents and/or fertilizer. Other practises such as planting pest-resistant varieties or land use for soil conservation practises can cause additional costs.

The costs of an IPM programme comprise the organization, financing and training of the field staff, including salaries and transport. The development of appropriate IPM concepts for the programme area requires research activities and external expertise. Furthermore, administrative overheads are required, as well as the financing of broader communication with agricultural experts and policy makers. Programme costs also include monitoring and evaluation activities. All these costs, illustrated in Figure 3 must be borne in order to guarantee the execution of planned programme interventions. If skilled labour from governmental organizations is involved in programme activities, their opportunity cost also has to be considered.

4.2 Defining Benefits

The benefits of IPM include market and non-market effects. Most important among the market effects is the reduction in pesticide use, constituting a saving in variable production costs and leading to other benefits, such as savings in expenditure on spraying equipment and labour. Yield effects are expected from improved cultivation practises, and a more effective prevention of crop losses from pests and diseases. Also, crop quality might improve, leading to higher output prices, if the market situation allows this.

Besides these monetary on-farm effects non-market benefits are expected, such as positive environmental effects, i.e. an increase in biodiversity and the stock of beneficial insects. The latter probably affects not only the crops of participating farmers, but also neighbouring plots. If pesticide use is reduced, also the probability that pests develop resistances against pesticides decreases, implying that the loss of effectiveness of active ingredients can be avoided (Waibel *et al.,* 2003). The reduced risk of health impairments due to a reduction in pesticide exposure of farmers and lower residue levels in the produce includes market and non-market benefit components.

Other non-market benefits at farm level may be generated through the establishment of farmer training groups. For example, if farmers recognize the benefits of community action in pest control, and if at the same time their capacity for joint experimentation increases, this can strengthen village institutions. It is clear that only some of these benefits can be measured within the context of this analysis, but this is where some linkage can be drawn to the other studies within the WLS framework.

At the level of the national economy, an increase in national income can result from increased agricultural productivity, and in particular a shift towards a socially optimal level of pesticide use. This can lead to cost savings for the economy, e.g. through lower levels of pollution of ground and surface water, and a decrease in the contamination of food. A decrease in occupational health hazards may also result in savings of public health expenditure.

The factors that influence the scope and the sustainability of the impact of IPM interventions have to be identified and discussed. In particular, the prevalent policy environment has been identified as an important issue in this respect. (Fleischer *et al.,*1999). Direct or indirect subsidies for pesticides are likely to stimulate overuse (Agne *et al*., 1995), and may reduce the effectiveness of IPM programmes.

4.3 Data Requirements

The basis of measuring the Programme's impact is the definition of the counterfactual situation. Therefore, the first question to be answered is how would the situation have developed without the Programme's intervention. Ideally, a baseline survey that refers to the situation before the start of the Programme would have been conducted. But the issue of establishing an appropriate counterfactual may be more complex: even if the Programme is offered to all the farmers in a community, the group of participants will probably not be a representative random sample. Participation may be related to the degree of education, the social status or the capacity to innovate, so that the economic performance of Programme farmers would differ from the non-participants even without the Programme's intervention. In this situation, a simple comparison with / without the Programme is not sufficient. Instead, continuous monitoring of participating and non-participating farmers is needed in order to attribute the observed changes to the impact of the Programme, controlling for differences in resource endowments and random events occurring in the different years of the Programme, such as exceptional climate conditions, changes in the political environment, in world markets etc.. Such a database would allow to apply the “difference in differences” approach with a twofold comparison: before/after and with/without the programme, thus accounting for these sources of bias.

An ideal design for data collection in economic programme analysis is illustrated in Figure 4. The baseline study provides a general picture and is needed for the formulation and conceptualization of the programme. During the active life of the programme, monitoring and evaluation activities include the comparison of impact with and without the programme, provide feedback enabling programme activities to be adjusted, and generate the data for intermediate and final evaluations.

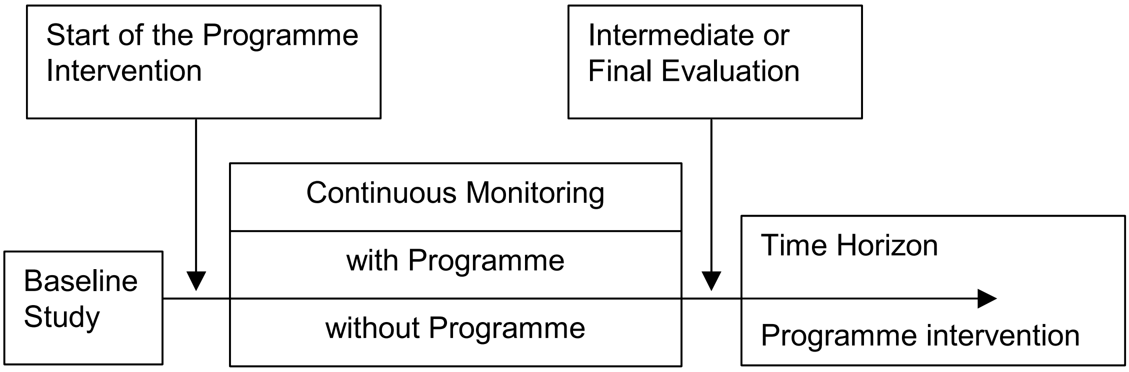

Figure 4: Concept of Data Collection for Economic Impact Assessment

Source: own presentation

In cases where the data are incomplete, alternative sources have to be identified. These can be found e.g. from agricultural statistics or can be taken from assumptions based on expert judgements. However, to account explicitly for the validity of such data sources, appropriate tools, for example risk analysis have to be used.

5 Financial Analysis of the Programme

In the financial analysis of the CATIE IPM/AF Programme, the question is asked whether net benefits at farm level are generated that are sufficiently attractive for farmers to adopt IPM methods. Thus, chapter 5.1 deals with the data on which the identification and quantification of the costs and benefits are based. The additional assumptions that have been made in order to be able to perform the calculations are subsequently explained in chapters 5.2 and 5.3. The results of the financial analysis are presented and discussed in chapter 5.4, and subjected to a scenario analysis, in which the factors on the financial indicators are examined (chapter 5.5). In order to deal with the uncertainty about Programme impacts, that is inherent in the data, stochastic simulation was applied as a tool of risk analysis, as described in chapter 5.6. Finally, chapter 5.7 presents the assessment of IPM experts in Nicaragua, which was included in the analysis.

5.1 Data Sources for Cost Benefit Analysis of the Programme

During the 14-year period of the Programme, the methods and procedures used to monitor the Programme did not remain constant, but were adjusted to fit the changing circumstances. As a result, the data available for conducting an economic analysis are not ideal. For example, no baseline study was carried out, that would have allowed a quantitative assessment of the economic performance indicators at farm level before the Programme intervention started (CABI Bioscience, 2000). The main objective of the Programme had not been formulated in quantitative terms, thus no measurable output indicators were defined at the outset. The internal M&E system (monitoring and evaluation) measured the effects of the Programme via several output indicators, according to a system of objectives at the different levels of intervention. At farm level these comprise, for example, farmers' capacity for pest identification, whether farmers establish pest monitoring, levels of yield and pesticide use. For the evaluation of the Programme, indicators of the expected effects were then determined such as yield increase, reduction in pesticide use, reduction in the exposure to and intoxication from pesticides, increase in agricultural income, improved protection of water and soil and increase in biodiversity.

The available data sources refer exclusively to the output of the third phase of the Programme, i.e. the scaling-up at farm level. In fact, phases I and II can be considered as inputs to phase III. The data provided by the Programme for the financial and economic analysis for phase III comprise several different data sources:

- the internal system of monitoring and evaluation of the Programme
- studies conducted by the Programme
- studies conducted by other agricultural projects and
- relevant literature and indicative economic data collected from farmer workshops in major project areas.

The small project approach of organising the farmers' training offers a valuable tool for evaluation, since each project produced project reports. These reports were based on formalised questionnaires, which were used to interview farmers. Their purpose was to assess whether or not farmers' knowledge had improved, and what changes in pest management practise had taken place. Data on damage from pests and diseases, and on yields and input use were also collected. Nevertheless, the possibility that recall data and farmers' perceptions of damage by pests are biased by the contents of the training cannot be excluded. For example, farmers were likely to focus on plant protection issues they had not considered before. While these internal project data are useful, no data were collected for control groups. Hence, comparisons are only possible between the situation before and after the training, which implies considerable uncertainty about the stochastic effects of, for example, climatic factors. Another data source from internal evaluation activities are the participatory evaluation studies (Evaluación Campesina) by CATIE (2001). This analysis presents case studies of farmers who were intensively involved in IPM activities; some of them were even farmer promoters of IPM at community level. These farmers were already advanced IPM adopters, and therefore are not representative of the average participant farmers. The case studies provide descriptions of the cropping system, including pest management practises and gross margins of the crops. The results were discussed within the community in participatory workshops, and compared to the conventional cropping methods. However, only few farmers using conventional practises were involved. Recognizing the lack of a control group, in 2002, additional case studies with non-trained farmers were conducted within the same or neighbouring communities, using similar methodology. The interpretation of these data representing a reference situation must take account of the fact that the surveys were carried out in different years, and therefore could be subject to biases in yield effects and pest damage.

Among the external studies, the joint evaluation of coverage and adoption of the CATIE Programme and the Swiss funded PROMIPAC programme[5] (Dumazert 2002), provides a broad data base for IPM-trained and also for non-trained farmers (control group). The study includes detailed data on the agricultural production of 1,647 farmers, as well as a typology of participating farmers. Similar to the above-mentioned participatory evaluation, the household survey only refers to one year (2001), thus merely presenting a snap shot of the situation. While this may be appropriate for the objective of measuring the coverage and adoption of IPM practises, the impact of the specific conditions of the year could be substantial, and therefore general conclusions about the effects of the IPM training cannot be derived. In order to assess the Programme's benefits adequately, information about yields, damage and input use over several years is needed.

Hruska and Corriols (2002) published a study of a CARE-supported training programme, which focussed on IPM in maize. They found that the programme had positive effects on farmers’ and farm workers’ health due to a reduction in the exposure to pesticides. Thus these data indicate the potential for a reduction in production costs, and for health benefits resulting from IPM. Again, these data provide observations from only one cropping cycle: however, they do give an idea of the magnitude of the possible impacts of IPM, and of the economic benefits that can result.

Ellenbroek (2002) collected data on the costs of IPM options at farm level. He compared different techniques of e.g. shade regulation, weed control or preparation of fertilizers/organic pest control agents, with the corresponding conventional practises. Since these data refer to single cultivation measures rather than to a production system, they are considered in qualitative terms only.

[5] This programme, which is funded by the Swiss Development Cooperation (SDC), is promoting IPM in a Farmer Field School type programme with training contents which were similar in some respects to those of the CATIE Programme.

An estimation of the health effects of pesticide use is given in the empirical results of a study about pesticide intoxication in Nicaragua by Corriols, *et al.* (2001). Based on this data, the frequency of intoxication among farmers and farm workers, and an estimation of the resulting expenses for the treatment of pesticide poisoning were identified (Corriols 2002).

At national level, indicative production costs for different production technologies in coffee, beans and maize (base year 2001/2002) are available from the statistics of the Ministry of Agriculture and Forestry (MAgFor). These technical sheets for the production of the most important crops include model cost benefit calculations in order to serve as reference information e.g. for the extension services.

Finally, the World Bank is currently financing a large-scale agricultural technology programme, co-executed by the National Agency for Agricultural Technology (INTA by its Spanish acronym). In their cost benefit analysis of the programme, conversion factors for the valuation of labour and export goods in the economic analysis are provided (World Bank 2000).

An overview of the available data sources for the financial and economic analysis is given in Table 2.

In summary, the data sources available for this study are certainly not ideal and they do not fully meet the requirements of a cost benefit analysis as demanded by economic theory. In particular, it is difficult to draw causal relationships between the different levels of Programme output, outcome and impacts because all studies mentioned above were carried out independently, and had different objectives.

We nevertheless submit that it is feasible and useful to conduct a quantitative economic analysis, as all these observations can be considered as elements in a data pool that represents the situation in Nicaragua. In view of this variability it would be erroneous to rely on rigid assumptions. In our study we explicitly recognize the uncertainty that exists about the impact of the Programme due to limited data availability. Hence we use a risk analysis methodology by applying stochastic simulation procedures using the @risk Palisade software package.

Table 2: Data Sources and Assessment for the Financial and Economic Analysis of the CATIE IPM/AF Programme

Source	Data included	Assessment
Internal monitoring system CATIE (2002)	Farmers' knowledge Damage from pests and diseases Yields of target crops Use of pesticides Assessment of quality of the produce	Reference scenario insufficient, changes refer to the year before the training started No control group established, only 2 years regarded Based on recall data
Participatory evaluation CATIE (2001)	Implementation of IPM practises Input and labour use Yields of target crop and additional benefits from mixed cropping Calculation of gross margins	Situation of advanced farmers is reflected, lack of control group
Dumazert (2002)	Coverage and adoption of CATIE and PROMIPAC IPM programmes Adoption rates Typology of participating farmers Monetary production costs, labour input, yield effects	Representative study Only one year is regarded
Hruska and Corriols, (2002)	Impact of IPM training on pesticide exposure of farmers and farm workers Calculation of gross margin in maize for farmers with different intensities of IPM training Potential pesticide savings in maize	Only one year is regarded
MAgFor (2002)	Reference data for the production of coffee, beans and maize for different levels of technology Pesticide Expenditure Labour input Yields and prices	May serve as reference scenario
Corriols *et al.*(2001); Corriols (2002)	Pesticide exposure and frequency of intoxication of farmers Estimation of health care costs	Based on representative study
World Bank (2000)	Conversion factors for economic analysis	Refer to economy as a whole and are therefore transferable to the CATIE Programme

5.2 Programme Costs

The costs of the Programme are made up of several components:

First, the total costs of the first two phases of the Programme, which cover the research and development of IPM practises and participatory training methods, are included in the calculations since they are considered as a necessary input to the field phase of the Programme's work. This is also true for the costs of related studies and scientific publications.

Second, the costs for the training of specialists and field staff, establishing the monitoring and evaluation system, working in national, regional and crop specific committees (i.e. inter-institutional working groups), and the publication of IPM topics in booklets for farmers and extension officers, are considered for the third Programme phase.

Third, other important cost items include the salaries of CATIE scientific project staff, foreign and national consultants, and the overhead cost required to provide the Programme infrastructure. These costs add up to the Programme budget of US$ 8 million from 1989 to the end of the Programme in 2003 in Nicaragua. Additionally the costs of counterpart specialists and extension workers, as well as the organizational infrastructure for the fieldwork were included.

Fourth, with regards to the field interventions, costs include the financing of the small projects for which CATIE provides budgets for transport, teaching materials, including inputs for demonstration plots, evaluation and report writing, and food for the participants during the training sessions.

Finally the records provided by the Programme also include an estimation of the opportunity cost of labour invested by the farmers as a result of participating in the training. The cost of IPM training from 2003 onwards is estimated as a continuation of the actual counterpart costs.

Detailed records of the allocation of funds have been made available for the field phase of the Programme, as shown for the years 1998 to 2003 in Table 3. For the estimation of costs in those years where no such detailed numbers were available, 1989 to 1997 and the projection into the future, 2004-2008, the distribution of costs was derived from other data sources. In the mid-term evaluation report Braun *et al.* (2002) stated that up to 2001, US$ 6.2 million were invested. From this, US$ 2.7 million were deducted, which have been attributed in Programme records to the first 4 years of the field implementation phase, from 1998 to 2001. The remaining US$ 3.5 million of this sum therefore, were spent in the first two Programme phases (1989-1997). For the analysis, these funds were distributed equally between the development and the pilot field phase, constituting an annual cost of about US$ 386,000. As external funding ended in 2003, for the following years, for which a continuation of IPM training by the counterpart organizations was assumed, a conservative cost estimation of annual US$ 500,000 was calculated

The cost for the farmers who participate in the IPM training is mainly made up of the time they put in by attending the training sessions. Owing to the fact that training usually takes place within the community (either at meeting points or in the participants' fields), transport costs to the training site are considered to be negligible. For farmers the adoption of IPM practises usually results in additional labour costs. Systematic pest observations, a key practise promoted by the Programme are time consuming. Also the preparation of organic agents from on-farm material requires additional labour. Data on the labour requirements of different IPM practises were made available through a special study (Ellenbroek, 2002). These however may be balanced by labour saving for pesticide application and avoided pesticide-related illness. Also, the adoption of a set of complementary and interrelated practises may change the complete labour organization of the farm, so that instead of single practises, the total labour use has to be considered. Dumazert (2002) did not find a significant increase in labour use per area, except for the highest levels of adoption, which are reached by a small share of the trained farmers only. In summary, no additional labour costs of IPM adoption were included in this analysis.

Other additional costs encountered in principle by IPM adopters such as opportunity costs of own land for experiments were not included because the small project budgets provided funds for experimental and demonstration plots.

Table 3 summarizes the total Programme costs as considered in the financial analysis.

Table 3: Overview of Programme Costs

Cost of Programme [US$]	1989 - 1997[a)]	1998	1999	2000	2001	2002	2003	2004 - 2008[a)]
Field cost (implementation)		39,400	241,051	423,796	670,457	147,235	188,177	
Salaries, transport, office, advisory services	386,944	296,700	350,000	303,134	382,891	291,938	224,383	
Labor cost for counterpart organizations and farmers			220,069	1,069,297	1,169,025	340,105	250,000	500,000
Total Cost	386,944	336,100	811,120	1,796,200	2,222,373	779,278	662,560	500,000

a) Figures refer to annual costs

5.3 Programme Benefits

5.3.1 Methodology

For a quantitative analysis of the benefits, the changes in agricultural income must be considered. According to the Programme's objectives, benefits are expected from yield increases, as well as from savings in pesticide use and correspondingly from reduced health costs. Also, crop quality is addressed in the Programme's objectives, and changes in quality could be reflected in price premiums for the agricultural commodities produced under IPM. The agroforestry component of the Programme promotes a diversification of the production system, encouraging the farmers to plant fruit and timber trees and grow additional crops such as different varieties of plantains, thus generating additional and more stable income. Ideally, gross margins for IPM and non-IPM farmers would be calculated in order to derive the farm-level benefits. Unfortunately, the data did not permit this procedure. Instead, benefits are estimated by components, based on the different indicators defined above, namely yield effect, price effect, pesticide use and health effects.

Expected non-market benefits on farm level include an improvement in the farm families' standards of living, and their perception of healthier and environmentally more benign crop production. These cannot be considered quantitatively in the benefit items, but may have a positive impact on adoption and diffusion of IPM. Capacity building through farmers' participation in the formulation of projects as part of the small project approach might turn into quantifiable market benefits in the future.

Although health benefits are included in the financial analysis, the cost of treatment for intoxication and the value of labour lost as a result of acute pesticide health hazards do not fully reflect the true benefits, associated with a reduction of pesticide health hazards. For example, farmers and/or their families may have chronic health problems that are not treated or even recognized. Reducing pesticide use is therefore considered to bring additional non-market benefits.

Following the methodology outlined above the quantification of the benefits is presented for each of the target crops.

5.3.2 Benefits by Target Crops

Benefits of the Programme are estimated in three crops targeted by the Programme, namely coffee, vegetables and food grains. Coffee is the only one of the target crops where significant yield increases were observed as a result of IPM training at the time of this study. However, because of the high variation in yield data, a conservative estimate has been made by calculating the mean of the average yield increase from the internal monitoring observations (CATIE 2002) and the survey results of Dumazert (2002). Evidence of substantial price effects has not been found yet, though the Programme report (CATIE 2002) indicates that for some of the farmers the IPM training was the starting point which enabled them to access the fair trade market, or even the organic market, where premium prices for better quality produce are paid. However, it is not clear what share of these benefits is attributable to the Programme's effect, because the organic market has additional requirements in production and certification, which include considerable extra costs. Nor is there any data provided on how many of the participating farmers chose to shift to organic agriculture, or to what extent IPM farmers realised price premiums. Therefore, in the analysis, no price effects have been considered and the coffee price displayed by MAgFor (2002) is used as an estimate for the average price.

The reduction in production costs due to savings in pesticide use was more obvious than the price and yield effects, as reported in the internal monitoring reports. However, these data have to be interpreted with caution, since input use in coffee varies with the coffee prices. In the observed time period, coffee prices and production declined in Nicaragua, thus some of the reduction in pesticide use has to be attributed to price effects. However, the fact that coffee production for the IPM farmers increased during this time, suggests that the Programme created a positive effect.

In vegetable production, the observed effects as a result of the adoption of IPM were restricted to savings resulting from a reduction in pesticide use. No yield and price effects have been found to date. As pesticide use was very high in cabbage, tomato and sweet pepper production, there were considerable savings. This was confirmed by the internal monitoring data, which report a 37% reduction in pesticide use in vegetables. This figure was used as an estimate of the benefits in the calculations.

With about 83% of Nicaraguan farmers involved in food grain production, maize and beans are the most important food crops in Nicaragua (CATIE, 2002). No significant yield effects resulting from the adoption of IPM were found at the time of this study for either maize or beans. Neither was there any data indicating an impact on prices as a result of adopting IPM in maize or in beans. Savings from a reduction in the use of pesticides, on the other hand, were assessed to be substantial (Hruska and Corriols, 2002; CATIE, 2002).

The assumptions about the benefits, in the cost benefit calculation, are summarised in Table 4.

Table 4: Annual Benefits at Farm Level

Indicator	Effect	Unit[1)]	Source
Coffee			
Yield increase	4.6	qq pergamino/mz	Dumazert (2002)
Price effect	0		
Reference price	32.5	US$/qq pergamino	CATIE (2002)
Reduction of costs for chemical inputs	42	US$/mz	CATIE (2002)
Area per household	4.25	mz	Dumazert (2002)
Adoption rate	35.6	%	Dumazert (2002)
Maize			
Yield increase[2)]			Dumazert (2002)
Price effect	0		
Reduction in costs for chemical inputs	61.9	US$/mz	Hruska and Corriols (2002)
Area per household	1.7	mz	Dumazert (2002)
Adoption rate	35.6	%	Dumazert (2002)
Beans			
Yield increase[2)]			Dumazert (2002)
Price effect	0		
Reduction in costs for chemical inputs	32.5	US$/mz	CATIE (2002)
Area per household	1.7	mz	Dumazert (2002)
Adoption rate	35.6	%	Dumazert (2002)
Vegetables (2 crops/year)			
Yield increase[2)]			Dumazert (2002)
Price effect	0		
Reduction costs for chemical inputs	31.5	US$/mz	CATIE (2002)
Area per household	1.7	mz	Dumazert (2002)
Adoption rate	35.6	%	Dumazert (2002)

1) mz = manzana, Nicaraguan unit for area, equal to 0.7 hectare
qq = quintal, unit of weight, equal to 40 kg
pergamino: the usual form, in which coffee is sold on farm level. The relation of this farm level pergamino coffee to the further processed green coffee beans for exportation is 2:1.
2) no effects observed

The estimates of adoption rates are taken from Dumazert (2002). In his study, he defined three different categories of adoption. Category 1 refers to the use of IPM practises in crop management and the application of organic pest control agents, category 2 to the implementation of water or soil conservation practises and category 3 to the planting of new varieties in order to increase biodiversity. The benefits included in this study refer mainly to crop management, and therefore the adoption rates for category 1 are used.

The number of trained farmers was derived from the Programme records as presented in Table 5. It is explicitly mentioned that farmers have a chance to continue with the training for more than one cropping cycle, consolidating their knowledge and strengthening the community interaction. This sequential training increases the probability that farmers will realize sustainable benefits, but must also be considered in the calculation, because the training cost per farmer increases as a result. For the analysis, the share of farmers participating in two training cycles is estimated from the Programme's records as 30%.

Table 5: Number of Farmers participating in IPM Training by Crop

Number of trained Farmers	1999	2000	2001	2002	2003	2004- 2008
Coffee	2,480	4,565	4,800	2,138	2,000	2,000
Food grains	414	911	1,171	499	500	500
Vegetables	1,121	2,338	2,601	1,130	1,000	1,000

In addition to unitary benefits, assumptions have to be made about the time horizon of the benefit stream at farm level, as well as about the continuation of the IPM training by the Nicaraguan counterpart organizations after the CATIE Programme ceases to provide support. The explicit objective of the multi-institutional interventions made by the CATIE-IPM Programme was to ensure the sustainability of the benefits of adopting IPM. It is therefore assumed that farmer training will continue for at least 5 years after the Programme has come to an end, maintaining the numbers of farmer training courses achieved during the last year of the Programme's work (see Table 5). The same lifetime is assigned to the benefit stream achieved at farm level.

Health benefits are likely to be linked to the intensity of pesticide use in different crops. Results of the survey by Corriols *et al.* (2001) indicated that the highest rate of intoxication due to pesticides is found in vegetable production, followed by beans, maize and coffee, but that differences between the crops are quite small. The small sample size of the pesticide health study does not allow attributing different health impacts to the different crops. In this analysis the health benefits are therefore estimated as being independent of the target crop.

5.4 The Financial Rate of Return

The financial internal rate of return for the project investment was calculated, converting domestic prices into US$ at a rate of 13.44 Córdobas per US$. Benefits and Costs were discounted with a rate of 12% following the assumptions by the World Bank (World Bank 2000). The results of the analysis with a financial rate of return (FIRR) of 19.1% showed that the Programme investment had paid off, see Table 6. The pay-off period is 17 years. In figure 5, the annual flow of net benefits of the Programme is illustrated. It is interesting to note that in the long period of the development and the pilot implementation phases the costs are rather low. With the main costs directly related to the field and scaling- up phase however, the benefits compensate for the costs after a relatively short time. Coffee as the most important crop, contributes 89% of the total benefits, as illustrated in figure 6. This results from the relatively high number of farmers who were trained in coffee IPM. Additionally the average coffee area per farmer is 2.3 times the area used for basic grains and vegetables.

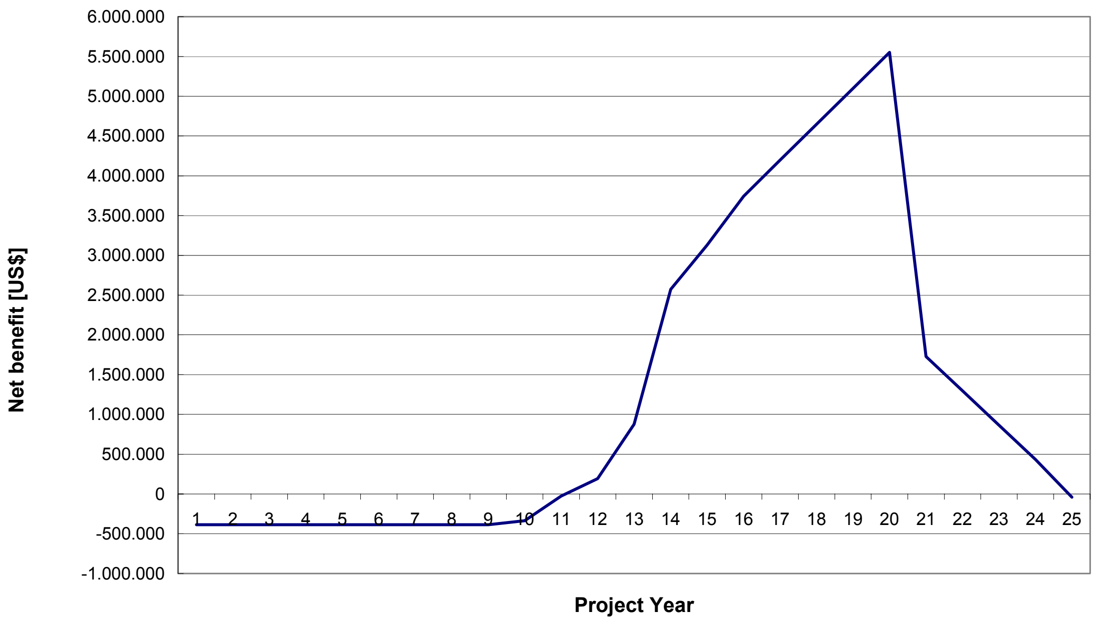

Figure 5: Annual Net Benefits of the Programme, Baseline Scenario

Source: own presentation

Health benefits do not have a strong effect on the results. Based on our calculations, the number of people saved from acute pesticide intoxication due to the IPM training is about 166 per year. Thus, compared to the productivity effects and the savings resulting from reduced use of pesticides, the monetary effect of the health benefits is relatively small. However, this aspect has not yet been analysed exhaustively. Existing studies by Corriols (2002) and Corriols *et al.* (2001) focussed on detecting those cases of pesticide intoxication, which were not reported in the public health system. The interpretation with respect to the effect of IPM training is therefore limited. The calculations include the private costs of illness for the farmer. These are defined as cost of treatment, the labour time of the ill and of the person taking care of him, as well as the cost of transport to the medical station. However these costs exclude any non-market effects such as the value of the reduced risk of intoxication, and the long-term and chronic effects of intoxication.

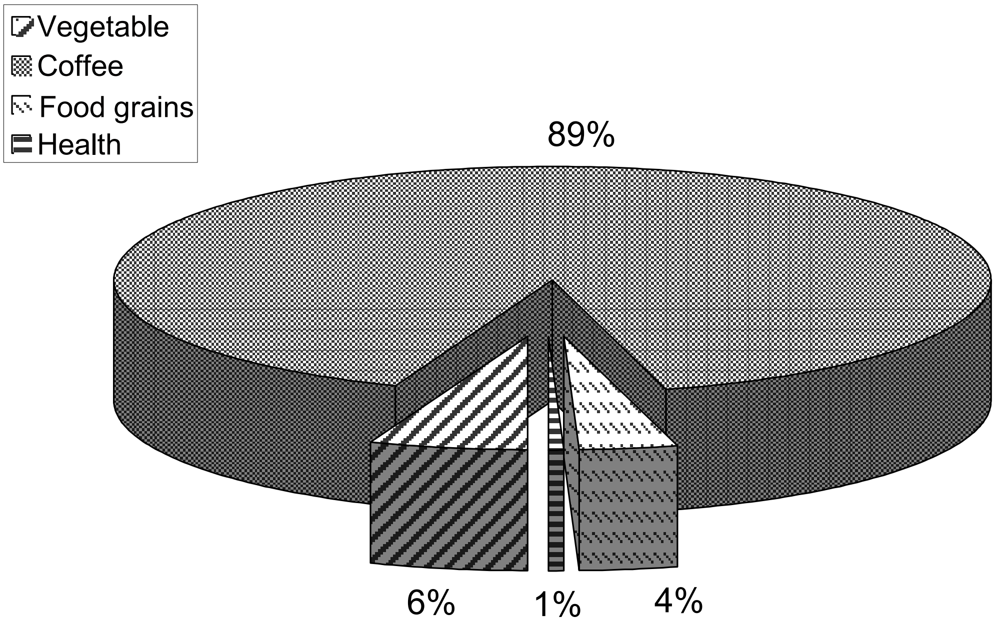

Figure 6: Programme Net Benefits by Crops

5.5 Scenario Analysis

Because of the high uncertainty in the data, the cost benefit estimates were subjected to risk analysis.[6] As a first step, therefore, we investigate by means of a scenario analysis the effects of modifying the benefit assumptions on the results of the financial analysis. This illustrates the impact of the different

[6] In fact, we would submit that this should be done for many development programmes, especially those working in IPM, because of the strong influence that random events can have.

components of the benefits and serves to check the stability of the results against unfavorable effects. Six different scenarios were calculated: a) the baseline scenario with benefits as specified above, including the continuation of farmer training for 5 years and retention of practises on farm level for 5 years, b) the baseline scenario, but without the yield effects in coffee, c) the baseline scenario with a coffee price reduction, d) the baseline scenario without savings in pesticides, e) benefits as in the baseline scenario but only calculated until 2003, when external support for the Programme ends, f) benefits as in the baseline scenario, but the farmers retain IPM practises for only 3 years and no new farmers are trained after 2003. The results of the scenario analysis are summarized in Table 6.

Table 6: Scenario Analysis

	NPV [US$]	FIRR	Benefit / Cost Ratio	Pay-off Period
Baseline situation[1)]	**2,585,025**	**19.1%**	**1.6**	**17 years**
Yield effect = 0	-2,025,387	0.6%	0.5	/
Coffee price = US$ 18,6	613,312	14,1%	1.2	20 years
No savings from pesticides	663,058	14.2%	1.2	20 years
No training and no benefits after 2003	-829,431	6.5%	0.8	/
No training after 2003, benefits for 3 more years	996,747	15.8	1.2	17 years

NPV: Net Present Value

FIRR: Financial Internal Rate of Return

[1)] Baseline situation refers to the calculation based on the assumptions described in Tables 3, 4 and 5.

The only crop with significant yield impact so far is coffee. The omission of this benefit in the calculation shows how dramatically the yield increase in coffee determines the magnitude of the total economic benefits. The positive results we have found are reversed if yields are assumed to remain the same, as they would have been without the Programme's intervention. It is therefore very important to consider how likely the expected yield increase is. The statistics of the International Coffee Organization (ICO, 2003) suggested that coffee production in Nicaragua has decreased over the period 1999 to 2002. Thus, the observations of Dumazert (2002) and CATIE seemed to indicate a quite remarkable success. However, since only 2 years were included in the surveys, a sustainable yield increase attributable to the CATIE Programme is uncertain. Another uncertainty is whether the yield increment is clearly attributable to the Programme. As pointed out by Dumazert (2002) it is possible that the more successful farmers are also more likely to participate in the training (selection bias).

The output price for coffee used in this analysis is based on the statistics of the Ministry of Agriculture (MAgFor, 2002). However farm gate prices used to be highly variable. We have therefore calculated a second scenario, where the same output price was used as in CATIE (2001), which was 250 Córdobas[7] /qq, representing a reduction of 43% in the output price of the baseline scenario. In this case, the internal rate of return drops to 14.1%. This shows that the economic viability of the Programme is robust, even in situations where there is a price crisis, such as in 2001. Observations in a complementary survey carried out in October 2002 (Garming, unpublished) indicated that 250 Córdobas/qq can be viewed as a lower bound or worst case coffee price. At the time of this survey, the price data ranged from 250 to 480 Córdobas/qq at the farm gate: these prices were unusually low in farmers' views and expectations were expressed that prices would rise already in the current harvesting period[8].

In the third scenario, the impact of the savings from pesticide reduction on the internal rate of return of the Programme was analysed. A key expectation of IPM is that the use of chemical pesticides will be reduced. This is usually regarded as even more important than the yield increment by those who fund and implement IPM programmes since a major part of the health and environmental impact of IPM is dependent on changes in pesticide use. If the reduction in pesticide use was zero for all the target crops, however, the returns would still be positive, as shown in Table 6. Given the relatively low importance of pesticide costs of about 10-15% of the production costs, it seems plausible that savings made on this cost item would have less impact on the total profitability than, for example, the yield effects in coffee.

[7] or US$ 18,6

[8] These expectations have proved to be right, since 2003 the prices are rising again (ICO 2005).

Nonetheless, the reduction at least in the use of highly toxic pesticides is a requirement if the non-market benefits relating to pesticide contamination are to be achieved.

One important factor that can be expected to influence results significantly is the retention of Programme benefits. A time horizon of 20 years, during which benefits remain constant is normally assumed when analyzing programmes[9]. However we did not make such assumption in the case of the CATIE IPM/AF Programme. The policy environment in Nicaragua is only partly favorable for IPM, although many organizations including INTA participated in the IPM project and may have taken over the goals for IPM training and promotion. But also, the government is implementing a programme to promote the use of modern varieties in the food grain production, mainly focusing on the modern inputs instead of IPM knowledge. This conflicting policy environment on IPM bears the danger that IPM training and follow-up support may terminate when external support from CATIE comes to an end. If the activities initiated by the Programme were to cease with the end of external assistance, this would make the investment inefficient. Sustaining the benefits is therefore a precondition for the Programme to be economically viable.

It is considered unlikely that the trained farmers will stop practising IPM, if they perceive substantial benefits from IPM. The last scenario shows that the realization of benefits from the Programme would have to continue for at least 3 years at the adoption level reached in 2003 in order to achieve benefits that compensate for the Programme costs.

Because of the Programme's long development and testing phase, it is worth asking what implications a reduction in the time span between developing the technology and implementing farmer training would have had on the economic efficiency of the Programme. Therefore, analysis was recalculated reducing the development phase to just 5 years. This increased the internal rate of return (IRR) only slightly, from 19.1 to 20 %. The reason for this low level of increase is the relatively low annual costs incurred by the Programme during the first two phases of its work, as shown in Figure 7, where the Programme's cumulative cash flow is represented. The largest share of the Programme cost is timely related to the field activities. Although the pay-off period seems very long, the distribution of costs and benefits suggests that the Programme

[9] see, for example, the World Bank Agricultural Technology Project (Picciony, 2000)

strategy of having a long but low budget development and pilot implementation phase is paying off. This seems plausible since policy dialogue is one of the focuses of the Programme's interventions. Changing attitudes and institutional conditions to achieve an IPM-friendly environment is obviously a long-term process, requiring long-term investment and support.

Figure 7: Cumulative Discounted Cash Flow for the Programme life span plus 5 years

5.6 Stochastic Simulation

The limitation of the scenario analysis is the *ceteris paribus* condition i.e. only a pre-determined set of assumptions is included. A more powerful risk analysis tool is stochastic simulation. In this analysis, the data can be regarded as random points on a range of possible outcomes. Defining simple probability distributions of the uncertain variables allows the distribution of the output indicator to be calculated. To provide additional information to the scenario analysis, conclusions about the probability of a negative net present value can be drawn, and hence an assessment of the risks that are inherent in the Programme’s performance can be made (Pouliquen 1970).

5.6.1 Methodology

The basic principle of this methodology is to identify the probability distributions of the uncertain variables that determine costs and benefits. As uncertain parameters we identified the yield effect, the price increment and the pesticides reduction as the difference between IPM adopters and non-adopters. Also the number of farmers that will be trained in the future, after the external Programme support ends and the number of adopters among the trained farmers are considered as stochastic variables. Figure 8 illustrates the stochastic simulation model. Basically, the benefits per farmers are calculated based on the yield and price effects, the savings in input use, and savings in health costs. The costs of training and of implementation at farm level are subtracted in order to calculate the net benefit at farm level. These benefits are scaled up over the number of trained farmers, subject to the estimated adoption rate. The probability distribution of the NPV and the benefit cost ratio of the Programme are then computed, taking into account the costs of the Programme, including counterpart contributions.

The simulation technique is based on the Monte Carlo type simulation, i.e. the distributions of the stochastic variables, for example a triangular distribution for yield, are transformed into cumulative distribution functions. To each possible realization value of the stochastic variable the distribution function assigns the probability P $(x<=x_0)$ of obtaining any value x below or equal to x_0. Drawing random values for P, the corresponding x-values subject to the distribution function are determined. This procedure is applied to all stochastic variables, generating a data set, which is used to calculate the target variable, the NPV. By repeating the draws from the model's input variables, and recalculating the output indicator, e.g. the NPV, a cumulative frequency distribution is obtained.

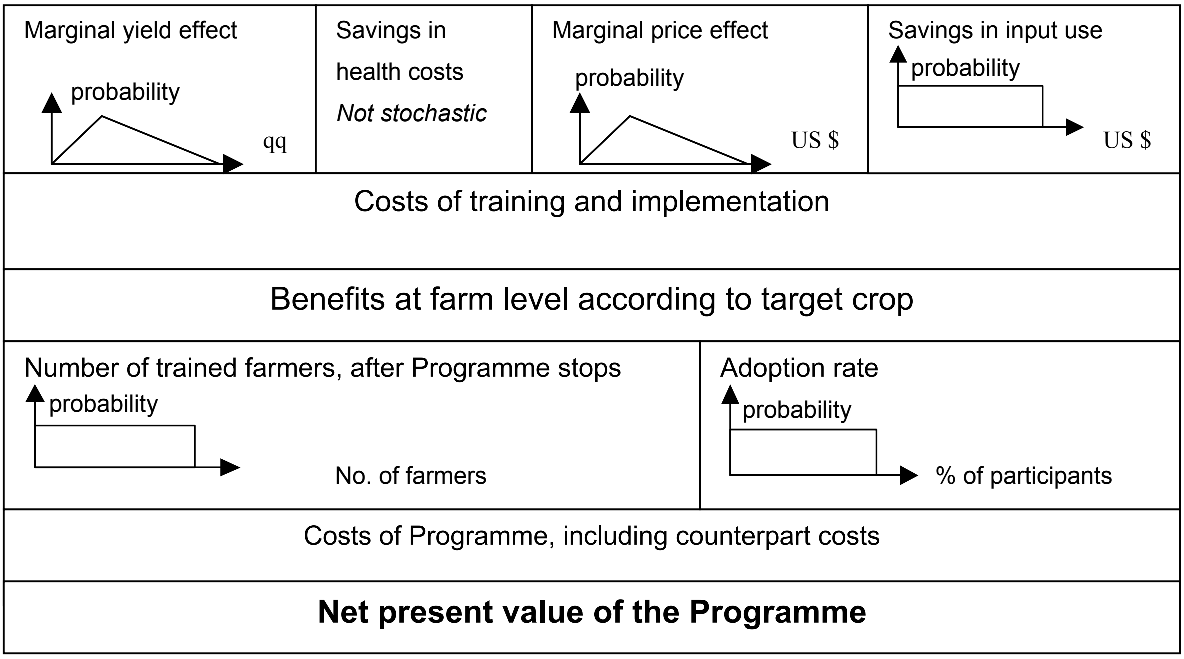

Figure 8: Outline of Stochastic Simulation Model of Costs and Benefits of the Programme

Source: own presentation

5.6.2 Assumptions

To determine the probability distributions used in the simulation, the mean values of observed impacts in the different data sources are used. The minimum value of all benefit parameters is assumed to be zero. This reflects the scarce data situation. In the absence of an appropriate baseline study, the observed effects cannot be proven to be representative nor can they be fully attributed to the Programme's impact. Theoretically, even negative impacts could occur, such as a negative yield effect if the intensity of crop production is reduced as a result of adopting IPM techniques. However, this case is not considered further, since it is reasonable to assume that a farmer who experiences this situation will return to his old production system. The parameters of the probability distributions as used in the simulation model are shown in Table 7.

The numbers of farmers trained up to date were documented by the Programme. However, whether or not training will continue is subject to uncertainty. For the risk analysis, it is assumed that the training continues for up to 5 years after the external funding ends, but the numbers of farmers trained for each crop ranges from zero up to the present status quo. Results of Paredes and Meir (2004) showed that the agricultural extension workers applied the new methods in different ways. In general it was shown that those who were trained intensively in participatory training methods adopted changes in their working style. However, the major source of uncertainty about this issue arises from the uncertainty of the financing of agricultural extension. In general it can be assumed that the fieldwork will follow the paradigm of the financing bodies. If these do not support the concept and execution of IPM, the Programme’s impact may disappear soon. Even if there is no significant shift away from the actual stated IPM-favorable agricultural policy, the maintenance of the IPM training for farmers, including new communities, is highly dependent on whether or not funds for the fieldwork can be established on a long-term basis.

With regard to the adoption rate, two indicators are available: the adoption rate from the results of Dumazert (2002), and an estimation based on the observed intensity of participation in the training, as recorded by the CATIE internal monitoring system (CATIE 2002). The latter does not include a survey of implementation of IPM practises on–farm, but considers the frequency of participation in the training, as well as farmers' contribution to discussions during the training events with data from their own farms.

As pointed out in the scenario analysis, the yield effect in coffee is the most important economic benefit of the Programme's work. Results of Dumazert's study (2002) suggest a significant yield effect for IPM training in coffee. The mean value used in the financial cost benefit analysis as explained above, was used as the modal of the probability distribution. The yields found in the participatory evaluation case studies (CATIE, 2001) were substantially higher than those of the previously mentioned data sources, indicating that the potential yield increase from IPM practise was probably higher than the mean value observed by Dumazert (2002). However, the variation in the data from the participatory evaluation survey is enormous: yields for IPM farmers vary from 15 to 90 qq/mz, and for non-IPM farmers they range from 2.8 to 72 qq/mz. With sample sizes of only 8 and 10 farmers respectively, it does not seem justifiable to use the mean values as the bounds of the probability distribution. The maximum value of yield increase was therefore assumed to be 7 qq/mz. This figure was based on the survey of Dumazert (2002) calculated as the difference between the yields of trained and untrained farmers.

As regards price effects two types of effects are possible. First, a variation due to world market effects, which affect the calculation through the value of the yield increment attributed to the Programme's impact. Secondly, price effects due to improvements in crop quality resulting from the application of IPM practises. These possible effects were not included in the study because there was no data available that could allow identifying price premiums directly attributable to participation in the Programme. In the stochastic simulation model, the modal coffee price was assumed to be the price given by MAgFor (2002), as used in the analysis above. To take into account the high variability of the data on coffee prices at farm level, the farm gate price observed in the participatory evaluation (CATIE 2001) was used as the lower boundary of the probability distribution, and the long-term average price (1982-2000) stated by MAgFor (2002) was regarded as the upper boundary.

The benefits that arise from the savings in pesticide expenditures on all crops were taken as being uniformly distributed between zero and the mean values determined in the internal monitoring records. This reflects the observation of Dumazert (2002) who did not find any significant differences in the cost of external inputs for adopters and non-adopters. External costs comprise seeds, fertilizer and pesticides; however, further details are not provided in the report.

With regard to the sustainability of the benefits, the same time horizon as used in the scenario analysis has been applied, with maintenance of the benefits for up to five years after the end of the Programme, while in a second scenario, the benefits are only calculated up to the end of the Programme in 2003. Subsequently, these scenarios are labelled "year 2008" and "year 2003", respectively.

Table 7: Assumptions in the Stochastic Simulation Analysis

Benefit Indicator	Type of Distribution	Bounds of Distribution lower	modal	upper	Unit[1)]	Data Source
Coffee						
Yield increase	triangle	0	4.6	7	qq perg./mz	CATIE (2002) Dumazert (2002)
Reduction in costs for chemical inputs	rectangle	0	-	42	US$/mz	CATIE (2002)
Area per household				4.25	mz	Dumazert (2002)
Farm gate price	rectangle	18.6	32.5	62.5	US$/qq perg.	CATIE (2001) MAgFor (2002)
No. of farmers in training after 2003	rectangle	0		2000		CATIE (2002)
Maize						
Yield increase	no effect observable					
Reduction in costs for chemical inputs	rectangle	0		61.9	US$/mz	Hruska and Corriols (2002)
Area per household				1.7	mz	Dumazert (2002)
Beans						
Yield increase	no effect observable					
Reduction in costs for chemical inputs		0		32.5	US$/mz	CATIE (2002)
Area per household				1.8	mz	Dumazert (2002)
No. of farmers in training after 2003	rectangle	0		500		CATIE (2002)
Vegetables						
Yield increase	no effect observable					
Reduction in costs for chemical inputs	rectangle	0		31.5	US$/mz	CATIE (2002)
Area per household				1.8	mz	Dumazert (2002)
No. of farmers in training after 2003	rectangle	0		1000		CATIE (2002)
Adoption rates						
Coffee	rectangle	36.6		73	%	Dumazert (2002) CATIE (2002)
Food grains	rectangle	36.6		39	%	Dumazert (2002) CATIE (2002)
Vegetables	rectangle	36.6		60	%	Dumazert (2002) CATIE (2002)

1) mz = manzana, Nicaraguan unit for area, equal to 0.7 hectare

qq = quintal, unit of weight, equal to 40 kg

perg. = pergamino: the usual form, in which coffee is sold on farm level. The relation of this farm level pergamino coffee to the further processed green beans for exportation is 2:1.

5.6.3 Results

The result of the risk analysis is the probability distribution of the NPV of the project, shown graphically in Figure 9 as the cumulative distribution function. The curves for the two scenarios show the whole range of possible outcomes. The crucial value is the probability of a negative NPV, which is about 9 % for the baseline scenario ("year 2008"). In case of a less optimistic scenario ("year 2003") this probability rises to 48 %.

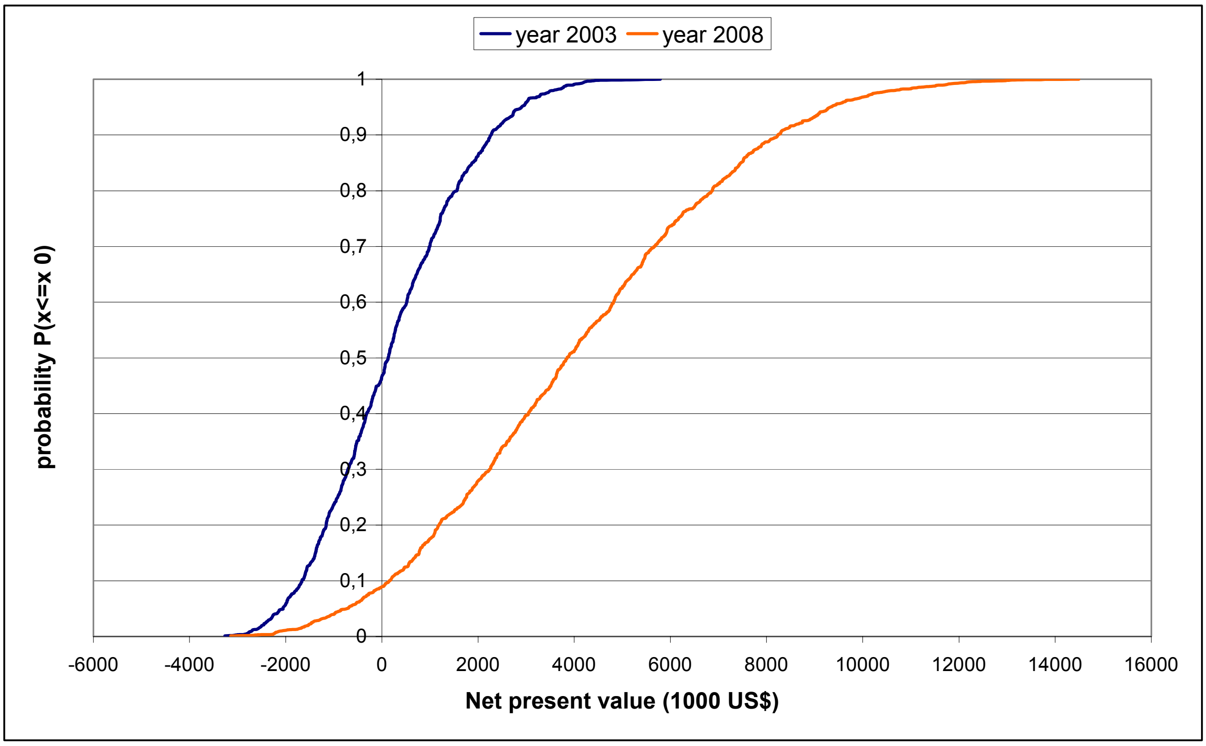

Figure 9: Probability Distribution of NPV for two Scenarios as a Result of Stochastic Simulation

Figure 9 shows that the rate of return from the Programme is determined to a large extent by the sustainability of the achieved impacts. The probability of a positive NPV is strongly related with the retention of the benefits. The design of the Programme, with its strong emphasis on participatory training methods, aims to induce a learning and discovery process, rather than transferring knowledge that is easily forgotten when the extension worker leaves the place. If the farmers start to apply IPM techniques and to gain experience with this approach to pest management, it is assumed that they not only improve their own situation but also communicate with their neighbours and family members so that the information spreads throughout the communities (CATIE, 2002). This spread of technology, together with the Programme's intervention at the level of agricultural specialists and decision-makers were meant to ensure the sustainability of the impact of the Programme's work. The work at higher management level within the counterpart organizations, especially involving decision makers and specialists in IPM regional groups aimed to create institutions that would take over IPM implementation after the Programme ended and enable those organizations concerned with agricultural extension to maintain participatory IPM training even without external funds.

However, the success of this strategy is uncertain. The number of farmers taking part in CATIE-funded training has already decreased substantially during the 2001/02 training cycle, while the Programme still worked with external funding. Furthermore, prevalent agricultural policy is an important factor, which must be considered (Waibel *et al.,* 1999; Agne, 2000). Intensification programmes, or a top-down approach to promoting technology packages, including pesticides, via public agricultural extension services, are concepts that effectively oppose the implementation IPM and endanger the success of participatory IPM training. The programme called “*Libra por Libra*” ("pound for pound") of the Government in which seeds of local varieties are exchanged for improved, higher yielding varieties free of charge, could be seen as an indicator of an approach to agricultural development, which relies on modern inputs rather than on farmer knowledge. Recent project data on increases in pesticide use in food grain production seems to confirm the trend suggested by this governmental programme. Nevertheless there is room to connect these policies. For example, IPM principles can also be applied in cropping systems where high yielding varieties are grown. This could lead to "cross-fertilisation" - a mutual re-enforcement of benefits between different programmes. If, however the crop protection strategies focus on distributing modern varieties and inputs, other components of modern extension could be overlooked. In the situation of increasing privatisation of the extension system there is also a danger that the input supplying companies might monopolize knowledge, and give priority to an output-oriented, rather than resource-efficient, agricultural strategy.

The estimation of benefits is based exclusively on data from Programme phase III. Considering that about 7500 farmers were involved in the Programme activities during the second phase from 1995 to 1998, when participatory approaches of training were developed, the benefits are probably underestimated. Unfortunately, there is no data on the Programme impact for this phase. Neither is information available indicating whether these farmers later repeated the training and would therefore be included in the beneficiaries of phase III.

Underestimation of benefits might also arise from only considering the benefits achieved for the crop on which the training focussed. If the training objectives were achieved, and adopting farmers started to base their pest management decision-making on the results of pest monitoring activities, it is reasonable to assume that this capacity also extended to other crops. Furthermore, farmers were encouraged to diversify their cropping system and to complete their farms with fruit or timber trees as part of the training. The participatory evaluation study, (CATIE, 2001) found that these practises supply additional income in the long run.

5.7 Stakeholder Workshop and Expert Assessment

Following the integrated approach of the Wider Learning Studies, the results of both the economic and the sociological studies were presented in a stakeholder workshop held in June 2003 in Nicaragua. In the case of the economic study, the focus was especially on making the assumptions on which the calculations are based transparent. The qualitative Wider Learning Studies (Paredes and Meir, 2004) provided a typology for each of the groups of actors in the Programme: farmers, extension workers, specialists and decision-makers. It was shown that different types of farmers had different objectives with respect to the training. Also, for the extension workers different groups were identified, each with a characteristic way of applying the new learned training methods. The studies on specialists and decision makers highlighted several goals that these actors had with respect to their collaboration with the Programme. Especially it was pointed out, that the Programme and IPM were largely perceived not as something external but as something they were an integrated part of and which they felt they had ownership of. These findings indicate substantial changes in the various groups of actors in the CATIE IPM/AF Programme thus the assumptions about sustainability and future IPM training taking place are supported.

During the stakeholder workshop, the stochastic simulation method was used as an efficient tool to stimulate the discussion among stakeholders and experts. A central topic of the workshop program was the discussion about the assumptions made for the cost benefit analysis, within the context of the findings of the sociological studies and the individual experiences of the workshop participants. Therefore, working groups were organized by target crops, including one group who discussed the health aspects. The objective of the working group discussion was to re-evaluate the probability of different scenarios, and the range of possible values for the key benefit indicators.

The assumptions made for the target crops were thoroughly discussed and subsequently adjusted by the workshop participants. In Table 8, the results of the working groups in form of changed parameters of the probability distributions are shown. In coffee, the yield effect was confirmed, while the coffee price range was narrowed. In food grains, the situation was viewed more optimistically, with a higher area per farmer included, as well as yield increase. The lower bound of the probability distribution was still chosen as 0 in order not to overestimate benefits. The expert group for vegetable production had a more precise opinion about the adoption rate than previously identified in the available studies, so that this assumption was adjusted. Yield increase was included for tomatoes as an example, and the potential savings in production cost of vegetable was seen higher than previously assumed.

The numbers of farmers in IPM training over the next 5 years was assessed based on the medium-term plans of those organizations represented by the participants; these were assessed as lower than assumed in coffee, but significantly higher in food grains.

In the ‘health group’, the assumptions about the quantitative impact of the Programme in the cost benefit analysis were rejected. It was pointed out that the underlying database was insufficient and that the health effects were underestimated. Rather than including the insignificant numbers in the quantitative analysis, it was suggested that the health effects should be discussed qualitatively and examined in more in-depth studies. Hence, health effects were excluded from the new calculation.

Based on the changes proposed by the workshop participants, the stochastic model was recalculated. The new results were then discussed in a plenary session, and used to debate for future action.

Table 8: Assumptions modified after Stakeholder Workshop

Effect	Initial Assumptions based on studies				Assumptions changed by Workshop participants			
	Lower	Modal	Upper	Unit[1)]	Lower	Modal	Upper	Unit[1)]
Coffee								
Yield increase	0	4.6	7	qq perg. /mz				
Reduction in costs for chemical inputs	0	-	42	US$/mz				
Area per household			4.25	mz				
Farm gate price	18	32,5	61,5	US$/qq perg	20	22,5	40	US$/qq perg
No. of farmers in training after 2003	0		2000		0		1500	
Coffee: adoption rate	36.6		73	%				
Maize								
Yield increase			0	qq	0		2	qq/mz
Reduction in costs for chemical inputs	0		62	US$/mz	0		40	US$/mz
Area per household			1,7	mz			3,1	mz
Beans								
Yield increase			0	qq	0		2	qq/mz
Reduction in costs for chemical inputs								
Area per household			1,7	mz			3,1	mz
No. of farmers in training after 2003	0		500		0		2150	
Food grains: adoption rate	36		39	%	50		80	%
Vegetables								
Yield increase, e.g. tomato			0		0		300	boxes/mz
Reduction in costs for chemical inputs	0		31	US$/mz	0		50	US$/mz
Area per household			1,7	mz			3	mz
No. of farmers in training after 2003	0		1000		0		1200	
Vegetables: adoption rate	36		60	%	40		45	%

1) mz = manzana, Nicaraguan unit for area, equal to 0.7 hectare

qq = quintal, unit of weight, equal to 40 kg

perg. = pergamino: the usual form, in which coffee is sold on farm level. The relation of this farm level pergamino coffee to the further processed green beans for exportation is 2:1.

The new results in Figure 10 show that the probability curve shifted to the right as compared to the original baseline situation (year 2008). Hence the stakeholder discussion reflects a more optimistic picture of the Programme's impact. The probability of obtaining a negative net present value descended to about 2%.

In the debate about these results, the stakeholders pointed out that future IPM benefits would not be achieved automatically. They agreed that the process of promoting the concepts of IPM in the national organizations and advocating IPM friendly policies has to be continued.

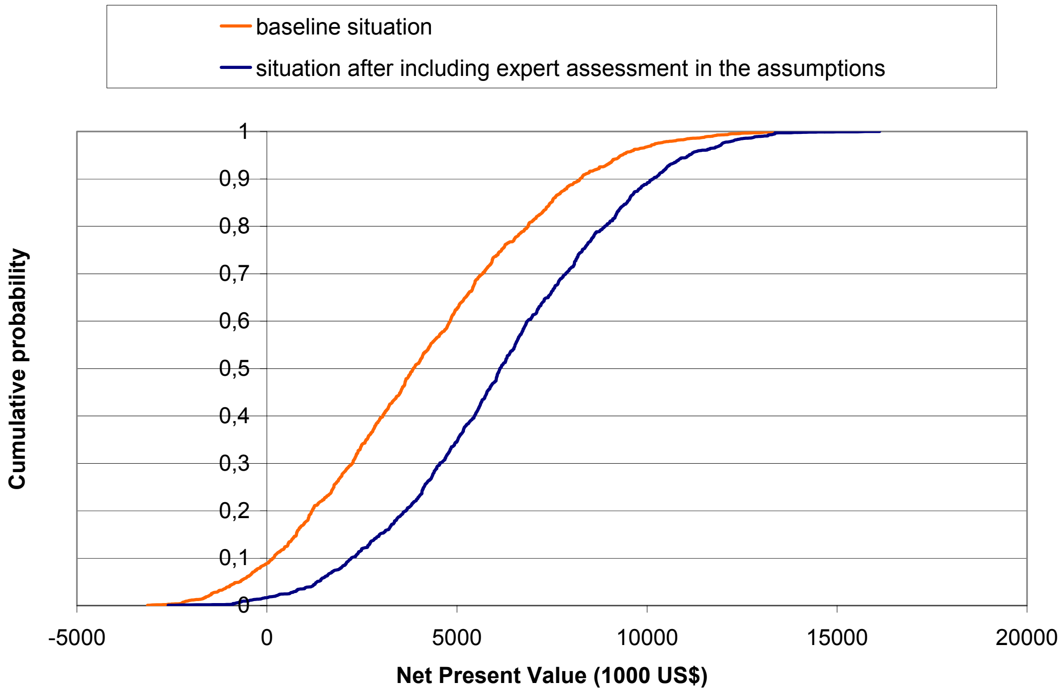

Figure 10: Cumulated Distribution of Net Present Value based on Assumptions generated at Stakeholder Workshop

6 Economic Analysis of the Programme

In the economic analysis, the impact of the Programme on the national economy is assessed. Adjustments have to be made to take account of the difference in prices of inputs and outputs between those used in the financial analysis and the shadow prices of the resources used, i.e. their value for the society as a whole (Gittinger 1989). Payments such as credit transactions, which are costs to farmers but do not entail real resource use, need to be excluded from the economic analysis. Transfer payments such as some taxes and subsidies are market distortions that must also be eliminated in the analysis. The protection of the domestic market by, for example, duties on import goods reflects a cost for society as a whole, while taxes on export goods are an additional income for the economy. Conversion factors have to be used in order to adjust domestic prices to shadow prices (Fleischer *et al.,* 1999). Finally, external costs and benefits must be considered to the extent that these resource flows can be quantified and valued.

Externalities are those costs and benefits not included in the farmer's budget, either because they occur only with a time lag, or they mainly affect other sections of society. In an IPM programme, the reduction of external costs attributable to chemical pesticides is considered to be of benefit to the society. Some may occur in agriculture, such as a reduced risk of pesticide resistance, but are not easily observable by individual farmers. Others, such as reduced levels of ground and surface water pollution, benefit consumers, although the actual effect may be difficult to measure.

6.1 Market Effects

IPM programmes could generate changes in the allocation of a number of traded goods. These are agricultural inputs, of which pesticides and fertilizers usually constitute the major part, as well as agricultural production for export or domestic consumption. An impact on labour requirements, and thus on levels of employment, may also occur. For the Programme, agricultural specialists, decision-makers and field staff working with counterpart organizations are important inputs. At farm level, the labour effects remain low, although farmers' time for participating in the training has to be valued. The budgets for the contribution of the Nicaraguan counterparts include an estimation of the value of the labour of specialists and of field staff, as well as an estimate of the labour invested by farmers in participating in the training. It was assumed that there were no significant distortions in the unit costs of these inputs, and therefore no adjustments were made.

Savings in pesticide expenditure are an important benefit resulting from the work of the CATIE Programme, representing a saving in expenditure on imported goods. In Nicaragua, the imports of agricultural inputs and machinery are not subject to duties and are exempted from value added tax (World Bank, 2000), so the domestic prices are assumed to be good estimates of the economic value of these goods.

With regard to the output prices, only coffee needs to be considered, because this is the only one of the target crops where yield effects were observed. While food grains enjoy some degree of protection in Nicaragua (Picciony *et al.,* 2002), for the major target crop of the Programme, coffee, the situation is reversed: given that in 2000 its agricultural export share was around 60% (Picciony *et al.,* 2002), coffee is a major source of foreign exchange income. There were no data available on the difference between the export parity and the farm gate prices, but for a conservative estimation, in the economic analysis, the output prices were adjusted with a conversion factor of 0.9, following the Word Bank estimations (Picciony, 2000).

The benefits to farmers' health include tradable and non-tradable elements. The cost of medication and that of the lost labour of the casualty and of the person taking care of the ill was already included in the financial analysis. If treatment in a hospital is necessary, as in 7% of the intoxication cases, additional social costs of an estimated US$150 per day are required. A decline in rates of intoxication is related to savings of these costs, thus representing social benefits resulting from the Programme's work, which were included in the economic analysis.

The result of the economic analysis is very close to that of the financial analysis: The Programme is still profitable with the adjusted assumptions, with an economic rate of return (EIRR) of 18.9 %.

6.2 External Effects

The introduction of IPM was fuelled by a growing awareness of the negative externalities associated with intensive pesticide use. Thus, in general, no external costs are expected from IPM programmes: instead positive externalities may occur. The external benefits that are supposed to be generated for actors other than the target groups refer particularly to the negative external effects avoided by shifting away from a pesticide-based cropping system, such as that specified as the reference situation. Health benefits arise with respect to reduced contamination of food and water from pesticides. Other external effects are related to the promotion of soil and biodiversity conservation. Over time, soil fertility may increase, which could bring benefits to individual farmers, and in the long run to society as a whole. For example, in a study carried out in Nicaragua after the hurricane Mitch, Holt-Giménez (2002) found that IPM farmers have a higher ability to cope with natural disasters, and that conservation practises help to protect soils, even in extreme situations.

The Programme's work with decision-makers in national and regional organizations might result in a reduction in the implementation costs for future IPM programmes. Quantitative assessment of such effects would remain rather speculative, because it would depend upon the type and concepts of any future programmes. At the level of farmer groups, one objective of the small project approach was to strengthen the capacity of these groups for organizing funds for follow-up community projects. However no information exists that would allow quantifying the productivity effects of such additional projects.

In summary the economic and financial analysis showed that under the conditions of the baseline scenario, the Programme has a positive NPV. This result is also robust to changes in parameters, as demonstrated by the stochastic simulation study. Furthermore, farm level studies showed that the benefits that can accrue from IPM are attractive enough for farmers to participate in the training. Considering the market and the non-market effects generated by the Programme only slight differences exist between the financial and economic prices. Thus the economic analysis confirms the results of the financial analysis.

7 Summary and Conclusions

The financial and economic analysis of the CATIE IPM/AF Programme showed that even in a situation of sparse data availability a meaningful economic study can be conducted if risk and uncertainty are addressed explicitly and appropriate tools for risk analysis are applied. Expert assessment can be used to complement missing statistical information and other incomplete data. The setting of the study and of the expert workshop within the Wider Learning Studies framework contributed to the quality of assessment. In the process of making the assumptions transparent on which this study is based, assessing them in cooperation with the stakeholders and discussing the results of the calculation using the adjusted variables, the participants' interest and understanding of economic evaluation increased. Also the ownership of the results was transferred from the researchers to the stakeholders, so that their relevance to practical decision-making, and the commitment of decision-makers to capitalize on the benefits of the Programme was promoted.

Based on the available data, the cost benefit analysis of the Programme showed that it was a viable investment and generated net social benefits to the Nicaraguan economy. However, the results need to be interpreted with care due to a number of uncertainties with which the Programme is faced. As the simulation study showed, there is a possibility that the benefits generated by the Programme may not justify the resources used. This case can be true if the benefits from IPM cannot be sustained beyond the period of external funding of the Programme.

The analysis also demonstrated the importance of establishing a programme monitoring system that generates quantitative data, which facilitated good economic analysis. Most importantly, such data should include scientifically valid information about farmer performance with and without programme intervention. A targeted monitoring system allowing the allocation of project inputs to specific project outputs using a logical framework approach would be essential to enable us to draw economic conclusions.

In the case of the Programme, the most important variables are the yield effects in coffee, and the magnitude of the savings resulting from reductions in pesticide use as a result of the adoption of IPM techniques. These two components of the Programme's benefits are influenced by the quality of the training, and the counterfactual situation i.e. how farmer productivity would have developed in the absence of the Programme. Overall, the crucial factor is the sustainability of the benefits after the external contribution of the Programme has come to an end. Similar results have been found for IPM programmes in other parts of the world, e.g. the FAO-EU IPM Programme for Cotton in Asia (Praneetvatakul *et al.,* 2005). The longer the farmers continue applying IPM practice, the higher the probability that the Programme investment pays off..

The aggregate effects of the Programme in the case of large-scale adoption also need to be considered. For example, if, due to other non-Programme interventions or random events, coffee prices fall, the incentive to adopt technologies, which increase yields, will be reduced. If the potential for yield increase is low because of a generally high level of productivity, such as in vegetables it is not certain what incentives would be required for farmers to change their production systems, and this uncertainty must be taken into consideration.

Improvement in crop quality is an aspect, which definitely needs to be further addressed. If achievements such as those occasionally mentioned by farmers and claimed in the Programme records have been made, these should be verified by independent scientific studies. As long as the market does not sufficiently recognize quality, the valuation of these effects remains difficult. The question to be raised is then whether IPM quality labels would be required to further stimulate the adoption of this technology, and to what extent market channels already in existence, including the organic market, can be adapted to recognize the quality of IPM products.

Another risk stems from CATIE’s rather complex way of organizing the training of trainers, extensionists and the farmers within the same cropping cycle, referred to as “zig-zag” approach (see Chapter 2.2). This system offers the chance for valuable feedback on every level of the training, and was especially appreciated by those specialists who otherwise have little direct feedback from farmers. However, for the field staff the process is very demanding. The extension workers are expected to change their existing working methods to use the promoted participatory methodology. They probably also face a situation in which they are supposed to train others in the field without having completed their own training. This can introduce misinterpretations and errors into the training process.

The design of the Programme in terms of its time horizon, with a long development and pilot implementation phase, involving long-term and low budget investment in policy dialogue, and the development of participatory approaches, can be assessed as capacity building strategy. The linkages between research and farmers' practise that were established in these phases are an important precondition for the success of the large-scale field implementation phase, and probably lead to good acceptance of the new techniques and high adoption rates. The long-term policy dialogue with Nicaraguan agricultural organizations and specialists had paid off during the field implementation phase. When the large-scale field level intervention phase began, the ground was already prepared: this included existing Nicaraguan agricultural organizations which were already "on board" and which used their own institutional infrastructure, thus lowering the implementation costs and supporting a more sustainable level of change in terms of technical assistance.

In terms of determining the degree of sustainability of the Programme's impact, additional indicators are needed. For example, what do the decision-makers in various organizations think about the Programme's IPM concepts? Do they in fact establish the principles of farmer participatory training in their organization? Are they interested in maintaining this type of technical assistance in the future or do they lean more towards other non-IPM farming strategies? This policy environment is important, as the CATIE Programme has recognised but the effects are very difficult to quantify. As shown in the sociological study (Paredes and Meir, 2004), the decision makers in agricultural organizations were strongly engaged in the project and some level of ownership was reached. The achievement of integrating IPM into the work plans of the organizations is also reflected in the somewhat optimistic assessments on the future of IPM in Nicaragua expressed in the policy maker workshop. These are important conditions that favour the sustainability of the Programme's output.

The quantification of non-market benefits such as the environmental effects and the impacts on farmers' and consumers' health would provide useful additional indicators for the assessment of the economic viability of the Programme. The inclusion of the savings in the cost of treating pesticide intoxication casualties which has been attributed to the Programme's impact significantly underestimates the generated benefits. However, this aspect has to be considered as highly uncertain. Contingent valuation has frequently been proposed as the appropriate technique for the assessment of the non-market benefits (Gittinger, 1989), and especially health benefits (Fleischer *et al.,* 1999; Ajayi, 2000). This method has already been applied to the evaluation of IPM programmes, (Cuyno *et al.,* 2001). While such analysis could not be conducted within the scope of this study, a forthcoming study deals with an in-depth assessment of farmer health effects of IPM, applying a willingness to pay approach (Garming 2005).

In summary the case of the CATIE IPM/AF Programme showed that investment in farmer training in IPM can be efficient if some minimum conditions are met. Primarily this refers to the retention of IPM practises by trained farmers. A similar result was found for the FAO-EU Programme for Cotton in Asia (Praneetvatakul *et al.,* 2005).

It has also been shown that economic analysis, even under conditions where data is sparse, can provide useful information. Such analysis can help pose further questions which can in turn guide future planning, not only in the field of IPM, but also in the wider field of agricultural extension.

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