Interactive design of farm conversion

Linking agricultural research and farmer learning
for sustainable small scale horticulture production
in Colombia

PROMOTOREN

Prof. Dr. Ir. N.G. Röling
Hoogleraar Landbouwkennissystemen in Ontwikkelingslanden

Prof. Dr. Ir. E.A. Goewie
Hoogleraar Maatschappelijke Aspecten van de Biologische Landbouw

SAMENSTELLING PROMOTIECOMMISSIE

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Prof. dr. P. Van Mele	CABI Bioscience UK Centre, Surrey, UK

Rebecca A. Lee

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Abstract

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Economic and ecological pressure on small farmer production in Colombia has increased since the globalisation of trade in the early 1990s. Although the climate allows for year-round production, the farmers live precariously due to a high dependence on external inputs, poor access to different sources of information on production technology and lack of control over market prices. Mechanisms are required to help these producers find alternatives to stabilise their income while reducing the negative effect their farming practices have had on the environment.

This book describes an innovative situation where agricultural research provides a viable methodology for moving towards sustainable agriculture involving new (technical) learning for the farmers and parallel capacity building to ensure long lasting effects of these efforts, at both farm and landscape level, using a case study approach. With the European prototyping as a starting point, a methodology for farm conversion is designed interactively with the farmers to ensure appropriateness to their situation. It is then applied by them using, and in some cases verifying, organic, botanical and biological management strategies based on scientific research. It looks at how conditions for using biological control at the farm level can be created at the landscape level. It looks at building a marketing strategy among small farmers. And it addresses the issue of replicability.

Emerging from the facilitation of the farmer learning process came a sequence of coherent and novel research activities designed to generate farmer learning: understand the context, implement participatory diagnostic research to anchor the work in real problems, encourage the creation of a learning platform, interactively (with farmers) design a system based on the farmers' priorities that is effective at the farm level, and that is acceptable to farmers, identify and test science-based applicable technologies at the farm level, scale up this system from the farm to higher system levels, and ensure long-term project impact and farming community autonomy by providing the tools for accessing new information and training local facilitators.

By studying the interface between the farmer learning pathway and the set of research activities involved in its facilitation, it became apparent that the farmers learning pathway is divided up into four phases. These are: 1. participatory diagnosis and the beginning of the creation of a learning platform, 2. improvement of production at farm level due to better technical knowledge leads to the realization of the importance of working together as a community, 3. this in turn leads to the search for solutions on a larger scale as a tool for regional development, and 4. building the capacity of the farmers to stand on their own. Each phase is related to the progress made by the farmers throughout the research based on accomplishments in the three dimensions of the development project: technical know-how for appropriate farm management, the creation of a cooperating group of farmers, and long-term sustainability through autonomy and self-reliance.

Key words: interactive conversion design / vegetable production / small farms / sustainable farming / Colombia / learning processes / facilitation / agricultural research methods

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I would like to dedicate this book to my co-researchers, the now ecologically-friendly vegetable farmers of Cota.

CONTENTS

Chapter 1 - Introduction and problem statement

1.1 Introduction

This study is about innovation, change and learning processes in a South American agricultural context. It is based on a project for the conversion of conventional vegetable farms to sustainable production[1] in a high Andean Colombian municipality, as an option to improve farmer income by supplying the growing niche for ecologically friendly produce in the local market. A methodology for farm conversion based on interactive design and implementation with the farmers is used to help them reach this objective. The particular research interest lies in improving or adapting methodologies for realising changes and learning processes required for such innovation to be successful, not only at the individual level, but also at the group or community and institutional levels. The intent is also to provide guidelines for policy making focussed at improving family farming in Colombia.

The municipality in which this study was undertaken, Cota, has an economy based largely on agricultural production, and of that vegetables contribute significantly. At the time this research was initiated, the horticultural sector was depressed and in dire need to look for ways to become more efficient and profitable with the least cost to the environment. Marketing was limited principally to the food terminal whose middlemen rarely offered a good, let alone stable, price for the produce. Combined with high production costs to pay for imported seed and chemical supplies, income to the farmers often did not cover expenses, nor provide the necessary cash to invest in the next crop and to provide for family needs. Fortunately, interest in ecological products, or at least healthier ones, had increased locally among consumers and

[1] 'Sustainable agriculture' in this report refers to integrated and ecological farm production.

defenders of the environment. The farmers themselves had shown concerns regarding the indiscriminate use of pesticides and their effect on the environment and on both their own and the consumers' health (tables A1, A2 and A3 in Appendix 1 show pesticides produced and sold in Colombia). Therefore, the possibility of creating the conditions for introducing safe and healthy[2] products to fill this growing niche, and offering quality-vegetables in a competitive market, appeared to be an interesting option for the producers of Cota. New distribution channels, support structures and even 'green' labels could be considered, allowing for greater interaction between the producers and the end consumers.

At the beginning of the study (September 1999), sustainable agriculture was still very incipient in the Colombian context, and ecological agriculture even more so. Only one vegetable company was licensed to sell ecologically certified produce nationally, with barely two hectares inscribed. In fruit, the tendency was stronger, with a total of 130 ha in the country. The otherwise conventional farming methods predominant in Colombia were based on heavy indiscriminate use of pesticides and chemically synthesised fertilisers, with visible negative effects on the environment and human health. In an effort to promote a more sustainable level of farming, the Colombian Ministry of Agriculture and Rural Development (MAGDR) through the National Programme for Agricultural Transfer of Technology (PRONATTA) gave preference to projects with an emphasis on integrated and ecological methods through yearly calls for proposals from 1996 to 2000. Additionally, in 1995, the government established a law to legislate ecological farming (Decree 544), based quite heavily on the International Federation of Organic Agriculture Movements – IFOAM legislation. The Corporación Colombia Internacional (CCI) was put in charge of evaluating and certifying farms[3]. By the end of 2001, the CCI had certified a total of 131 hectares in vegetables, with an additional 26 in transition, and 327 and 559 respectively in fruit (Uriel Contreras – CCI, pers. comm., February 2002).

[2] Crops that are produced under integrated crop protection principles, ie. with clean water, use of toxicological category III or IV pesticides only and if required, and a tendency toward ecologically friendly practices, are considered safe and healthy. 'Ecological' production allows only natural sources for fertilisers and pest and disease management, following the Decree 544 for ecological production practices which is based on the international recommendations set by the IFOAM for organic production. Under the Colombian legislation, the term ecological includes all farming methods alternative to mainstream methods (organic, biological, biodynamic, etc.).

[3] The CCI is the only entity allowed to certify products for sale nationally. It, as well as two other organizations, Biolatina and Biotropico, also certify for export. Areas certified by these two organizations are not included here.

1.2 Societal problem addressed

Despite this incipient institutional interest in the ecological movement, implementing organic practices, and in fact converting areas to this 'new' style of production, was not considered by the majority of farmers as possible or viable. Most projects, as found earlier in the international scene, were limited to specific settings, with results limited in scope, impact and replicability.

While interest in safer and healthier food existed at both farmer and consumer levels, the existing infrastructure and institutional make-up were inappropriate for serious adoption of sustainable production practices. In effect, although promoted by PRONATTA, effective participatory research methods were little known in the agricultural sector, agronomic designing was virtually unheard of, public extension programmes were being reduced and the existing mechanism for enforcing the legislation on ecological farming was weak. There was a need to devise a trajectory that would help the farmers move toward sustainable agriculture, useful on a larger scale, and replicable, as well as to determine the contextual factors required for its success. This in turn required training since ecological practices are not adopted as easily as the recipe-like applications of synthetically produced agro-chemicals (Somers, 1998). However, in order for such a project to be successful, change in the producers only is not sufficient. It is also required throughout the production – consumption system, and for such change to occur, increased awareness and a learning process are implied at several levels of aggregation (eg. Farmers, farm, region, country - Hart, 1980).

1.3 Research addressed problem

The societal problem, the design of a learning trajectory or path, along which farmers can move towards a more sustainable and autonomous livelihood, needs to be facilitated by interventions or activities. This thesis reports on a set of coherent but novel research activities that is designed to generate farmer learning. This was not done in a planned and hypothesis testing approach. Rather, the work emerged as a result of an 'adaptive' approach, probing, monitoring, adjusting, rethinking, discussing with the stakeholders, and so forth. What emerged are two sets of related processes, (a) the learning trajectory or path taken by a group of horticultural farmers as they move from being atomised, dependent, defensive individuals to a group of autonomous, self-reliant, pro-active partners; and (b) the set of research activities involved in facilitating (a). The interest of this thesis is the interface between these two processes.

1.4 Overview of research design

The study described here is about an innovative situation where agricultural research provides a viable methodology for moving towards sustainable agriculture involving new (technical) learning for the farmers and parallel capacity building to ensure long lasting effects of these efforts, at both farm and landscape level. It is not an experiment in which a hypothesis is tested, but a new way of looking at agricultural research which is beginning to emerge in various international networks. A case study approach is used here to design and try out this research methodology and draw lessons from it. The case study itself has many new elements. In addition to promising practical and useful outcomes, it raises many scientifically interesting issues. For example, the project applies some aspects of participatory methods in a small farmer context. It applies, and in some cases verifies, organic, botanical and biological management strategies based on scientific research. It looks at how conditions for using biological control at the farm level can be created at the landscape level. It looks at building a marketing strategy among small farmers. And it addresses the issue of replicability.

Thus, this book describes an exercise in research about agricultural development research. In recent years attention has increasingly been paid as to how to make agricultural research more relevant to development. The quest began in the early seventies when the flush of Green Revolution success was wearing off. Adoption of science-developed technologies, especially in the risk prone, diverse and resource poor areas of the world, proved to be largely unsuccessful. The lack of impact of linear research approaches on farmers' practices led to farming systems research, i.e., to ways of designing technology that were built on thorough knowledge of the actual farming systems for which they were intended. Soon, ways of involving farmers in the design of technologies became a focus of interest. 'Interactive agricultural research' emphasised that research impact was the emergent property of the interaction among diverse stakeholders with multiple perspectives and multiple interests (Röling, 1996). Effective research becomes a journey with a number of path-dependent steps. For example, a project currently co-ordinated by Wageningen University, 'Convergence of Sciences Project', (FAO Global IPM Facility, 2001) emphasises

(a) initial technographic studies to explore the opportunities and social map of potential innovation;
(b) diagnostic studies to anchor the research effort in a thorough understanding of needs and opportunities;
(c) science linkage to ensure that the efforts are linked into the best knowledge available. Such linkage might involve original fundamental or applied research, but also a thorough survey of scientific literature;

(d) interactive design (with farmers and other stakeholders) of systems that work, AND are acceptable in terms of local interests, knowledge, ability, and feasibility; and
(e) ensuring that the established systems are sustainable and can be scaled up.

Earlier research by Van Schoubroeck (1999) and by Tekelenburg (2001) have helped to orient the work here. Posted as a young entomologist to Bhutan, Van Schoubroeck was told to study stem borers in maize because everybody grew maize and all were suffering from stem borer problems. When Van Schoubroeck looked more carefully into the problem and interviewed farmers, he found that farmers did not experience stem borers as a problem at all, and felt they had sufficient maize to eat. In fact, they used quite a bit for brewing alcohol. Van Schoubroeck subsequently spent months with farmers to identify problems that he could usefully spend his time on. In the end, he discovered that farmers were exporting tangerines to India but suffered heavy crop losses due to early fruit fall. An analysis of this problem brought to light the work of what later proved to be the Chinese fruit fly (*Bactrocera minax* Enderlein). Thus a diagnostic phase anchored the rest of Van Schoubroeck's work firmly into the local scene and farmers' felt problems. Only then did Van Schoubroeck start 'real' scientific work to identify the fly, its lifecycle, the pheromones that are effective, and so on, by carrying out experiments in the laboratory and reading the literature.

Then he went back to the farmers. It soon became obvious that the scientific knowledge he had developed was not sufficient to do anything about the fruit fly. It proved impossible to control the fly at the farm level because its population dynamics involved higher system levels than the farm. Local Buddhist culture prohibited killing organisms. Ways that fitted the farming calendar, and proved effective at the field level, had to be invented. So Van Schoubroeck started a year-long process working and experimenting intensively with villagers to develop a system that worked.

In the end, he did have a system that worked. However, when he wanted to extend it to other villages through the extension service, he failed. He obviously needed another process. But his time was up. However, what he had achieved from a research point of view is that he clearly put on the map a number of phases of research that are crucially important in making research relevant for development and in pioneering explicit phases of research that are not normally part of 'methodology'.

Tekelenburg (2001) went further. He used an in itself very interesting development project in Cochabamba, Bolivia, to explicitly tease out the roles of agricultural research by developing what he calls a 'toolkit' of research approaches that are built into such processes as problem analysis and knowledge integration. He distinguishes four tasks:

- Explaining and understanding phenomena;
- Designing effective agricultural management techniques;
- System optimisation of effectiveness and efficiency; and
- Farmer satisfaction and decision making.

He then identifies research activities to perform these tasks:

- Fundamental research;
- Applied research;
- Designing systems that work; and
- Designing systems that are acceptable.

Building on the work of Van Schoubroeck and Tekelenburg, the present research seeks to take the development research methodology a little further. In effect, the farm conversion project implemented in Cota became an evolving learning pathway for the farmers, which will be covered in more detail in Chapter 5. This pathway was in turn the result of an evolving series of agricultural research activities or interventions, that in hindsight constitutes a research sequence that facilitated the farmer learning pathway. This book does not follow the historical logic of the project. Instead it presents a coherent set of sequential research activities based on the literature. It then presents the project as a case study that seeks to facilitate a farmer learning pathway through research activities.

The sequence of research activities used to facilitate the learning pathway are listed here:

a. Understand the context in terms of relevant actors, opportunities and constraints;
b. Implement participatory diagnostic research to anchor the work in real and felt issues, problems and opportunities;
c. Encourage the creation of a learning platform by providing the farmers with learning tools for observation and analysis;
d. Interactively (with farmers) design a system based on the farmers' priorities that is effective at the farm level, and that is acceptable to farmers;
e. Identify and test science-based applicable technologies at the farm level (by the farmers, with project team support);
f. Scale up this system from the farm to higher system levels: market, organisation and landscape; and

g. Ensure long-term project impact and farming community autonomy by providing the tools for accessing new information and training local facilitators.

Through the design and testing of such a research sequence, we hope to determine whether there is in fact a link between the research activities and the farmer learning pathway. The project that the book reports on is a case study for gaining greater understanding of this link. As such, this case study is not a carefully controlled scientific experiment. It is a one-shot intervention. But it is a very rich and complex one that allows extensive questioning and probing with a view to better understanding of the research sequence that leads to an effective learning path for farmers.

The case study allows us to look into several questions. For each step of the research sequence, we want to explore the lessons that can be learned about that step, by carrying it out in practice. These steps therefore feed into the farmer learning pathway through the implementation of the specific research activities (a to g, listed above). In the end, we also want to find out whether looking at the research sequence in this manner provides a comprehensive and sound perspective on how to design sustainable agricultural development.

In summary, in hindsight we can systematically graphically present the design of the study as follows:

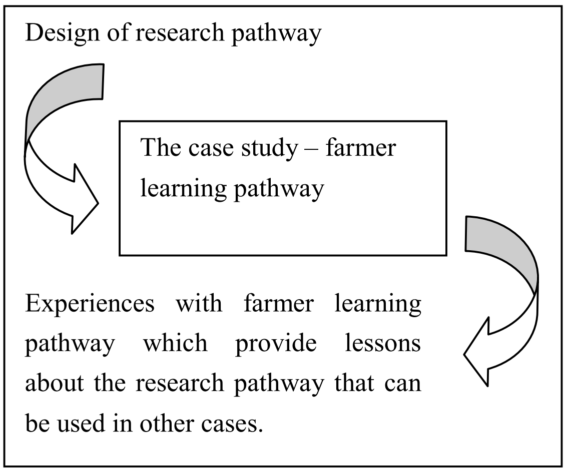

Figure 1.1 General view of research and learning pathways followed in the study.

The research questions will thus be oriented toward specific issues that follow the seven steps listed above, while the project will address issues that deal particularly with farmer learning.

1.5 Brief project description

The research questions were introduced into a project that was presented to the PRONATTA in the fall of 1998 and approved in the summer of 1999. The office of the mayor of Cota financed a smaller project on the same theme during the fall of 1999 in order to keep the momentum created by the expectations of the PRONATTA project. The original proposal was based on the needs of the different sectors provided in a municipal analysis undertaken through public consultation. After validating the needs of the vegetable producers, the proposal suggested an interactive design and implementation of a methodology to convert vegetable farms to more sustainable production. A step-wise procedure for re-orienting the farm toward ecologically sound agriculture would be developed based on ecological sequence, farmers' needs and capacities, and market demand. A third project, also approved and co-financed by PRONATTA, was later incorporated to address more specifically the issues dealing with marketing and post harvest management.

This case study project is in itself a series of innovations, at four levels of aggregation (farm, community, region, and organization for the future), related to the research questions. The methodology to convert farms to sustainable agriculture was inspired by the prototyping experiences undertaken successfully in Europe (Vereijken, 1995, 1996, 1998; Kabourakis, 1996) and which will be described in detail in Chapter 2. Technical methods for farm conversion were adapted from local knowledge as well as from the literature, based on needs determined by a participatory diagnosis. Up scaling the conversion process was studied by looking at the option of redesigning the landscape within the context of sustainable production. Alternative marketing channels were worked on, as well as the corresponding changes required in post harvest techniques, through farmer training and research in these areas. Thus all aspects linked to agricultural production, and particularly agriculture based on ecological practices, were considered as within a system.

Because ecological farming particularly is based on observation and inference to understand the relationship between the plants and their environment and so prevent future problems, the effects of actions must be looked at in the long term. The farmers were therefore required to go through a serious process of learning in order to implement sustainable agricultural practices (Hamilton, 1995). The farmers gradually felt the need to group themselves in a stronger more organized fashion. Organisational learning, including learning how to negotiate among themselves, and in the future set standards and methods to control the implementation of the standards, among many other aspects, had to be looked at. Hence, the nature of innovation and of farmer and organisational learning needed to be considered. The specific nature of facilitation through research activities that emerges out of the needs of sustainable farming also had to be studied from the points of view of farm conversion, landscape redesign, farmer learning, and organisational learning. The knowledge on theoretical perspectives of social learning, mentioned by Woodhill and Röling (1998) as requiring study, has therefore been expanded. Technical insights in the conversion to ecological farming are described and the role of science research within this participatory conversion process is evaluated with a view to drawing lessons about the design of agricultural development research.

Finally, the entire project is evaluated by identifying factors that could demonstrate the success or failure of the project. Such information is relevant to other stakeholders working in this field.

1.6 A multi-disciplinary research team

As can be gathered from the above brief project description, a multi-disciplinary approach was necessary to adequately implement the project. The members of the research team did in fact come from a variety of disciplines. As project director, I came with a plant protection and rural extension background. To support the work on natural sciences related themes, there were soil scientists, a soil microbiologist, a plant physiologist, agronomists, and an entomologist at different times during the project. Marketing specialists and a psychologist looked after the socio-economic aspects. Students from related areas provided support as well.

As essential partners in this interactive research effort were the farmers. They are small farmers, dependent for the most part on their farming activity for their survival. They provided the indispensable input that oriented the research and in fact, by providing feedback on the research activities designed to solve the problems they had themselves identified, they helped the emergence of the learning pathway.

1.7 My involvement

I moved to Colombia in 1991 with my Colombian husband. While he set up a plug business for a large flower farm, the first in the country, I helped manage the 45 ha family-owned vegetable farm in the year-round production and marketing of the vegetables, as well as initiate plug production of vegetables (also a first for the country). My husband left the flower company and having decided that plug production had potential as a business on its own, in

1995 we set up Suamena Plants Ltda. under his management. Around the same time, I joined the Horticulture Research Centre of the University of Bogotá Jorge Tadeo Lozano (Appendix 2 describes this Centre), starting as research coordinator and then creating a new area in extension. This programme later was changed to Participatory Research. Initially the purpose of the programme was the dissemination of the research results of the Centre through one-day courses and publications. Once that was established, I set out to change the University's concept of extension which was limited to courses and publications, to introduce working more directly with the farmers for whom ultimately the research was supposed to be done. This was given a great impulse when a colleague was transferred from the main campus and the project we presented to the PRONATTA was approved with one of the highest points in the country. Recognition for the Programme has grown significantly thanks to the results that are described in this book.

1.8 Conclusions and how to read this book

The situation of small farmers described above is a complex one as is the position of the agriculture researcher who seeks to design research activities that will facilitate a learning pathway of farmers to a 'better place'. Hard and soft information must be integrated, as must experimentation and design, learning and teaching, and facilitation with the building of autonomy. The art is to address the issues scientifically in order to obtain operational answers to practical questions asked by the farmers. Such answers will facilitate the building of an environment conducive to sustainable agriculture. In this case, the set of research activities will involve a combination of work on technical aspects of sustainable agricultural practices with work on social aspects, or the human side, required to ensure long-term success of innovation efforts. Such a combination demands a dynamic process for training the farmers in becoming skilled producers, while at the same time leading them in becoming managers of their own local resources. The final result will also provide guidelines for orienting the new research methodology for agricultural development research.

The second chapter of this book reviews the theoretical framework on which the research study and the project are based and introduces the questions that both are guided by. Theory of research on research for development is briefly discussed. Paradigms, theories and methods relating to ecological agriculture and farmer participation are then covered. The research methodology, based on a case study approach to the learning pathway of the farmers, is described. Chapter 3 describes the initial context in which the project case study was implemented.

The farmers learning pathway is divided up into four phases. Each phase is related to the progress made by the farmers throughout the research based on accomplishments in the project.

Phase I describes the situation at the beginning of the conversion process to sustainable production and includes the participatory diagnosis (Chapter 4), the methodology used to design the conversion process and its implementation (Chapter 5) and the results achieved (Chapter 6).

Phase II moves from a situation where the farmers have begun to use some of the technical knowledge to improve their production and to realise the importance of working together as a community. New issues arise and are dealt with, such as marketing (Chapter 7) and organisation of the farmers and team building (Chapter 8).

With the build up of knowledge and community feeling developed in the first two phases, Phase III delves deeper into the need to provide solutions to a wider area as a tool for regional development. Chapter 9 studies the usefulness of knowing more about live fences and the arthropods that inhabit them, while Chapter 10 provides a practical application of that information through the creation of a network of live fences at municipal level based on enhancement of natural control of crop pests.

Phase IV looks to the future by beginning to build the capacity of the farmers to stand on their own. To that end, Chapter 11 describes the training of local facilitators, reinforcing their abilities in both technical and didactical methods, in an effort to help the farmers toward more autonomy.

After looking at the case study through the four phases of the farmers' learning pathway, we use the last chapter to provide a critical review of effectiveness in terms of learning pathway design. An analysis is provided of the end results of the entire effort, reviewing what was successful, what not and why, and what other facilitators can learn from these results. Conditioning factors for the success of the project and its continuity are also looked at. Finally, the research activity sequence is analysed from the point of view of its success as a methodology and the implications of the results for research on agricultural research.

Chapter 2 - Theoretical perspectives and methodology

2.1 Research on agriculture development research

2.1.1 Theoretical framework

Agricultural research and extension have been designed to generate 'development'. Results from research centres initially were deemed sufficient to solve small farmers' problems (Reijntjes et al., 1995). Extension was a one-way process whose objective was to transmit to the farmers the results obtained in the research centres, in order to stimulate the diffusion of innovations process best described by Rogers (1995). Widespread dissemination of certain technologies, considered as perfect solutions to the problems studied by scientific researchers, was attempted throughout many decades. Students were taught professional roles with a linear view of themselves as either fundamental or applied producers of knowledge, or as experts in 'delivering' science to farmers as ultimate users. The model was quite successful for those innovations for which the treadmill effect works, i.e., where a price squeeze propels innovation (Cochrane, 1958; Hubert et al., 2000). Technologies associated with the Green Revolution did in fact increase productivity for some crops and conditions, to the point where they significantly contributed to solving food security problems at the time. However, those technologies were not reaching the most needy: the resource poor and resource less farmers. Science-based technology was not having the desired effect in agriculture; secondary effects were being overlooked (Lee, 1989; Lee and Shute, 1991). Moreover, where environmental innovation was concerned, success was very low. This was mainly due to economic considerations: environmental management often requires major changes to farm production procedures and is too expensive for the individual farmer, even if non-management represented costly long-term adverse effects (Vanclay and Lawrence, 1996). Research on farmer adoption grew (Leeuwis and Van den Ban, forthcoming), as did criticisms of the diffusion model. These criticisms go back as far as the 1970s and include the blanket view of science as solution to all problems, the unequal distribution of impacts and benefits, its application to production technology while leaving out conservation aspects, the marginal use of local farmer knowledge, and the lack of consideration of the particularities of each person, situation or agroecological context (Vanclay and Lawrence, 1996; Norman, 2000: Röling et al., 1976).

The aim then changed so as to 'put the farmer first' (Chambers et al., 1989). Research on farming systems grew, primarily as a quantitative diagnostic process for researchers to acquire a better understanding of how the farming household worked (Collinson, 2000). Farming systems research (FSR) evolved over time. According to Hart (2000), it started in the 1970s with large survey work based on lengthy questionnaires on cropping systems for improvement of productivity. Then, it gradually expanded its framework in the 1980s to include livestock and consider the farming system in order to improve on stability as well. In the 1990s, the framework was expanded further to include community systems and watersheds, adding sustainability to the attributes it wished to affect. Much can be learned from studying the history of FSR; however, one of the points that will be brought out here is the importance of working *with* the farmers. This led to the development of participatory research, some methods of which are described in section 2.2.4. Through FSR, issues such as empowerment, indigenous knowledge, and farmer learning and experimentation were brought forth. In this way, FSR led directly to Participatory Technology Development (e.g. Jiggins and De Zeew, 1992).

Returning to the issue of research on development, we remind the reader that such research is precisely 'research that has development as its primary aim' (Mettrick,1993). The implication is that:

> *"...it is to be judged by its impact on the livelihoods of people, rather than by intermediate outputs such as successful solution of a research problem or even widescale adoption of a research-generated innovation. It is an attitude to research and may encompass a range of different research methods. It is a dynamic concept*

that which has to be sufficiently flexible to respond to new concerns as markets change, policy shifts or development ideas progress (ibid).”

In the same vein, Mettrick considers two specific features as central to development oriented research, namely that it is problem centred and context based. By problem centred, he refers to the need to help farmers solve problems *they* have identified and prioritised. By context based, he explains that the complexity of development processes require that they be considered within the realm of the particular farmers. Because of the numerous disciplines involved in development, Mettrick suggests that a multidisciplinary approach be taken and for that, the systems perspective is particularly appropriate. To be effective, research on development must therefore work on farming problems as identified by the farmers within the social, political, economical and cultural context they live in, which is also the one in which they must take decisions that ultimately will affect their survival.

At Wageningen University in The Netherlands, additional questions have been recently raised about how to design research so that it really does help the farmers. Some of the activities that are being included in research design to address these questions are described next.

Context

An analysis of the context at different system levels is used to identify conditionalities for effectiveness and to contextualise the research activities. It is of importance to identify the parameters within which the activities must be successful, as well as the opportunities they seek to tap.

Diagnostic research

These questions include a much greater emphasis on diagnostic research, recognised as an essential element to ensure that development research is building on the needs of the beneficiaries. Therefore research must not only include a chapter reviewing the literature so as to ground research in the scientific tradition. It must also include a chapter on diagnostic research to ground the research in development issues. Van Schoubroeck has shown in his dissertation how difficult it is to go into a farmer context with a preconceived idea of the solution to their problems and actually have a positive effect. On the basis of longstanding experience as a development administrator, Hounkonnou (2001) grew increasingly convinced that external interventions had not been effective, and the only point of ‘light’ in African development was ‘local dynamics’, the way local people themselves seek to generate better lives. Hounkonnou is convinced that effective interventions must be anchored in such local dynamics; he calls this ‘listening to the cradle’.

Designing systems that work

Obtaining research results, or incorporating those results into a farm design, is no guarantee that the system will work. The proposed system must be economically, ecologically and technically feasible in the farmers' situation. This is not normally a part of research. The tendency of researchers is to focus on technologies that work, regardless of what others, including the targeted farmer users, may think of them. This can be a problem since those farmers can always say no. In the case of Van Schoubroeck, hard data alone did not allow him to help the farmers. Increasingly, however, these other considerations are taken into account, as in the case of Participatory Learning and Action (Hamilton, 1995).

Designing systems that are acceptable

However, not only should the technology work. The real challenge is to make sure it is acceptable to the farmers from cultural, economical, and technical points of view: labour required, cash flow availability, access to inputs, social expectations and the like. Knowing the context in which research is to be undertaken will determine the appropriate orientation and final outcome of the work. Such considerations must therefore be part of the research activity.

Designing systems that lead to self-reliance

Systems that depend on outside input from 'experts' for their maintenance will be difficult to maintain in the long run. The technology should not only not lead to increased dependence on outside help, but in fact help the farmers become more independent and able to make informed decisions about their farm management.

2.1.2 Research questions

On the basis of the literature and overview of previous research, a new 'design' for development research emerges that contains the following elements that together form a logical sequence for facilitating farmer learning:

- Context appraisal
- Participatory diagnosis
- Building a platform for learning with farmers
- Design a technology that works and is acceptable to farmers based on their priorities
- Building farmer autonomy

This leads to the following research questions:

a. What is the nature of the aforementioned elements and their relationships within the sequence of research activities?
b. What is the nature of the interface between the sequence of research activities and the farmer learning pathway?

The presumed link between the research activities and the learning sequence can be drawn as follows:

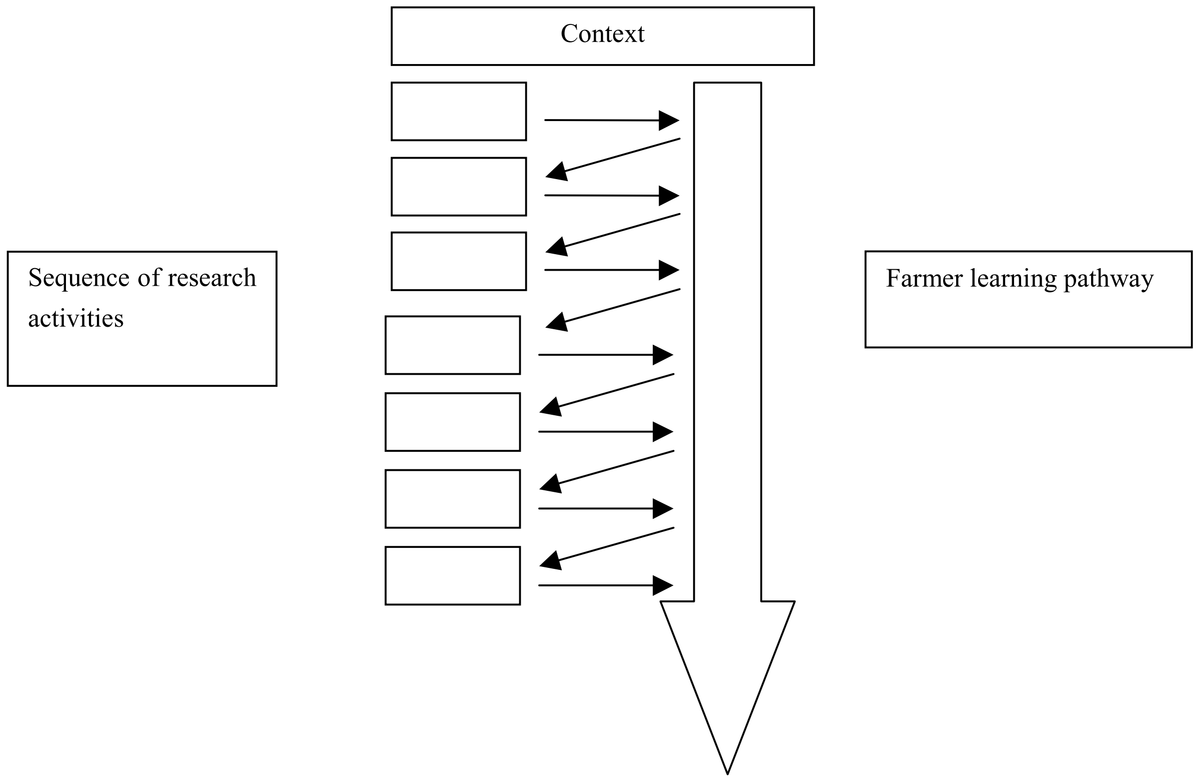

Figure 2.1 Presumed link between research activities and farmer learning pathway for the design and implementation of farm conversion to sustainable horticulture production.

These research questions were put to the test through the implementation of a project aimed at the interactive design, with interested farmers, of a process to convert their vegetable production to more sustainable methods. In the next section, we review the theoretical underpinnings of such a project.

2.2 Theoretical background of the development project

2.2.1 Introduction

Our research questions are multidisciplinary by nature. This implies that, to be able to obtain answers, we must use methods and techniques covering more than one discipline while still being integrated with each other. More precisely, we have to integrate the hard data oriented disciplines such as agronomy, ecology, soil sciences and integrated crop protection (indicated by β sciences) with the soft data oriented disciplines such as management, agrosociology and economy (indicated by γ sciences). A third dimension is that leading to autonomy, which includes in this case local organisational issues linked to inter-personal relationships and self-confidence. The latter area works by bringing together the β and γ sciences so as to obtain farmer self-reliance.

2.2.2 Characteristics of γ and β knowledge

Characteristic of γ sciences is the central position of the sense making human being as an agent for change (Röling, 2000). On the other hand, β sciences are characterised by the fact that the causal knowledge involved is objectified through conditioned experiments. Knowledge in β sciences is regarded as absolute by nature. In γ science, knowledge is the result of negotiations between human beings. A one-sided application of either γ or β knowledge will lead to different types of farms. When β dominates in farm designing or extension to farmers, the result will be the development of farms where the human being as decision maker and manager plays no role. For example, if we want to repeat the positive results of a conditioned experiment on a crop protection problem at the level of a real farm, we first have to condition the farm's surrounding (for example, making sure soil fertility or pest population densities are uniform). So it is not the farm that determines what the experiment should look like, but the experimental conditions which determine that the farm must be the same as those of the original experiment. The result is that all natural diversity inside the farm becomes levelled. Pesticides must level all agrobiodiversity and chemical fertilisers must level all natural diversity in the soil (Wolfert, 2002).

In this particular case, we wanted to apply β knowledge in a γ setting, and take into account the flexibility of farm structure and the learning nature of farm management. In effect, there are three different ways to look at a farm:

- The farm is considered an experimental field, in which results obtained in a research centre are implemented, often by the researchers themselves;

- The farm is an ecosystem in which research must play a role; and
- The farm is managed by the farmer who decides whether to incorporate research and research results into his/her farm management practices.

This has consequences for the methodologies in this project. In this case, it is not about providing a blueprint to bring the Cota farmer toward development, but rather it is a step-by-step and cooperative search for answers on how to achieve a conversion process that can be maintained in the long run. In order to be able to do so, I had to take the following steps.

- Find the characteristics of successful interpretation of γ and β knowledge in the literature;
- Design a learning pathway to find appropriate solutions;
- Chose a set of criteria that would help to determine whether we have reached our goals and to 'measure' the rate of progress and change in the project.

The theory on which this case study project is based brings together paradigms and concepts from different perspectives. The objective of the project used as case study is the conversion of vegetable farmers to more sustainable practices. In this setting, we are dealing with an agroecosystem, therefore we must discuss ecological perspectives within the agricultural context. The changes were undertaken at individual farms, considering each farm as a particular agroecosystem. But especially in the context of small farms, to reduce the effect of negative external factors on the conversion process, larger areas should be considered for conversion. This requires looking at the agroecosystem at landscape level at least.

People are the basis for change in the management of an agroecosystem, bringing in the need to discuss stakeholder participation. Negotiating among stakeholders, discussing potential solutions to restrictions to production and implementing these alternatives require an understanding of learning processes. Since we are talking about change at farm level as well as at the landscape level, there is a need to understand what the farmers need in order to learn as individuals and within their organisations, especially when considering long-term aims such as farmer self-reliance and autonomy. Facilitating these processes may require different approaches and methodologies according to the situation.

2.2.3 *The agroecosystem perspective (β sciences)*

The fact that conventional agriculture has caused serious problems of environmental degradation, social inequity, resource concentration and excessive use of natural resources and that such systems are not viable in the long run has been discussed at length elsewhere (Altieri, 1993, 1995a, b; Reijntjes et al., 1995; Gliessman, 1997; Lightfoot, 1999; Van Elsen, 2000). Germplasm improvement alone is not likely to improve agricultural productivity in a sustainable way due to a limited agricultural resource base (Izac and Sanchez, 2001). The alternative is some sort of environmentally friendly practice that at least reduces the current trend of negative impact to the agroecosystem and hopefully looks at options to help recover from the damage done.

A move toward ecological production not only means reducing the use of synthetic agrochemicals, and in the future doing without them, but also taking into consideration the entire agroecosystem and its surroundings. From agricultural niche management, or 'making the best use of the variation in natural resource endowment within an agroecosystem' (Lightfoot, 1999), one can then move on to larger agroecosystems in order to contribute to sustainable farming (ibid). It is not just a question of substituting artificially synthesised pesticides and fertilisers with botanical or organic ones (Primavesi, 2001). It is a question of a change in the attitude toward life, especially in respect for life (Mollison, 1988). It means optimising knowledge and management so as to combine agroecological, economical and social visions, in order to acquire a wider knowledge system (Kabourakis, 1996; Tillman and Salas, 1994). It also means involving all levels of production, perhaps even to the point of reconstruction of the agroecological system so as to include zones for flora and fauna biodiversity (Mollison, 1988; Van der Ryn and Cowan, 1996; Smeding, 2001), leading towards more stable production over time and less dependence on external inputs. Instead of maximising economic and biological productivity, methods must be devised to rehabilitate and regenerate natural resources (Lightfoot et al., 1993). The concept of integrated natural resource management (INRM) brings together these ideals. INRM has been defined as 'the responsible and broad-based management of the land, water, forest, and biological resources base (including genes) needed to sustain agricultural productivity and avert degradation of potential productivity' (CGIAR-INRM-group, 1999). The agroecologist works toward recovering the resilience, self-regulation and strength of the agroecosystem (Mollison, 1988).

Conway (1985) defines an agroecosystem as an 'ecological and socio-economic system, comprising domesticated plants and/or animals and the people who husband them, intended for the purpose of producing food, fibre, or other agricultural products.' A hierarchy can gradually be visualised from soil micro-organisms for example, to plants, to crops or herds, to people. Each agroecosystem is a component of the agroecosystem at the next level and part of a much larger network whose parts are all inter-related (Capra, 1996; Lightfoot, 1999; Izac and Sanchez, 2001; Walker et al., 2001). Properties of a network include that it is non-linear and messages may follow a cyclical path creating a feedback loop. The community can therefore learn from mistakes, thereby regulating itself and leading to the capacity for self-organisation, which Capra mentions as perhaps the central concept where the systems view of life is concerned. 'Self-organisation is the spontaneous emergence of new structures and new forms of behaviour in open systems far from equilibrium, characterised by internal feedback loops and described mathematically by non-linear equations' (1996).

Agroecosystem properties

For Conway (1985), the primary goal of the agroecosystem is increased 'social value': the provision of goods and services to meet human needs. From that point of view, he describes four agroecosystem properties:

a. Productivity: the output of valued product per unit of resource input – measured as amount of biomass produced or yield or income derived from the harvest in calories, proteins, currency, etc.
b. Stability: the constancy of productivity in the face of small disturbing forces arising from normal fluctuations and cycles in the surrounding environment. It is measured by the coefficient of variation in productivity.
c. Sustainability (or system resilience): the ability of the ecosystem to maintain productivity when subject to a major disturbance: how far is productivity depressed and does it return to its initial level?
d. Equity: the evenness of distribution of agroecosystem productivity among the human beneficiaries.

Analysis of agroecosystems helped to bring an 'ecological perspective to farming systems research, helping researchers understand the wider ecological setting – again a recognition of the hierarchy of systems' (Lightfoot, 1999). By working with the farmers to collect the required information, communication between farmers and researchers improved, techniques such as Rapid Rural Appraisal (RRA) became Participatory Rural Appraisal (PRA), and the farmers began to apply the different techniques for information collecting themselves (ibid).

This is somewhat similar to Astier and Masera (1996) who add:

e. Dependability: reaching a high level of productivity through efficient use and synergy among the components and resources of the agroecosystem.
f. Adaptability: the ability of a system to reach new levels of equilibrium, while maintaining productivity in the long run despite changes, moulding itself to new biophysical, economical and cultural conditions through innovation and learning processes.
g. Self-reliance (or autonomy, as used in Conway, 1987 and Tekelenburg, 2001): the ability to control and regulate the system and its links to externalities, for example complementary production of inputs and products.

Altieri also uses productive capacity of the agroecosystem and ecological integrity (defined as 'preservation of natural resource base and functional biodiversity'), but includes social health ('enhanced social organization and reduced poverty') and cultural identity ('empowerment of local communities, maintenance of tradition and popular participation in the development process') (1995b). He then relates these attributes to a list of indicators of sustainability (table 2.1).

Along the same discussion lines of providing goods and services, results of the Pilot Analysis of Global Ecosystems - PAGE (UNDP/UNEP/WB/WRI, 2000) provide a preliminary overview of the state of five basic ecosystems making the link between biophysical aspects and the provision of human well being. In the case of agroecosystems, the goods and services they compare are:

- food and fibre production
- provision of water in sufficient quantity and quality
- maintenance of biodiversity
- storage of atmospheric carbon
- provision of recreation and tourism opportunities.

With regards to agroecosystems, the same study found that although the trend for food and fibre production is still on the increase, a decline is likely to occur due to land degradation in at least 16% of agricultural land worldwide. Clean freshwater is not being produced as fast as it is consumed, while ground and surface water are progressively more contaminated and salinisation is an increasing problem. Competition of water for drinking and industrial use is getting stiffer every day. Expansion and intensification of agricultural land has significantly reduced biodiversity. The amount of carbon stored in agroecosystems is just about equal to that stored in the soil, resulting in an uncertain value attributed to this service. No data was available on the use of agroecosystems for recreation purposes. Generally, a rather negative picture was painted with fair to poor quality of the agroecosystem compared to 20-30 years ago. One of the solutions of this report was based on the adoption of an 'ecosystem approach' to productivity. This is defined as an integrated approach that looks at all possible goods and services and attempts to optimise the mix of benefits for a given ecosystem, making tradeoffs efficient, transparent and sustainable.

Table 2.1 Association between rural development assessment attributes and indicators of sustainability (from Altieri, 1995b). The table shows how each attribute compensates the deficiencies of the other attributes, suggesting that all of the indicators should be addressed when considering sustainability.

Indicator	Productive capacity	Ecological integrity	Social health	Cultural identity
Crop productivity	x			
Soil fertility and nutrient cycling	x	x		
Soil erosion		x		
Crop health (pest, disease incidence)	x			
Biodiversity status (native germplasm, forests)	x	x		x
Landscape health (watershed status, biological corridors)		x		
Health and nutritional status			x	x
Community participation and solidarity			x	x
Income and employment			x	
Required external inputs, costs of production	x		x	
Cultural acceptability of technologies				x

Indicators used to measure the different aspects and attributes of an ecosystem approach to agricultural production vary among authors, although there are several points in common. A summary of the different indicators used by some authors is provided in table 2.2.

Table 2.2 Indicators used by different authors for the measurement of sustainability

Indicator	Altieri, 1995b	Vereijken, 1995	Van Mansvelt & Van der Lubbe, 1999	Wolfert, 2002
Crop productivity	x	x	x	x
Soil fertility and nutrient cycling	x	x	x	x
Soil erosion	x			
Soil cover		x		
Crop health	x	x		x
Biodiversity status	x	x	x	x
Water quality and use		x	x	x
Air quality			x	x
Landscape health	x	x	x	x
Health and nutritional status	x			x
Community participation and solidarity	x		x	
Access to education			x	
Income and employment	x			x
Required external inputs, costs of production	x			x
Economic and efficient use of resources		x	x	x
Cultural acceptability of technologies	x		x	

On the other hand, Lightfoot et al. (1993) limited themselves to four indicators when working with farmers in The Philippines: economic efficiency, defined as net farm income; bioresource recycling, defined as the number of bioresource flows the farmers identify on their farms; species diversity, which includes both species cultivated and those with other uses; and natural resource capacity which is obtained by dividing biomass output of all natural resource types ($kg.ha^{-1}$) by the number of resource systems (also called agroecological niche capacity by Lightfoot, 1999). Throughout this discussion, the need to involve the human population by construction of social capital (the ability of a society to unite in learning and in problem solving – Villegas and Caraballo, 2000) becomes more and more apparent in order to be able to manage adequately the natural capital ('stocks of resources generated by natural biogeochemical processes and solar energy that yield useful flows of services and amenities into the future' – Izac, 1997 in Izac and Sanchez, 2001) at their disposition.

Working from an agroecosystem point of view thus requires taking into account objectives that not only improve on biophysical aspects of the system. Since human beings are part of the system, socio-economic aspects must also be included.

Sustainability at farm level

A practical example of integrating agroecosystem objectives at farm level is provided in the software developed by Pérez (1999). He looked at biophysical-technological, economical and socio-cultural aspects of the system to compare sustainability among dairy farms in the Bogotá Plateau. The seven agroecosystem properties described above were used to characterise each of the three aspects in order to decide on the indicators to use to compare farms. In table 2.3, these properties and their parameters and indicators were adapted to the context of vegetable production in Cota as a starting point for indicator selection in the present research.

Table 2.3 Initial selection of parameters and indicators for the Cota project based on Pérez (1999).

	System attributes	Parameter	Indicator
BIOPHYSICAL AND TECHNOLOGICAL	Productivity	Yield	Total biomass
		Efficiency	Tonnes per area
	Stability	Biological diversity	Shannon´s Biodiversity index
	Resilience and reliability	Conservation of natural resources	Soil salinity
			Soil structure
			Soil compaction
			Satisfaction of water requirements
			Biological control of pests and diseases
		Efficiency	Productive efficiency of the water
			Crop efficiency
		Quality	Carbon / Nitrogen ratio
			Available phosphorous
			Calcium+Magnesium/Potassium relationship
			Soil mineral nitrogen
			Soil pH
		Response to extreme conditions	Susceptibility of the crops to drought, heavy rains and frosts
	Self-dependence and self regulation	Efficiency	Energy efficiency
			Self supply of dry matter
			System nitrogen balance
		Recycling	Use of waste
		Self-control	Losses due to pests and disease
ECONOMICAL	Productivity	Profitability	Cost – benefit ratio
			Net annual profitability
		Yield	Gross real income
			Net benefit
SOCIO-CULTURAL	Equity	Participation	Level of organisation
			Generation of employment
	Adaptability	Capacity for change	Generation and adoption of technology
	Stability	Conservation of resources	Perception of sustainability

These indicators were adjusted throughout the project according to usefulness, ease of use by both farmers and researchers, and appropriateness, as will be seen in Chapters 5 and 6.

Sustainability at landscape level

Within the systems approach, resilience of an agricultural system will be highly dependent on the surrounding landscape. Understanding the multitrophic relationships of an ecosystem, particularly where potential crop pests are concerned, will help the farmers to manage their farm as habitat for more than just themselves and enhance diversity of species that will in turn help the farmer. Lewis et al. (1997) are particularly emphatic on that point:

> *"First we need to understand, promote, and maximise the effectiveness of indigenous populations of natural enemies. Then, based on the knowledge and results of these actions, we should fill any gaps by importation. Finally, therapeutic propagation and releases should be used as a backup to these programs when necessary"*

From an ecosystem perspective, we must move from the application of the different properties of an agroecosystem at individual farm level, on to their application at a higher ecosystem level. In other words, although the conversion process can be implemented in each farm, factors beyond the farm can influence the outcome of the effort at this level, especially in the context of the small farms in this case. For change to be more efficient, a larger area must be included in the process. System sustainability and resilience have been linked, for example, to biodiversity in the case of pest management, although selective diversity is required to regulate the desired pest population (Dempster and Coaker, 1974). Biodiversity can be increased, among other methods, by creating niches and corridors to increase the movement of birds, bats, reptiles and insects between islands of vegetation, especially where these communicate with forests or woods (Van der Hammen, 1998). This is more feasible at landscape level where small farms are concerned. Redesigning landscapes within the context of ecological farming should therefore be contemplated within the context of conversion to ecologically friendly practices (Mollison, 1988; Kabourakis, 1996; ATTRA, 2000).

Prototyping

In Europe, a methodology to ease farmers through the conversion process to integrated and/or ecological production was developed, called prototyping (Vereijken, 1995, 1996, 1997, 1998; Kabourakis, 1996). The methodology consists in establishing a hierarchy of prioritised objectives with the farmers, transforming these objectives into measurable parameters (indicators of farm sustainability) and linking these parameters to production techniques, all of which will lead to the design of a preliminary prototype. In summary, the prototype is a collection of practices designed with the farmers to lead to more sustainable agriculture. The preliminary design is tried out and improved on until the objectives are accomplished. Once the prototype is adjusted, it can be disseminated to places of similar context through pilot groups and local networks.

Prototyping has been implemented by research teams in nine pilot projects in different European countries since 1993, sponsored by the European Union, to design, test, improve and disseminate Integrated Arable Farming Systems within the context of the region. According to the particular situation and the order of prioritisation given by the farmers, the relevant standardised methods were used to design the theoretical prototype which was then to be tried out.
The methods are:

- Designing a multifunctional crop rotation (MCR)
- Designing integrated or ecological nutrient management (I / ENM)
- Designing minimum soil cultivation (MSC)
- Designing ecological infrastructure management (EIM)
- Designing integrated crop protection (ICP) and environment exposure-based pesticide selection (EEPS)
- Designing farm structure optimisation (FSO)

The six methods are described as follows (summarised from Vereijken, 1995 and 1999a). Results of other research in some of the topics are used to complement the basic information on the methods.

- Designing a multifunctional crop rotation (MCR)

The objective of this method is to preserve soil fertility (biological, physical and chemical) and the environment, with minimum inputs while still maintaining production quality. The selection of the crops to be used and their rotations take into account marketability, profitability, effect of the crop on soil cover, structure and fertility, and feasibility in terms of harvest time, crop residues and adverse effects of the previous crop. This method should affect parameters[4] such as soil fertility measured as NPK available reserves (NAR, PAR,

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[4] Parameters in the prototyping method are quantified objectives of the farmers who want to redesign their farms.

KAR), quality production index (QPI), net surplus (NS), pesticide residues, energy efficiency (EE) and labour efficiency or hours hand weeding (HHW).

By using appropriate crop rotations, plant production can be positively affected by improving soil fertility (improved biological, chemical and physical components) and reducing the pressure of pests and diseases (Sumner, 1982). However, the following guidelines are recommended in order to optimise the sequences (Millington et al., 1990; Vereijken, 1995):

- combine crops in the sequence that either build up or exploit soil fertility;
- include at least one leguminous crop;
- avoid planting crops with similar pest, disease and weed susceptibilities back to back;
- include the use of green manures and cover crops;
- implement practices that will increase organic matter content over time.

- Designing integrated or ecological nutrient management (I / ENM)

The purpose of I/ENM is to provide solutions to problems of soil management related to erosion and fertility. It complements MCR by ensuring inputs replace outputs in order to maintain adequate soil reserves in terms of NPK. By gradually replacing inorganic sources with organic sources of amendments, the farmers move from integrated to ecological nutrient management. This method should affect QPI, EE, N in groundwater or drainage water (NGW, NDW), PK annual balances (NAB, KAB) and organic matter annual balance (OMAB).

Nutrients in agricultural soils must be available in quantities adequate for plant growth, without being in excess. Recycling nutrients by incorporating crop residues or other means cannot guarantee total reposition, as 'losses' occur when the crop is harvested or 'extracted' from the farm system. If these losses are not replaced by natural sources (bedrock weathering, rain water, etc.), supplements must be introduced (Arden-Clark and Hodges, 1988). Conventional producers seem to consider the soil as an inert substrate and use synthetic chemical sources to provide nutrients to the plants in a simple form, and so are dependent on off-farm sources of fertilisers, which in most cases in Colombia are imported. Advantages of these fertilisers include that they have a guaranteed composition, are easy to store and handle and provide fairly predictable yields. On the other hand, organic producers work with the soil as a living system, enhancing natural cycles and biological processes which lead to system resilience, relying as much as possible on on-farm or regionally-available resources. Disadvantages include variability in nutrient content, difficulties in handling leading to uneven application and the time required to prepare them. However, the long-term beneficial effects of organic sources of fertiliser outweigh their disadvantages: the organic matter content improves soil structure which in turn reduces leaching to subsoil water and the effect of soil compaction, the micro-organism population is increased (Sivapalan et al., 1993), helping render nutrients available to plants through decomposition processes (Oberson et al., 2001) and the release of enzymes such as phosphatase (Dighton, 1983). These effects are particularly visible when the addition of organic fertilisers is combined with other practices of ecological agriculture as described in section 5.4.4 on multi-functional cropping systems (Arden-Clarke and Hodges, 1988). Specific differences between conventional farming systems and those organic have been described by Arden-Clarke and Hodges as follows:

- Soil pH: wider fluctuations in soil pH can be found when inorganic fertilisers are used, due to chemical reactions in the soil and the negative effect on soil organic matter content. Most effects lead to acidification. Organic manures, in contrast, provide an increased buffering capacity of the soil, which prevents wide fluctuations in pH.
- Salt concentrations: inorganic fertilisers are made of soluble salts, some of which stay in the soil solution thereby increasing osmotic pressure, rendering difficult water and nutrient uptake by the roots. High levels of salts also affect soil fauna.
- Biological effects on soil ecology: the amount of soil organic matter (SOM) present determines to great extent life in the soil. Comparisons have been made of organic carbon levels: where manures have been applied, carbon levels increase on a yearly basis, whereas in the case of application of inorganic fertilisers, the levels drop dramatically.
- Effects on soil fauna: this is directly related to the amount of decaying plant or animal wastes applied. Inorganic fertilisers have been shown to have a negative effect on some elements of soil fauna. Earthworm populations are a good indicator for soil health in that respect. Up to 1100 $kg.ha^{-1}$ have been reported in pasture soils where in arable soils that can fall to as low as 100 $kg.ha^{-1}$. Applying organic fertilisers at rates of 35 $T.ha^{-1}$ has increased that increased to 900 $kg.ha^{-1}$. Furthermore, several years of work by Romero (1998) in the Bogotá Plateau have shown the positive characteristics of worm compost. This reinforces the results of several authors summarised by Arden-Clarke and Hodges (1988) that showed effects on soil fertility through improvement of soil structure, improved aeration, porosity and drainage, increased distribution of nutrients within soil layers, and higher nutrient availability in worm casts than in the original soil they worked on.
- Effects on soil micro flora: the addition of plant residues and generally of organic fertilisers has shown to help in the management of soil-borne plant pathogens, among

other reasons, due to the production of antibiotics by saprophytes and changes induced in chemical soil make-up. Additionally, Sivapalan et al. (1993) found higher populations and species diversity of fluorescent pseudomonads, fungi including many antagonistic fungi, actinomycetes and bacteria except for gram-negative bacteria, in organic soils.

- Other effects include better availability of nutrients, a higher cation exchange capacity (CEC) which helps regulate the supply of calcium, potassium and magnesium, and addition of micronutrients which are left out in the typical N, P, K applications of conventional agriculture.

Deugd et al. (1998) used a combination of six technologies to obtain INM, based on farmers' preferences, biophysical setting and economic conditions: mineral fertilisers, mineral soil amendments, organic inputs, improved crop/livestock systems, improved crop-tree systems and soil conservation. The technologies used in this project are very similar, using the existing research results described above to choose methods and inputs sources that would lead to similar outcomes, as will be shown in the results discussed in Chapter 6.

- Designing minimum soil cultivation (MSC)

After determining whether non-inversion tillage, zero tillage or direct drilling are needed and indeed, feasible, the crops for which such procedures are most appropriate are established. This method should affect QPI, OMAB and soil cover index (SCI).

Generally, soil structure should improve. In the case of Cota, the intent was to attempt to recover some degree of soil aggregation. Burns and Davies (1986) use the following definition for soil aggregates: 'agglomerations of sand, silt, clay and organic matter arbitrarily described as having a diameter between 0.25 and 10 mm'. The existence of stable aggregates is associated with soil fertility. Stability of the aggregates makes them stable to rainwater and irrigation, wind erosion and compaction by farm machinery. Unstable aggregates on the other hand disintegrate when they are wetted, clay particles then detach themselves, reducing further soil fertility (ibid). Although there is a direct relationship between organic matter content in a soil and aggregate stability, mere addition of organic matter to the soil is not sufficient to acquire such stability. It is in fact the decomposition process and it effects resulting from the ensuing microbial activity that is the cause (ibid). Fungal filamentous entrapment of soil particles, polysaccharide production by bacteria, and stabilisation of aggregates by vesicular arbuscular mycorrhizae seem to be among the factors leading to stable aggregates. The soils of the Bogotá Plateau are generally high in organic matter. However, they respond to additional applications of organic matter, possibly due to increased soil stability as a result of the decomposition process. Because the soils are generally derived from volcanic ashes, or affected by them, the soils tend naturally to have a powdery texture and low structural stability. Structure is completely lost under conventional farming methods due to excessive mechanisation of soil preparation (Amparo Medina - CIAA, pers.comm., 2002).

- Designing ecological infrastructure management (EIM)

This purports to provide the habitat and necessary corridors for natural control of crop pests, while making the landscape more enjoyable. This method should affect QPI indirectly as well as the ecological infrastructure (EI) and plant species diversity (PSD).

Pesticide use would be indirectly affected by enhancing the presence of fauna. Pimbert (1999) mentions that over 90% of crop pests have natural enemies found in field borders. On the other hand, estimates for pesticides that replace these 'natural pest control services' show figures of about US $54 billion per year (CAST, 1999 in Pimbert, 1999). Effect on groundwater might also be reduced, as trees have been found to help prevent nitrogen leaching from subsoil (Rowe et al., 2001).

- Designing integrated crop protection (ICP) and environment exposure-based pesticide selection (EEPS)

Pesticide impact on soil fauna and flora has been demonstrated by a number of authors and summarized by Arden-Clarke and Hodges (1988): populations of earthworms and insects are seriously susceptible to soil fumigants, fungicides such as benomyl have negative effects on earthworm populations, and pesticides generally affect the predator-prey relationships. Herbicides affect soil populations indirectly by reducing plant residue availability. It is estimated that despite the increase in chemical pest control, crop losses due to arthropods, weeds and diseases has increased from 34.9% in 1965 to 42.1% in 1988-1990 on a worldwide basis (Lewis et al., 1997).

One of the management alternatives used to remedy this situation is the natural one. It is an important component of the 'total system approach' described by Lewis et al. (ibid), in which the therapeutic approach must be questioned and pest management viewed within the larger picture of the agricultural production system.

The ICP method helps manage potentially harmful species with a minimum amount of toxic pesticides, whereas the use of EEPS should reduce environmental exposure to pesticides so that there are no longer adverse effects on the rest of the species. These both are expected to affect pesticide index (PI).

- Designing farm structure optimisation (FSO)

This method brings together agronomic and ecological considerations with those economic so as to optimise the farm operation. This is undertaken by structuring a model which defines the minimum amounts of labour, land and inputs required to obtain the desired net surplus (NS) and EE.

Summary

The study of agroecosystem properties leads to an initial list of indicators that may be used to monitor progress in the conversion process. To facilitate the conversion process, prototyping appears useful not only because of its potential coverage, but also because it helps to reach some objectives of sustainability of the production process described in the previous section. Because it brings together the attributes of an agroecological system in practical methods for their application, I considered the prototyping methodology as potentially useful for this study. In effect, a number of the methods listed were used as a starting point in the conversion process described in this case study.

2.2.4 Stakeholder participation (γ sciences)

Stakeholders here are defined as any person or entity that might influence one way or another the outcome of the (development) project. The main ones are the farmers, without whom the process may not even be considered. In this case, I have grouped all other potential stakeholders under the title, Institutional Stakeholders, as their exact identity will be described under Chapter 4.

Farmer participation

Scientific research alone has not been very efficient in answering the need to change production in the field to more sustainable conditions. This is particularly because its reductionist vision (or lack of holistic vision) does not allow for complex situations (Checkland, 1981). A given reality is expected and so there is little room for variations due to the human factor. It is therefore unable to adapt to the local conditions, nor does it typically involve the participation of the people (Fierro and Alvarez, 1998; Pretty, 1994; Trutmann et al., 1996). Farmers are considered as individuals rather than part of society (Barkin, 2001).

Furthermore, this 'hard science' view tends to address merely the biophysical issues and omit the social 'soft' causes of the environmental problems (Woodhill and Röling, 1998; Leeuwis, 1999a). It tends to leave out the rich source of knowledge accumulated within the community, based on ancestral wisdom, experience and the incorporation and adaptation of information from the outside. A uniquely human characteristic is the capability for purposeful action derived from knowledge acquired through experience (Checkland and Scholes, 1990). This knowledge, coupled with individual histories, is what provides each person with a different interest and perspective on a situation, leading to the fact that each person and therefore situation should be addressed differently (Pretty, 1994). More attention should be paid to farmers' opinions and the rationale they use to decide on adoption or not of innovations (Vanclay and Lawrence, 1996). Farmers make their decision based on many considerations: complexity (ease of implementation), divisibility (the possibility of breaking up the innovations in smaller parts, or partial adoption), compatibility with their own objectives, economics, risk and uncertainty (the objective of the innovation may not work out), conflicting information, cost of implementation both financial and intellectual (learning), loss of flexibility, physical and social infrastructure (for example adequate marketing channels or conforming to social norms), and media promotion of environmental situation (the farmers rarely are living the dramatic situation pictured). Inclusion of the farmers in the entire process from problem identification through research on alternatives to decisions on the most adequate solution and its evaluation, as participants in their own development, is more likely to ensure that the solution chosen be appropriate to the farmers' situation and therefore be adopted (Andrews et al., 1992; Etling and Smith, 1994; Walker et al., 2001). They should be looked at as managers of complex social and productive systems rather than as backward end users of predefined technology (Barkin, 2001). In this case, we wanted to ensure that the farmers would be more involved in all aspects of its implementation. This is in line with the concepts described above as to ensuring participation of the farmers as co-managers in their own development (Röling, 1999), so that the entire exercise is responsive to what they want. Biewinga (1999) provides an example of what is proposed. 'Each farm development plan will be based on the objectives and an analysis of the farm concerned, written in close co-operation between farmers and researchers. The resulting plan must fit in with the farm style, capacities, ambitions and motivations of the farmer'. The conversion process designed here with the farmers allows for adjustments as the participants go along, according to monitored results. An option for scaling up is also provided, based on a standard list of steps to be followed. Just as with others' experience (Tekelenburg, 2001; Kabourakis, 1996; Da Silva, 1999; Röling and Van der Fliert, 1998), trial results are even better when farmers get together in study groups and have the support of some kind of advisory group.

Thus, the results generated by research must be appropriate to the agroecological context in order to be of use to the farmers. Research undertaken under perfect conditions for field work in this sense is not appropriate, since the experiments will not be confronted by the obstacles which occur in the farmers' fields. At the farm level, ecological production is based on observation and an understanding of how things work. The farmer is therefore considered an expert, not just a user of knowledge. The accumulated rich source of knowledge within the community, based on ancestral wisdom, experience and the incorporation and adaptation of information from the outside is acknowledged. It also leads to the existence of individual processes for making decisions and resources to carry them out.

To integrate that knowledge and to respond more efficiently to the farmers' needs, participatory research has become more the norm. Methods used involve the farmers in all stages of a project: from problem identification to the evaluation of the results. In many cases, farmer groups were implemented. Examples abound, as in the case of the Comités de Investigación Agrícola Local in Colombia (CIAL - Local agricultural research committees - CIAT, 1993; Ashby et al., 1997), the farmer brigades in Zaire (Mapatano Mulume, 1997) and other forms of farmer-researcher teams (Stolzenbach, 1997, in Mali; Wettasinha et al., 1997, in Sri Lanka; Oerlemans et al., 1997, in Holland; and Van Schoubroeck, 1999 in Bhutan). The Farmer Field Schools in Indonesia provide another example of how farmers learned to rely on their own powers of observation and collective decision-making to manage their rice fields by jointly working with researchers (Röling and Van der Fliert, 1994, 1998). 'Farmers learning from researchers and researchers learning from farmers about agroecosystems have provided a route to more sustainable rice farming' (Lightfoot, 1999).

These associations allow the exchange of experiences, ideas and solutions not only between farmer and researcher but also among farmers. Methodologies such as participatory action-research and participatory rural appraisal deal with the processes whereby knowledge is not merely transmitted but rather it is built jointly by researchers and farmers (Tillman and Salas, 1994; Ornelas, 1997). Many joint learning approaches have come from the application of 'systems thinking' techniques in agriculture. As Lightfoot (1999) comments, 'Experience shows that methods are context specific and must be adapted or re-invented to fit each situation'. This is also what forms the basis for constructivism, upon which research and training proposals must be built in order to qualify for review by the National Programme for Agricultural Transfer of Technology (PRONATTA) in Colombia. By fulfilling a series of stages (Conway, 1985), new knowledge is experimented and the results evaluated, returning to the beginning of the cycle (Checkland, 1990; Capra, 1996; Arratia and De La Maza, 1997; Smith, 1997). Because the research is founded on what the farmers consider to be the problem, they can relate more to the results and should feel more ownership of the solution, which should in turn ensure more adoption. As suggested by Leeuwis (1999b), by starting from the existing social and technological knowledge and experience, and gradually introducing options through farmer learning and experimenting, it is quite possible that adoption of sustainable practices be more efficient. Andrews et al. (1992) list six main reasons for farmer participation:

- Knowledge: farmers have a wealth of knowledge that is site and culture specific, and so can help ensure that solutions are appropriate according to local conditions;
- Empowerment: through effective participation, the farmers develop self-confidence and pride in themselves and their knowledge systems;
- Focus: The research resulting from participatory methods of situation diagnosis are more likely to be focused on the real needs, for example, and by participating in the evaluation processes, the farmers' criteria are incorporated in determining success;
- Support: farmers often participate in the research with inputs, time, ideas which help with the operational aspects;
- Validation: the research can be undertaken under realistic conditions and the farmers themselves participate in the local adaptation of the technologies;
- Extension: a first step is already made in ensuring that the new technology will be used; word of mouth from the participating farmers will help its extension to neighbours.

A large variety of participatory methods have been developed in the last decade (World Bank, 1994); what is now needed is the replication on a large scale of the most functional ones (Farrington, 1998).

Institutional stakeholders

Other than the farmers, additional actors in the agricultural system must also be taken into account, such as those involved in providing inputs and, as in Engel (1997), financial-support institutions, research and development entities, those involved in marketing, and those who formulate and implement government policies. Any changes to the status quo will inevitably involve these actors at some point, so it is advisable to have them aware of what is going on and, if possible, to have them on our side. For that, some type of interaction will occur which might lead to negotiation, conflict management, learning and agreement (Röling, 1999).

A second group of institutional stakeholders also appears. In the context of vegetable production in a town so close to a large city such as Bogotá, it is quite possible that the multiple perspectives that exist for land use (staple farming, flower production – cash crop, tourism in the form of restaurants, and urbanisation) will lead to conflicts at a different level. This leads us to the recommendation by Leeuwis to create some kind of social or organisational arrangement around biophysical set-ups in order that they 'become an explicit part of the design' (1999a). Although this aspect is not dealt with directly in the present study, some of its side effects could help mitigate possible conflicts by precisely offering interesting alternatives based on staple farming with an ecological twist.

When thinking of institutional stakeholders, policy makers within government ministries also come to mind. An example is provided by the Indonesian case in which the government under President Suharto prohibited 57 chemical products and declared IPM as the national strategy for crop protection in 1986, pushing rice farmers to look for viable alternatives. After the traditional Training and Visit system of transfer of technology failed dramatically, Farmer Field Schools emerged as an efficient method to reach large numbers of farmers relatively quickly to help them learn how to work with nature by observing the interactions between plants and insects and their environment. Through this newly found understanding, they were able to reduce the amount and type of pesticides used by 50% without yield loss (Röling and Van der Fliert, 1998; Lightfoot, 1999).

On the other hand, it is not always advisable to undertake policy decision-making entirely without the participation of those to be affected. A good example is provided by Aarts and Van Woerkum (1999) where the Nature Policy Plan of The Netherlands was developed without farmer participation, and resulted in their refusal to implement it even with compensation. Hence the need for *interactive* government steering in nature policy development and *integral* approach to policy design. They propose that this include:

- Multi-functional tackling of regional problems: instead of isolated plans made by the different departments of agriculture, environment, etc.
- Interactive management style: refers to decentralisation as it implies the involvement of local actors, creating local ownership and engagement through participation (government as facilitator rather than regulator).
- Inter-disciplinary exchange and enquiry: for different perspectives and thereby potentially different objectives that can be transformed by communication among disciplines.
- Use of implicit and social knowledge: recognition of the actors' rationality.
- Reinforcement of the regional cultural identity: increased enthusiasm for promoting and producing regional products.

2.2.5 Questions addressed by the case study project

To go from the initial situation to the desired one, a systematic mechanism was required to 'move' the farmers, or help them to make the changes they desired. As mentioned in the section on research for development (2.1), the research activities must feed into the learning process of the farmers to have an effect. A brief comment on learning is hence due. In this case, Kolb's experiential learning theory, which is based on the 'central role that experience plays in the learning process' (1984), is used. From Kolb, we take the following relevant characteristics of experiential learning:

- Learning is best conceived as a process, not in terms of outcomes. In other words, since experiences modify learning, ideas are not fixed but modifiable. In fact, should a person maintain fixed ideas too long, one could consider that s/he has not been learning recently.
- Learning is a continuous process grounded in experience. Knowledge evolves from the integration of new information or experiences into the person's 'life baggage'. Sometimes substitution can occur, but integration of new ideas into the persons' accumulated knowledge is more likely to be lasting.
- Learning is an holistic process of adaptation to the world and involves transactions between the person and the environment. Interaction with situations or particular environments leads the person to act in a certain way, to adapt to the circumstances. This is a similar concept to that of structural coupling mentioned by Maturana and Varela: as long as the environment and a particular element remain compatible (ie. not destructive), they will 'act as mutual sources of perturbation, triggering changes of state' in a process of creative structural coupling (1998).
- Learning is the process of creating knowledge. Facilitators must therefore understand well the information that is to be shared in order to know how to share it.

Thus understanding farmer learning, and how it is facilitated, is crucial to understanding how research can help it. Although the following process actually was a result that emerged from the project, presenting it now should help the reader understand what happened.

We have already discussed the three basic dimensions that can be seen in the project: β aspects look at how farmers can become skilled and productive managers of natural resources; γ aspects work on how to help the farmers help themselves by working as a community; and the third dimension leads to how to ensure that the movement becomes sustainable in the long term. The second dimension is associated with a group format, which seemed to be a better option to farmers working alone. Therefore this dimension could be associated with how to create a co-operating group of farmers. The third dimension is associated with long-term sustainability in terms of autonomy and self-reliance.

Guiding issues were followed in order to help provide answers to these lines.

How to become a skilled and productive farmer

Guiding issues along the dimension of farm management arise where the focus is on small farmers acquiring knowledge about their commodities and about the control of their production surroundings, so as to become skilled resource managers for the region. The process involved has very much to do with what agronomists describe as 'knowledge building on various scales of land use' (e.g. crop, field, farm, region, country). So, supported by β knowledge (agroecology), the pathway goes from:

Crop-bound knowledge to knowledge about the quality of life in the region

β ⟶

(Experimental deepening of agroecological research)

Figure 2.2 Farmer learning pathway based on β-type knowledge.

The guiding issues on this dimension include the following:

a. What commodities should be produced, can farm yield become more efficient and can that be done in a sustainable way?
b. Trials for experimental crop research on farmer plots and concerted discussion about the results.
c. Interest grows for the farm as a system conditioned for commodity production (such as appropriate soil fertility, balancing potentially harmful organisms, agro-diversity).
d. Once the farming system reaches its desired quality and structure, interest moves to conditioning factors outside the farm (farm surroundings). At that moment farmers are 'mature' to talk about ecological infrastructure, agrobiodiversity, live fences and landscape protection.

During the process of knowledge building, the four guiding issues aggregate into relevant regional knowledge that does not conflict with farmer’s interests in yields and efficiencies.

Building a co-operating group

Guiding issues arise as soon as there is an attempt to move the farmers from being isolated individuals, complaining about their poverty and the political disinterest in them, to being respected members of a team within a community. The process involved has very much to do with what sociologists mention as 'group forming' (Uphoff, 1996). So, with the help of γ, the pathway goes as follows:

From self-centred individual to co-operating team member

γ ⟶

(Sociology of group forming)

Figure 2.3 Farmer learning pathway based on γ-type knowledge.

The guiding issues involved are:

a. Individuals share goals, methods, means and position in the society.
b. There is a co-ordinating person who keeps everybody together (binding factor).
c. Process forming happens implicitly from working on explicit problems and solutions.
d. Individuals must be rewarded for their co-operation by seeing that the fulfilment of their initial objectives is at least attempted.

During the process of team building the four guiding issues change weight. They should, however, also always be present during the whole process of team building.

Towards autonomy and self-reliance

The third essential dimension in the learning process is autonomy or self-reliance. The process must become self-organising and resilient, independent of the facilitator.

From dependent individual to autonomous member of society

⟶

Empowerment

Figure 2.4 Farmer learning pathway for capacity building.

The guiding issues involved here are:

a. Identification of limitations that hold the farmers back.
b. Characteristics of knowledge that is relevant for resource-poor farmers.
c. Building networks that allow farmers to reach beyond their immediate surroundings.
d. Capacity building that leads farmers to recognise their own abilities (discovery learning) and analyse information.
e. Organisation

Bringing together the β and γ type knowledge with the third dimension

The three learning pathways do not occur separately, rather they occur simultaneously and to differing degrees at different times. By superimposing the β and axes with the third dimension (figure 2.5), four areas are brought forth which can be referred to as the different phases the farmers go through in the learning pathway. These phases are described as follows and are covered in more detail in the rest of this book.

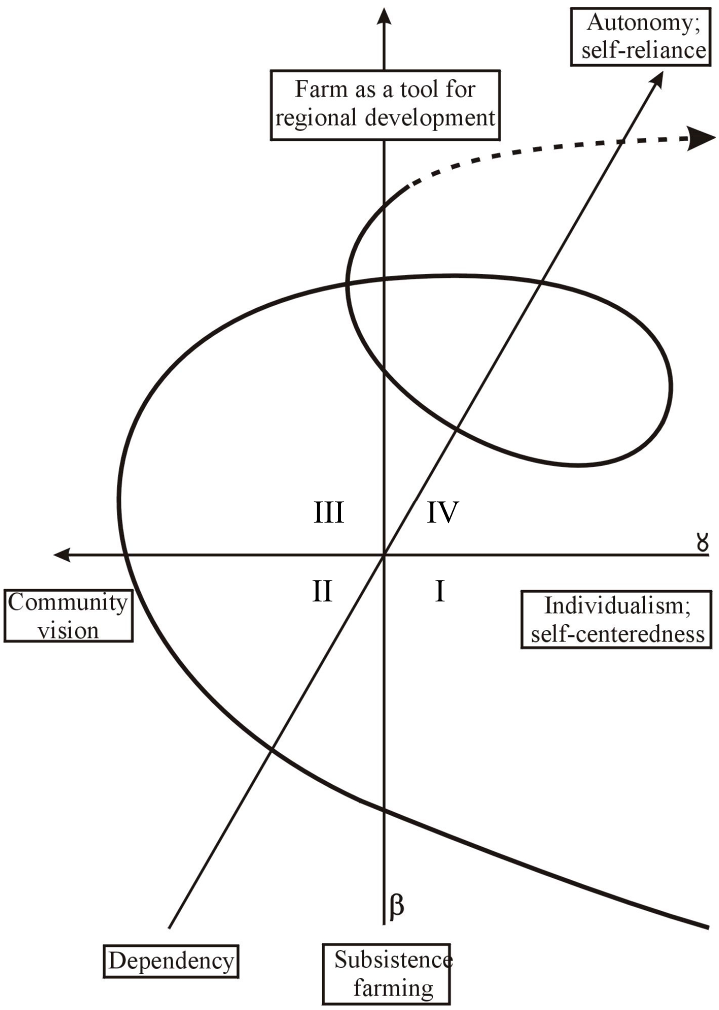

Figure 2.5 Convergence of the three learning pathways based on β and γ knowledge and the third dimension of autonomy. The beta axis shows how improved skills and knowledge lead to change from subsistence farming through technical and technological innovation to regional development. The gamma axis represents how an improved attitude toward team-work helps the farmers move from an individualistic outlook and high dependence on external factors to the development of a sense of community. The third dimension strengthens the farmers' capacity for decision-making (empowerment), leading to autonomy and an understanding of the role of individual farms within the issue of regional development. The numbers I – IV refer to the phases through which the farmers went in the learning pathway, represented by the curve which moves around through the four phases and up the third dimension toward autonomy.

Phase I

The farmers move from subsistence and individualism (egoism) to increased productivity and begin to see the advantages of co-operating with fellow farmers. The role of the facilitator here is strong on both technical and leadership aspects.

Phase II

With improved productivity on the farm, the producers begin to work on co-operative decision-making, to join forces for better marketing power. The facilitator plays more of an intermediary role, helping the farmers to take over gradually.

Phase III

Having begun to build a platform for negotiating for themselves, regional development is attempted by expanding the results of now profitable, individual farms to landscape levels. The farmers take the lead in the process, with occasional support of the facilitator.

Phase IV

At this stage, which corresponds to the time period post-project in this case, profitable, autonomous, cooperating networks of farmers are gradually visible. The role of the farmers is now strong; the facilitator is no longer in the picture.

2.2.6 Research questions revisited

The soft and hard issues brought up in the brief overview of the local context (Chapter 1) and in the research questions provided in section 2.1, now allow us to specify the research questions in a more practical way. To define what research methodology can be used to facilitate the conversion of farmers to more sustainable agriculture in a developing country under continuous cultivation, I identified research activities associated with:

1. Designing, under such conditions, a farming system that gives higher yields at lower costs, economically and ecologically, so that productivity as a whole is improved (β dimension, Phase I).

2. Facilitating small farmer group formation and organisation so as to ensure emergence of concerted action (γ dimension, Phase II).

3. Designing landscape level elements at a higher scale (region) to support the new farming system, moving from small farm management to applications at a regional level (β dimension, Phase III).

4. Facilitating ownership of the process that will ensure continuity after the researcher – facilitator has left. We can call this the 'facilitation of self-facilitation' (third dimension, Phase IV).

2.2.7 Summary

There is no final pathway, but rather a journey is made in which the facilitator and farmers together determine each next step according to the results of the previous phase. In order to determine the extent of success, indicators are added or withdrawn or created new as the research journey progresses, according to those indicators that are useful and easy for the farmers to continue monitoring on their own. The final indicators will be decided on as monitors of whether we are approaching our final goals. The overall objective is to empower the farmers to become successful farm (and resource) managers. Learning does not end with the project. Rather, as long as the soft dimensions in figure 2.5 are dealt with, what begins as a learning curve in the shape of a horseshoe, actually turns into a spiral moving around the β and γ axes and up the third dimension. How these issues are dealt with from a research methodology point of view as well as throughout the project case study is explained in section 2.3.

2.2.8 Initial methodology for the conversion process

Based on the above literature review and contextual information (described in detail under Chapter 3), an initial methodology was drawn up for the design and implementation of farm conversion for this particular project. This methodology was formulated for the grant-winning proposal to PRONATTA before the project started.

Through the project, the process of farm conversion was to be designed and implemented by the application of a series of steps developed with the farmers of the municipality of Cota. The methodology was based on the methodology of prototyping described in 2.2.3 with some modifications which intended to incorporate some of the improvements that had been suggested in the literature. Among these improvements were a more substantial and significant participation of the actors in the farming system, particularly the 'beneficiary' farmers and especially in the definition of objectives; negotiation with stakeholders on the design process and technologies to be used; and use of an open facilitation process instead of directives from the researchers (Leeuwis, 1999b).

The methodology initially proposed here consisted in defining the steps required to achieve the conversion from conventional agricultural production to a more sustainable one, within the specific context of vegetable production, following what might be a logical ecological sequence, taking into account the farming and marketing contexts. As these steps were to serve as a guide for future implementation in other communities, representatives of those areas would also be invited to participate in some of the activities. A conversion design in this context was therefore defined as a set of principles to be applied in a stepwise fashion, based on a logical ecological sequence, farmers' needs and capacities and market demand. It follows very much the Rapid Appraisal of Agricultural Knowledge Systems - RAAKS sequence (Salomon and Engel, 1997): conceptualisation of the problem acceptable for all stakeholders concerned, articulation of the problem in relation to its causes, identification of solutions and implementation of proposed solutions. Emphasis was made on its flexibility, required as it is designed interactively, and in fact evolves throughout the project as improvements and adaptations are made to it. The activities planned were the following:

Activity 1: Participatory diagnosis

- Workshops on participatory diagnosis to identify and prioritise the problems in vegetable production and marketing. The purpose was to go in depth into the problems defined in the Municipal Development Plan, determine the source of the production and marketing problems, undertake joint fact-finding to fill in the knowledge gaps, and prioritise the search and implementation of solutions according to needs. Discussions on the definition of an 'ideal' agroecosystem were to be made, as well as the differences between such a system and the current one.

  The actors involved in the various aspects of vegetable production and marketing in this area would be identified. Linkages among the actors would also be looked at, as would the level of interdependence among them.

  Conditions required for the success of the conversion process would be discussed and studied with the farmers. The actors involved would be invited to participate, in this way gradually building a negotiating platform to meet and discuss such aspects as the promotion of sustainable agriculture, which linkages among actors need reinforcement, the constraints and opportunities for such agriculture, and any interests that needed to be negotiated.

- Workshops to define strategies to design the initial conversion process and agree on techniques and indicators for monitoring. Strategies were to be defined to resolve the local problems using as a basis the previously defined 'ideal' agroecosystem, the differences identified with the current system, and the problems faced by the farmers within that context. These strategies were to respond to the objectives of sustainability through the use of alternative agricultural techniques, and thereby provide the basis for the design, made up of the various steps to be followed to obtain a sustainable production system. The intention was to determine what the logical sequence of changes would be according to ecological knowledge and farmer rationality based on socio-economic factors. Methods used in the European prototyping experiences would be included here as potential options in a basket of tools, along with options available locally and new ones developed during the project.

Changes due to the implementation of these techniques would be monitored through the use of farm sustainability indicators (see table 2.3), first to evaluate the initial state, then the intermediate and final states of each of the pilot farms selected in the next stage. To this end, soil and water samples would be taken for chemical and biological analyses. Additional data on costs of production, productivity, sale price, quality criteria, types of crops, pest and disease damage levels, among others, would also be collected. The indicators proposed initially were to be discussed with the farmers throughout the project to decide on terms significant to them.

- The creation of local research committees for the implementation and follow-up of the prototype.

  Local research committees, or some other form of organisation, were planned in order to respond to specific needs during the project, and to do the follow-up of the prototype. The committees were initially thought of to do on-farm research on the chosen alternatives to a particular problem, the evaluation of the results on the basis of the chosen indicators and pass on their experience to the other members of the community. Each committee was to consist of two or three farmers interested in the research on the chosen techniques, a producer or technician with the abilities and motivation to communicate, and finally one or two farmers as observers, based on the local agricultural research committee method developed at the CIAT (Ashby et al., 1997). The committees were to represent different neighbourhoods of the community and meet with the support group to define the formation and activities.

Activity 2: Implementation, monitoring and adaptation of the prototype

- Selection of farms where the different techniques of the preliminary prototype would be tried out. In this activity, the members of the committees were to begin the implementation of the prototype. Support was to be provided for research in 10 plots of $1000m^2$ each, without excluding the possibility that there be a higher number of farmers involved or larger areas per farmer.

- Monitoring and support to the farmers during conversion. The project team as support group was to visit each farm twice a month in the first six months and once a month thereafter.

- Implementation evaluation by the committees and the project team. A workshop was planned for every six months. The farmers and extension workers of the committees were to evaluate the situation of each farm on the basis of the selected indicators, and compare it with the initial state. The results were then to be shared with the rest of the community. These evaluations were to serve to make the appropriate adjustments that would eventually lead to the final prototype. Furthermore, the discussions were to remain open with the committees during the farm visits through the use of the on-farm evaluation method according to Maître and León (1996).

Activity 3: Dissemination and socialisation of the prototype

These activities were to be implemented among the members of the community of Cota, as well as the technicians and officials of the municipality.

- Workshops for the training of extension workers in the area of sustainable agriculture. The people selected as extension workers were to participate in a workshop in which they were to share tools and strategies to facilitate interaction with the rest of the community, and thereby transmit effectively the objectives, strategies and results of the prototype.

- Workshops for project self-evaluation and the design of the final prototype. This was to involve a process of reflection and discussion on the results of the project. It was hoped that a high level of feedback would occur among the committees, the extension workers, the representatives of the UMATA[2], the co-operatives and the support group. This self-evaluation process was to be undertaken twice within the project period.

[2] UMATA: Unidad Municipal de Asistencia Técnica Agropecuaria, or municipal agricultural extension unit. By law, each municipality must have one. It depends directly of the mayor's office and is in charge of technology transfer to small farmers.

- Open house at the end of the project to share the results and experiences.
  All project participants would be invited, including the members of the co-operatives and the farmer association and the Rural Women's Association, interested farmers and technicians of the municipality, as well as farmers and technicians from the surrounding municipalities of the departments of Cundinamarca and Boyacá. Copies of the resulting manual on how to convert farms to sustainable production would be distributed to the assistants and a video will be shown on the implementation of the project.

Activity 4: Market development

Farmers tend to decide on which crop to seed based on the market at the time of seeding, and not on what it is likely to be at time of harvest. This leads to great uncertainty for both producers and buyers as well instability of farmer income. Any attempt at stabilising this situation should therefore include such as aspects as market studies and consumer desires or trends. The following activities were proposed:

- Workshops for the definition of strategies and agreement on what action to take to improve marketing: agreement was to be reached on the current state of vegetable marketing, the general demand for vegetable products and in particular the demand for ecological products, product availability, and potential new markets. Strategies would be defined on how to reach the new markets, including the requirements on how to obtain the 'green' label.

  Some alternatives to be discussed with the community were market diversification through a 'green route' which tourists could follow to learn about ecological production and purchase 'green' vegetables and other products (milk, cheese) on the spot; the implementation of closed markets between producers and buyers, or the acquisition of a locale in the city, all of which avoid the middleman.

- Training in the areas of post harvest technology and marketing as well as organisational strengthening was also provided.

Although this original methodology for the design and implementation of the farm conversion process based on prototyping provided a useful starting point, serious adaptations were required following the participatory diagnosis and subsequent monitoring of progress. These will be discussed in Chapter 5 after describing the participatory diagnosis and prioritisation with the farmers. Implications for the design of replications will be discussed in the final chapter.

2.3 Research methodology

Having read the previous two sections on theoretical background for both the research activities and the design of the learning pathway through which the conversion process was designed and implemented, the reader can well imagine that the research methodology used here does not follow the traditional experimental design approach. In effect, a case study approach is used. This is not unusual. The Department for Research on Agrarian Systems (SAD) of the National Institute for Agronomic Research (INRA) in France, for example, uses observation, case studies, participatory approaches and modelling to study the practices and processes of development. In that country, a systems approach to farming has prevailed throughout history (from the 16th century) instead of developing the linear approach common to most other research and education systems around the world (Bonnemaire et al., 2000).

As a form of qualitative research, case studies allow for the inclusion of the 'constraints of the everyday social world ' (Denzin and Lincoln, 1994) which cannot be separated from the research initiative, and even less so under the conditions of small farmer development in Third World countries. As Patton (1990) summarises, systems theory is based on both qualitative and quantitative forms of inquiry: direct observation, informal interviews, naturalistic field work and inductive analysis; it is sensitive to context, interactive, dynamic and process-oriented, situationally responsive and adaptive.

Patton (1990) also observes that qualitative methods are appropriate to use when the study is about *how* something happens (process) rather than on the outcomes or results obtained (in this case, both aspects are discussed). He also recommends them when individualised outcomes are under evaluation (this links back to the consideration of the individuals as participants contributing their own reality to the development process), which allows for diversity of outcomes. He considers case study approaches particularly useful when the program under evaluation is individualised, a systems approach to learning is employed and the programme is process-oriented. He points out that the case study is a method which value is recognized for example by the World Bank and USAid, where quantitative and qualitative data are combined. Patton goes on:

> *"If program implementation is characterised by a process of adaptation to local conditions, needs, and interests, then the methods used to study implementation must be open-ended, discovery-oriented, and capable of describing developmental*

processes and program changes. Qualitative methods are ideally suited to the task of describing such program implementation".

A final situation suited to qualitative study is that of documenting development over time. Here Patton says that because the pre/post test method suggests linear, upward growth and development, it is not the most appropriate for process –oriented approaches of facilitating change. It does not tell you how the results were obtained. Development is not linear. Qualitative methods help to capture developmental dynamics.

Agricultural research must be responsive to societal demands in reference to current relevance of current forms of research (Alrøe and Kristensen, 2002). Reductionist methods may serve to answer specific punctual problems but in the context of complexity, and where society now asks that producers be responsible for their effects on the environment, an approach that allows for such complexity must be used. The systems approach is precisely that. And as Patton mentions (above), the case study is particularly useful to analyse systems. Here the case study is a development project aimed at far conversion in which the researcher herself was heavily involved.

The hard science view that researchers must be detached observers of the object of their study and not get involved, is blind to the fact that research in fact has an effect on what it studies: it is systemic (Alrøe and Kristensen, 2002). These authors continue in their analysis by stating that researchers must therefore acknowledge that fact so as to be able to recognise when they are acting on the object of study (they are actors or insiders), and when it is time that they step out mentally to look at what has happened and analyse the effects of their actions (the researcher becomes observer or outsider). They observe that,

"Taking an outside viewpoint is the hallmark of science and also an indispensable part of systemic research. The outside viewpoint first of all detaches the interests and goals of the observer from the dynamics of the system. Moving from an inside to an outside view in systemic research, approaching the position of 'objective' observer, therefore allows for a distinction between dependent and independent dynamics in the learning process. The observed system dynamics are henceforth uninfluenced by the observer's intentions, and this allows the observer to learn about the independent dynamics of the system. But given the self-reflexive circle of learning, the outside or 'objective' stance always rests on a specific inside point of departure – it is not the privileged, detached, value-free, Archimedean point of observation that is entailed in the conventional criterion, or ideal, of objectivity".

Hence the involvement of the researcher in the research activity is used explicitly to gain greater insights. But it requires detachment and 'alienation' to be able to step back and pull out lessons in a credible and trustworthy manner. In the present case, as researcher I moved between participant observation and objective observation, according to the moment. As facilitator of the conversion process, participant observation was used to monitor progress and change. Then I had to step out mentally, as objective observer to be able to analyse what was happening. For this, I used a variety of methods. Sometimes I used information about farmers (farm level) to provide combined view of the whole project (project level). In that sense, the farmers were my unit of observation, but the project was the unit of analysis. Through participatory observation, I worked intensively with the farmers, keeping records of daily progress. I kept detailed notes which I later used for analysis when looking back at what happened. Outside specialists in specific topics were brought in periodically to triangulate my observations. Comparisons were also made through the literature with other experiences. Other methods used in the case study include: quantitative farm level information to assess progress of the farmers in terms of farm 'sustainability', original biological observations of insects in native vegetation for the live fences work, and on-farm agricultural research and testing, applying and adapting various agricultural techniques and procedures on small farms with farmers, and helping the farmers to draw conclusions from these experiments. This entire reflexive process was guided here by the overall design of the conversion process, which itself was emergent, evolving, farmer-led and designed on the basis of what worked from the farmers' point of view. The case study is used in fact to provide insights into the nature of agricultural development research for which the conversion process evolved a new design.

Here we propose to try to address these issues precisely: the case study here is inserted within a research structure that will allow for the analysis of what happens because of the intervention (figure 2.6). The case study approach to the research study proposed here thus justified, the specific integration of the case study will now be graphically explained.

As drawn earlier (figure 2.5), the case study will in fact play out the four phases of the learning process the farmers will go through in the conversion of their farm to more sustainable practices. The chapters described earlier will therefore fit as follows into that scheme.

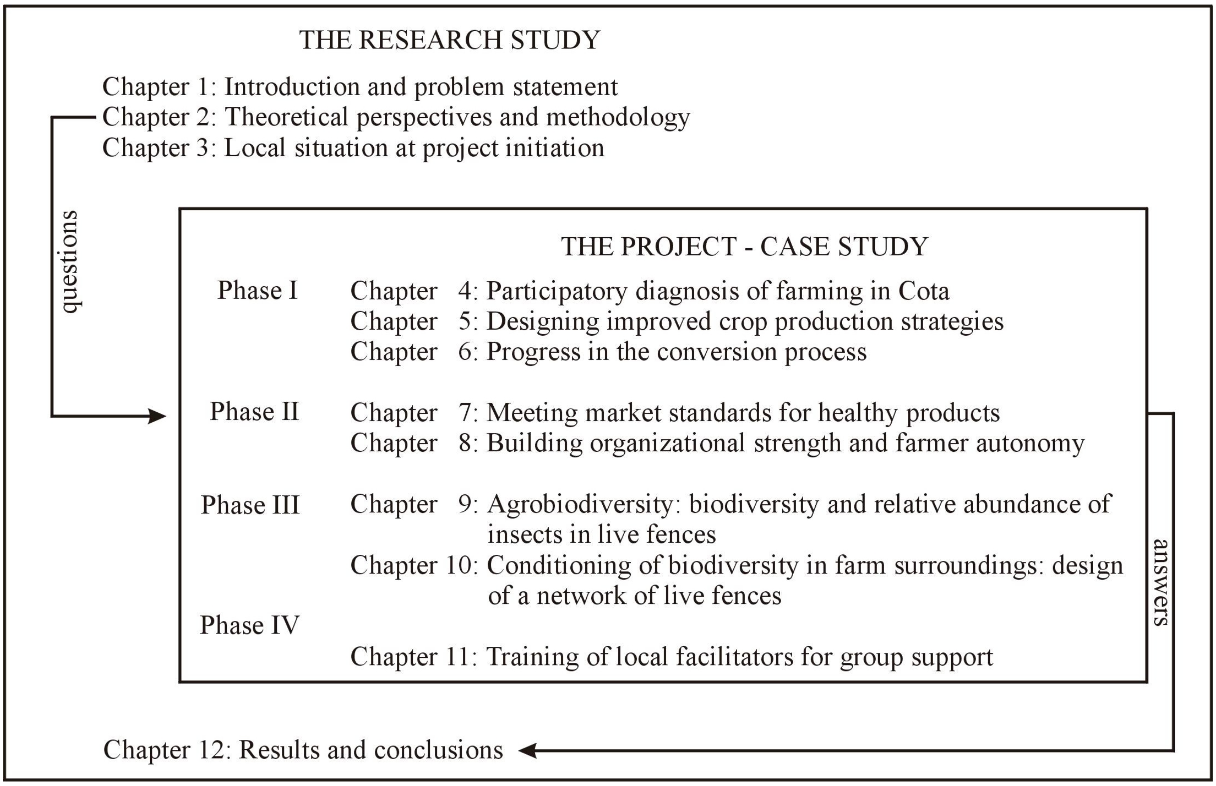

Figure 2.6 Detailed view of how the research pathway feeds into the farmers' learning pathway. The questions posed in the research study are played out in the case study, which in turn provides answers in the final chapter. The results of both farmer learning and research processes have implications for research on agricultural development research.

Chapter 3 - Local situation at project initiation

This chapter describes the context in which both the research and the project case study were developed. An understanding of this context is essential to ensure that both research and project are grounded in the reality of the people whose lives are supposed to be affected by the intervention. The information provided in this chapter was collected prior to project implementation and was in fact used in the proposal for financial support. In that sense, this chapter contextualises the development activities and establishes the conditions within which the project must work.

3.1 Problem context

Prior to my involvement in Cota, a Municipal Development Plan - PDM (Concejo Municipal de Cota, 1998) and the Municipal Programme for Agriculture and Animal Husbandry - PAM (Luna, 1998), had been developed through consultations in popular assemblies and working groups with the community, organisations, institutions and offices of the municipal administration, a practice that all Colombian municipalities were expected to implement. Through this exercise, the following problems in the agricultural and related environmental sectors were identified:

- monoculture with high production costs and low profitability,
- existence of middlemen, who buy from the farmers at low prices and resell with large margins,
- restricted access to market channels,
- unemployment,

- lack of income from tourism and trade,
- lack of support for small and family enterprise,
- lack of environmental and agricultural technical abilities and knowledge including aspects of biodiversity and alternatives to commercial inputs,
- lack of equipment and knowledge of land preparation,
- water and soil pollution through the application of agro-chemicals,
- inability to diagnose oncoming frosts and sudden climatic changes,
- lack of technical assistance in the municipal plant nursery and generally in production of good quality vegetables,
- problems of environmental degradation, and
- lack of knowledge on recycling.

From this list, the inhabitants of the municipality identified specific problems for each area in 1998, again through the PDM and PAM. Those particularly relevant to this study are detailed here:

- Excessive land preparation

  This is done by rotary cultivator, among other implements, resulting in the loss of structural stability of the soil, which acquires a powdery appearance, as well as in reduced water conduction in the soil profile, problems in aeration and hardening.

- High input dependence, especially pesticides

  Traditionally agro-chemicals (synthetically made herbicides, fungicides, insecticides and fertilisers) tend to be used in large quantities. According to the municipal agricultural extension unit - UMATA, their excessive use is considered to be the main cause for induced resistance in pests, for soil, surface and underground water pollution, and for a large part of the costs of production (approximately 50%). Nationally, three million litres of chemical products were used in the agriculture sector during the period from 1993 to 1999, of which 80% were of toxicology categories I and II. This corresponded to costs of US $30 million to the farmers (Yarumo, 2000). Over 11 million kilograms of active ingredient were produced and sold in Colombia in 1997 (see tables A1, A2 and A3 in Appendix 1). An additional problem is that many of the pesticides are currently not registered for use in vegetable production. Although these figures include products used in extensive farming, such as cotton and coffee, they do reflect the general attitude towards pesticides as quick fixes, and a lack of integrated pest and disease management.

Organic fertilisers are misused. Chicken manure is traditionally used as such a source, applied annually at an average rate of 6 tonnes per hectare (Luís Alberto Cano, UMATA Cota, 2002, pers. comm.). However, as it is not applied according to soil analyses and recommendations, this has been shown to lead to nutritional imbalances in the soil and in the plants over time, applied according to soil analyses and recommendations. In fact, soil samples taken from farmers' fields in Cota in 1998 and analysed by the soil analysis laboratory at the University of Bogotá Jorge Tadeo Lozano Horticulture Research Centre have shown that 95% of the samples have excessive amounts of nitrogen and phosphorus and that 75% have high to excessive amounts of potassium. Most of the samples showed deficiencies in trace elements. Other problems associated with fresh chicken manure are high salt levels and the presence of antibiotics, and that when it heats up it dislodges oxygen from the soil.

Use of water for irrigation is typically in excess of crop requirements as watering is done by routine or by visual observation and left on until the crop is virtually inundated. This has effects on the costs of production due to the energy used and the cost to the environment because of the inefficient use of a scarce resource. Furthermore phytosanitary problems, already existent due to high relative humidity levels at night, may increase even more (Goewie and Duqqah, 2002).

- Low product quality

  The farmers' lack of knowledge on pests and diseases leads to the misuse of pesticides and poor levels of control. It is difficult to produce large quantities of quality vegetables.

- Poor market intelligence

  Farmers tend to decide on which crop to seed based on the market at the time of seeding, and not on what it is likely to be at time of harvest. This leads to great uncertainty regarding product availability for both farmers and buyers, as well instability of farmer income.

- Poor management in marketing

  Regarding marketing infrastructure, the municipality does not have a receiving centre as such. The town has a market place, open Sundays only. Two horticulture cooperatives emerged in the late 1990s (CoopHortiCota and Coomagro). The membership of these cooperatives, whose main function is the marketing of produce, represents 20% of the municipality's vegetable growers. In 2000, AsodeCota, the Association of Business

> Farmers of Cota, was formed but started to commercialise only in late 2001. The principal market is Corabastos, a 70 hectare food market in Bogotá through which 85% of the vegetables produced in the department of Cundinamarca is sold (see Chapter 7 for more on marketing aspects). Prices are subject to supply and demand and can vary drastically from day to day. The remaining 15% of the produce makes its way to supermarket chain stores.
>
> The low product quality, lack of market intelligence and knowledge of few locations to sell their produce reduce the farmers' ability to negotiate reasonable prices. Furthermore, low product quality and the lack of continuity in product availability make the farmers unreliable from the buyers' point of view. Farmer profits therefore are low, especially since the real price to the farmer has decreased from year to year because of inflation rates.

The information thus collected in the PDM on the municipal diagnosis of the local agricultural sector also provided the groundwork for the preparation of the municipal Plan for Territorial Organization (Plan de Ordenamiento Territorial – POT). The POT is a state policy and planning instrument that orients the process of occupation, utilisation and transformation of the territory for a nine-year period. It expresses and spatially projects the policies and environmental, social and economical development objectives of a society, while guaranteeing an adequate level of quality of life to the people and conserving the environment. It is a process of collective construction through which the human settlements, the socio-economic activities and the physical infrastructure are located and assigned space in such a way as to preserve the natural resources and environment, improving the quality of life of the inhabitants, under the premises of sustainable development (Andrade 1994, quoted in Alcaldía Popular de Cota, 2000). In Cota, it has been developed over three years with the population in order to include their expectations regarding development of the Municipality in the short and medium term, taking into account equity, sustainability and competitiveness.

Municipal solutions

Among the solutions proposed in the PDM and the PAM are: better technical assistance leading to ecologically sustainable production, support for the small agricultural enterprises (which corroborates the experience of the Agricultural Development Institute, INDAP, in Chile, and is contrary to most agricultural strategies that are oriented toward large farmers), a training and extension programme for environmentally friendly and economically profitable production techniques, and the recovery of water sheds and protective zones. Of these solutions, those also mentioned by the farmers in the participatory diagnosis (Chapter 4) are addressed in the present project.

Such therefore was the situation encountered in the municipality at the onset of the project. The beginnings of an awareness existed as to the urgency to do something about the negative effects of agriculture on human and environmental health. However, practical knowledge on technical aspects and methodologies for change was unavailable, even if, as we shall see in the next section, there was a growing interest in the country for products obtained through sustainable production practices.

3.2 Potential for sustainable products in Colombia?

Ecological agriculture in Colombia is not yet as well established as it is in Europe or North America. As being able to sell the end product is obviously crucial to success, the reader might well question how ready this country is for the integrated and ecologically grown products that will be a result of all this effort. Projects currently underway in various areas of the Colombian agricultural sector show that the potential does exist. Three examples are provided here.

3.2.1 Florverde

The Colombian floriculture sector exports about US$ 600 million a year, and provides around 75,000 direct jobs and 70,000 indirect jobs on a surface area of just over 5,000 hectares. Colombia is the second world exporter of flowers, with 12% of the market, after The Netherlands which provides 58% (Asocolflores, 2001). In 1996, the Colombian Association of Flower Exporters, Asocolflores, created Florverde as a management tool to help the flower growers work toward sustainable development. They defined sustainable development as 'social responsibility and environmentally friendly production, coupled with productivity and profitability' (ibid.). They base the program on cleaner production (less water, less energy and fewer toxic inputs), continuous improvement, measuring and recording and benchmarking (comparing themselves to other farms in the program). The principles behind Good Agricultural Practices as well as ISO 14000 and other international agreements are the basis for this program. Participation is highly encouraged among the members of Asocolflores; however, it is voluntary and does not lead to any kind of certification of the farms nor are the results made public.

From 1996 to 2001, the number of farms participating went from the 28 pilot farms to 143, of the total of 220 members of Asocolflores. Results include the development of personal and family growth programmes; strict compliance of labour legislation and conditions; improved occupational health management; significant reduction in the amount of active ingredient used per farm (in 1998, the 126 participating farms used an average of 155 kg of active ingredient per hectare per year, whereas in 2001, that amount decreased to 115 kg average among the 143 participating farms); recycling of residues; use of fertilisers and organic amendments on the basis of soil analyses; soil preparation and irrigation according to soil properties; use of rain water for irrigation to satisfy 75% of the requirements; and training and monitoring of the farms by a specialist group on all aspects of the program. Asocolflores itself has benefited from the programme through institutional strengthening due to its leadership in the programme, the improved communication achieved between it and the growers as well as among the growers, and to the fact that Asocolflores now has a practical idea of the performance of its membership. The quality of the programme has been recognised nationally and internationally by being replicated in the Colombian banana production sector as well as by the Ecuadorian flower growers.

3.2.2 IPM in coffee[5]

Soon after the traditionally shade coffee plants were replaced by the more productive *caturra* type throughout all of the coffee growing areas of Colombia, the incidence of pests and diseases rose dramatically. The situation went from an ecosystem friendly production system where the coffee coexisted with orchids, banana trees and other trees that offered shade, to a situation where the shade trees were torn down and high amounts of fertiliser and water were required to meet the productivity expectations. The coffee berry borer, *Hypothenemus hampei* (Ferrari), previously not a problem, became such a limitation to production that the Coffee Growers' Federation set up a research programme which studied possibilities of control which ranged from genetic engineering to resistant plant species, including work at Cornell University that sought to introduce *Bacillus thuringiensis* into coffee plants. Other integrated control methods included the 're-re' (which is the time and labour consuming collection and removal of mature, over-mature and dry coffee beans which are the most susceptible to infestation), the application of entomopathogenic fungi (which are highly dependent on optimal climatic conditions) and the introduction of two parasitic wasps, *Prorops nasuta* and *Cephalonomia stephanoderis*. These wasps did not prove to be very efficient in their control and current research is centred on the parasitoid *Phymastichus coffea* La Salle (Gutierrez et al., 1998). Although the root of the problem has not been acknowledged, this experience does show the tendency at national levels to include more natural forms of control in crop management strategies.

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[5] I am grateful to my colleague Dr. José Ricardo Cure for his insights on the state of the art of biological control in coffee in Colombia.

3.2.3 Ecosecha®

A small number of vegetable farmers in the Bogotá Plateau had been producing ecologically on their own with great difficulty. They could not afford the high costs of certification, and so they were unable to advertise themselves as ecological. They were also a lot better at producing than at selling. Through the leadership of the Sustainable Agriculture Programme at the Horticulture Research Centre (CIAA) of the University of Bogotá Jorge Tadeo Lozano (Appendix 2), these farmers joined as a non-formal farmers association in August 2000. With the technical support of the CIAA, the group received ecological certification as a production system rather than farm by farm, thereby reducing the cost per producer to a tenth. The first six farmers included were those who could show that they had been producing ecologically for the last several years. Gradually thereafter, the other farmers joined as their official period of transition was accomplished. By the end of 2001, 18 farmers were included in the system mainly from the high Andean zone, but also from more temperate areas, and a total of 35 different fruits and vegetables were offered. The demand-based production is marketed through the CIAA under the University-registered brand name Ecosecha®, exclusively to local supermarket chains. As a result of this trial on group certification, the certifying body, CCI (see section 7.1.2 for more on certification) has been promoting this mechanism around the country. Group certification has been growing world wide, to the point where meetings have been held to organise internationally accepted protocols (Schoenmakers and Augstburger, 2001).

3.3 Country description

3.3.1 Geography

Colombia covers a surface area of 1,141,746 km^2, is surrounded by Panama, Venezuela, Brazil, Peru and Ecuador, and has access to both the Caribbean and the Pacific seas. It is made up of 32 departments, one capital district and three special districts. There are 1050 municipalities.

The population of Colombia is approximately 42.5 million (World Bank Group, 2002) of which nearly 6.4 million live in Bogotá, the capital (DANE, 2001). The rural population makes up 29% of the total. The World Bank (World Bank Group, 2002) describes Colombia has having a solid growth for the past forty years of about 4.5 percent a year. Population growth has decreased to 1.8 percent per year and life expectancy at birth is currently at 70 years, compared with 59 years in 1965. Both enrolment at primary school level and the literacy rate were nearly 90 percent in 1990. However, although the number of Colombians living below a commonly accepted subsistence level has decreased significantly over the past decades (from 50% in 1964 to 19% in 1992), poverty is still a problem. Three out of four of these poor live in rural areas. The country's macro-economic policies have not helped. As in many other countries (Stiglitz, 1999; Barkin, 2001), in 1990, the Colombian government opened what was considered by many an unprepared country, particularly in the agricultural sector, to globalised trade. The struggle for survival has been unending since then. The economic recession of the last few years has not made things any easier.

The Andean region and the department of Cundinamarca

The Andean region extends along the Andes mountain range, which covers the centre of the country North-South, and is made up of three chains (Eastern, Central and Western), and the Magdalena and Cauca river valleys. This altitudinal diversity is what gives the country the possibility of such diversity in agricultural production, since the climate varies from very hot on the coastal areas, through gradually more cool areas to the cold mountains. The Eastern sub region is located between the highlands of the departments of Cundinamarca and Boyacá, and is known for its varied agricultural production and industrial activities.

The municipality in which the study was undertaken, Cota, is located in the Department of Cundinamarca, in the Andean region. Because of its closeness to Bogotá, Cundinamarca is often blended in with the city, both politically and historically.

Cundinamarca was the name first given to the country as a whole. In fact, it was the name used by the original people when referring to the area East of the mountain chains (cordillera), and has been interpreted to mean 'those heights where the condor flies' and 'the place the God Cun comes from'. The name was maintained during the *Gran Colombia* empire (1819 to 1831). It was used in various ways from then on until 1886, when it was revived as the Department of Cundinamarca (Velandia, 1971).

Due to a relatively good level of social infrastructure and no serious deficiencies where public services, education and health are concerned as compared to the rest of the country, this department has been described as having a high standard of living. Economically, the department has been categorised as industrialised (Anonymous, 2000). In 1997, 115 municipalities were registered in Cundinamarca, with a population of 1,875,337 disseminated over 22,670 square kilometres of plateau, slopes and plains (DANE, 1997). The Departments of Boyacá, Meta, Tolima, Caldas and Huila surround it. Of the population, 11.2% over five years of age are illiterate, split equally between men and women (DANE, 1996) and 49% have an unsatisfied basic requirement (Anonymous, 2000).

3.3.2 Cota: 'good climate, fertile soil'

It is difficult to pinpoint exact foundation dates for most of the cities and towns of Colombia as there is very little written testimony. The establishment of towns has been divided historically, however, among the following periods: pre-Columbian (e.g. Chía), conquest, colony (e.g. Tabio, Tenjo), independence, republican (including Cota), Twentieth century and unknown (Velandia, 1971). Some are on the original indigenous sites, others sprung up for other reasons such as location of water, evangelism, work, or as stopover points on long journeys.

On the general location of what is now Cota, there was originally a Muisca indigenous settlement. The first Dominican arrived there in 1570, and the first priest in 1680. During the Republic (1829 to 1900), period in which Cota was founded, the law that oversaw the founding of new cities required that they be strategic from a military point of view or help subjugate the indigenous people. Velandia (1971) quotes the historian Alejandro Carranza B.: 'According to the Law of the Indies, a place was chosen for its good climate, fertile soil, abundant source of wood, water and natural pastures'.

The town was first in what is now the rural neighbourhood Pueblo Viejo. According to local oral history (Martin Castañeda, pers. comm., 2001), it was first founded in 1604, founded there again in 1667, then transferred to Tres Esquinas de Cota in 1871 which is the current location, as ratified by the Council in 1873. The reason for the move was to be on the national road which went from Chía to Funza (Velandia, 1971). Farmers in the area also mention flooding of the Bogotá River as being a main reason for the move.

As to how Cota got its name, there are several versions. The first, that as Gonzalo Jiménez de Quesada, the founder of Bogotá, arrived at the settlement, a peaceful attitude was observed among the Muisca, so he took off his coat of mail ('cota de malla' in Spanish) and gave the site the name of La Cota. The second was that epistemologically, Cota in the indigenous language meant CO (support) and TA (cultivation). Finally, oral history has it that the original name was Cauta, meaning 'dispersed', as the houses were spread throughout the area. But Jiménez de Quesada did not like the sound of it so changed it to Cota.

Cota today

Cota is located approximately fourteen kilometres Northwest of Bogotá. It is included in the Western Plateau (Sabana Occidente) geographical province of Cundinamarca.

The population of Cota was estimated at 14,187 for 1998 of which 50% is under 25 years of age and 4% over 64. Just over half of its inhabitants live in rural areas and just under half in urban areas. It can be considered a typical municipality of the Bogotá plateau in that the city is surrounded by many similar vegetable-producing villages and is dependent on them for the supply of cold climate crops. Cota covers 5,344 hectares of which 144 belong to urban areas and 5200 to the rural areas. Of these, 505 ha belong to the Native Reserve (Concejo Municipal de Cota, 1998). About 1500 ha are mountainous and 4200 ha flat lands.

At an average 2600 meters altitude and 4° latitude, the climate in Cota is cold and dry with temperatures ranging from 0.6 to 23°C and an annual average of 13.7 °C. Occasionally there are frosts with temperatures slightly below 0°C, especially in early January. Daily evaporation rates are at an average 3mm. Rainfall is between 800 and 1000 mm a year, typically concentrated in two rainy seasons (October-November and March-April), although in the last few years this has not been quite as predictable due to the influence of El Niño and then La Niña climatic phenomena.

Cota includes flat areas with 0 to 3% slopes, slightly inclined areas (3 to 12% slopes) and mountainous, rugged areas (12 to 50% slopes), including the Reserve. Soil in the foothills is well drained, of low to medium fertility, and suffers some degree of laminar erosion. In the mountainous areas, protective native forests cover the more humid parts and where the soil has built up. In areas with only a superficial layer of soil, vegetation is low-lying. The Chicú and Bogotá Rivers as well as the Hichitá stream go through Cota.

The closeness to Bogotá provides certain benefits, especially in health, higher education and work opportunities. The town has its own water supply from wells in each rural neighbourhood, which will soon be connected to a regional water line. The peak of Majuy at 3050 m and its landscape are a tourist attraction, as are the restaurants and saunas. It is known as an artists' refuge and a stimulator of new young talents especially in music and sports (Alcaldía Popular de Cota, 2000).

Land use

There is competition for land use among flower growers, farming, urbanisation and restaurants catering to Bogotá Sunday tourists. Extensive and semi-extensive animal husbandry can be found in the flat lands. Subsistence cropping is usually found close to the houses. Among the economic activities of Cota, the agricultural sector occupies the highest number of people after services. Vegetable production, floriculture and animal husbandry employ 1214 people, or 38% of the working population, of which 901 are men and 313 women (Concejo Municipal de Cota, 1998).

Most of the municipal territory is rural (97.3%). Of that, 40% is environmentally protected (infiltration and recharging of aquifers) - 1089 ha, integrated management - 139 ha, environmental recuperation and rehabilitation - 9 ha, around rivers and bodies of water - 521 ha, recreation - 124 ha, 20% for agriculture and animal husbandry - 868 ha, 16% for suburban but with a mainly agricultural vocation -675 ha, and urban - 49 ha (Alcaldía de Cota, 2000).

Municipal institutional presence

As in each municipality in Colombia, Cota has an office for local technical support in agriculture and animal husbandry, the Unidad Municipal de Asistencia Técnica Agropecuaria – UMATA. It was well supported by the mayor when this project started. However, elections were held part way through, and although the new mayor declared himself 'friend of the campesino' during the campaign, he has been somewhat ambivalent about it now that he is in power. Added to the fact that disbursements from the central government to the municipalities have been reduced, the UMATA barely has enough budget to pay for personnel. Under the circumstances, it is hardly surprising that the some 400 registered small farmers do not feel that the UMATA provides the technical assistance they require.

Other institutions have also sporadically provided technical assistance, although lack of continuity between projects and efforts has dispersed the results of these interventions. The ICA (Instituto Colombiano Agropecuario) has had researchers there off and on, as well as the SENA, a government subsidised college type educational institution geared toward low income workers.

Other institutions in the municipality, relevant to the project, include:

- Juntas de Acción Comunal – JAC (community action groups): there is one for each rural neighbourhood and the headquarters. The JAC of the Cetime rural neighbourhood was the counterpart required for the presentation of the marketing and postharvest project (see Chapter 7).
- Cabildo Verde or Green Council: generally base their work on small educational projects and occasionally organise a larger event, for example, the Congress on Organic Agriculture in October, 2001.
- Indigenous Community: a group of the elders.

Although these institutions are the strongest, they are still in the process of strengthening.

Other relevant municipal institutions include:

- Municipal Planning Council,
- the Technical Council for the Territorial Organisation Plan (POT),
- the Municipal Planning Board,
- the Municipal Technical Assistance Committee,
- the Municipal Rural Development Council,
- the Municipal Commission for Technology and Agricultural Technical Assistance,
- the Municipal Recreation Committee,
- Municipal Institute for Recreation and Sports,
- Rural and Indigenous Women's Association,
- Youth Organization of Cota.

The municipality is also a member of ASOCENTRO- Asociación de Municipios de Sabana Centro, which brings together eleven towns of the area for regional projects.

The town infrastructure includes a health centre, school health programme, 11 private schools, 11 public schools, social work office and an integral medical centre, homeopathy medical office, and a spa.

Two cooperatives for commercialisation of vegetables existed prior to the initiation of the project. Part way through, representatives of the National Department of Planning came to talk to the farmers to see whether they would be interested in participating as a pilot project within a national scheme called Productive Alliances for Peace. Six or seven such pilot projects were being started up in different parts of the country representing the different sectors (African palm, banana, etc). The government preferred that these pilot projects be located in areas where public order was an issue, thereby providing economic solutions to the well-known obstacles this country has been facing in the last five decades. However, they were lacking one in the vegetable sector, and as Cota is known for its vegetables, it was seen as a viable option despite the fact that the municipality is a relatively peaceful place. The idea was to link the various actors from input providers through the producers to the commercialisers in a win-win situation. Talks began in February 2000, including many of the participants of this project, and by August the farmers had formed an association, which has a format more flexible than that of cooperatives. The Association of Business Farmers of Cota – ASODECOTA- is based on the premise that the farmers will gradually move over to ecological production.

3.3.3 Vegetable production in Cota

Description of the farmers

The research worked with a group of small farmers homogeneous from socio-economic and technological points of view. Vegetable farming in Cota is typically a family business. As found by some psychology students from the Pontificia Javeriana University (Bogotá), the family structure is very much reflected in the hierarchy of the business (Prada, 2001; Oliveros, 2001; Bello, 2001). The father, or in his absence the eldest son, usually is the head of the business. The mother typically looks after orders and sometimes helps out on the farm as well. The sons and sometimes the daughters help out and when required, and it is financially possible, outside labourers are hired.

Description of the farms

It is important here to distinguish among the different farm sizes used to describe Colombian agriculture: small, medium and large. The farm size corresponding to each of these groups varies according to location: where small vegetable farmers in Cota own a maximum of 2.5 has, in the Llanos or prairies, they would own about 12 has. The area is defined as the amount required to make the equivalent of two minimum salaries (approximately U$300.00) a month.

For the purposes of this study, although the information and activities were available to all interested farmers, the project was specifically oriented towards small farmers, as specified in the terms of reference of PRONATTA, who co-financed it.

The majority of landowners in Cota have small plots; 57% own 6.6 % of the area, with less than a hectare each. A further 10.7% have plots between 1 and 3 hectares each, equivalent to 9.4% of the area. Thus, a total of 67.7% of owners has three hectares or less each and represents 16.1% of the area. Most members of the Reserve have family with land in the flat areas. The size of the farms is a reflection of the process of fractioning that has been going on partly due to the demand for land for agricultural use or new homes and partly through inheritances. In the latter case, the divisions may not even be reported and are often of sizes inferior to that allowed by the municipal planning office. Unofficial figures put the number of owners at nearly double of those reported due to this phenomenon (Alcaldía Popular de Cota, 2000).

Vegetable production in Cota was registered predominantly in five rural neighbourhoods: La Moya, El Abra, Cetime, Pueblo Viejo and El Rozo. These are differentiated by their geographical location within the municipality, as well as soil types and the source of water for irrigation.

Vegetable production represents approximately 10% of the agricultural area (300 of the 3,271 hectares) in Cota. The principal crops are spinach (31% of the area in vegetables), coriander (20%), cauliflower (10%), beets (6.6%), Swiss chard (3.65%), lettuce (2.6%), and other crops (25.2%) such as broccoli and celery.

Crops can be grown year-round, the only climatic limitation (frosts) occurring typically around New Year. Thus the farmers can get in 2 to 3 crops per year in the case of longer cycle crops such as beets, carrots, corn or potatoes. By growing short cycle crops, the farmer can get in 3 to 4 crops a year, depending on how well s/he manages time for land preparation between crops and whether s/he uses direct seeding or plugs.

Generally, the small farmers have more than one crop at a time, planted at different intervals. However, the one crop is usually seeded all at once. This makes it easier for land preparation since most of them must hire in a tractor. Crop maintenance and buying the necessary inputs are simplified as well: it's all done at the same time. Harvesting in the case of selling in the food terminal is also easier, as the displacement is not justified for small quantities (they still have to send an entire truck). However, they are also negatively affected when the prices for the particular product go down since they usually cannot wait too long to harvest once the crop is ready. They are market –dependent farmers that sell all their produce.

Just recently, plugs have gradually replaced seeding where the crop justifies it (lettuce, broccoli, etc.). The plug business in Colombia is barely ten years old. However, by the end of 2001, at least seven large plug producers existed, as well as many small ones.

As mentioned in section 3.1, there is a high dependence on external inputs. Furthermore, local stores do not carry inputs that do not have regular demand such as those of organic, biological or botanical sources.

Most farmers have access to some form of water source for irrigation: drill, wells, streams and in extreme cases, the Bogotá River, one of the most polluted in the world. However, in dry periods, these sources slow up, making farming more difficult. There is currently no system for capturing rainwater or watershed water. Previously, the latter was possible because of the ditches that ran throughout the municipality, capturing the rainwater off the mountain. With time, these have been filled up to widen roads or the neighbouring fields. An additional problem that came up late in 2001 was the fact that the regional environmental authority required all methods of water extraction be registered. Each farmer has their own source of water, be it a drill, a well, or a spring, from which they extract water with their own pump with the obvious costs of gasoline, oil and maintenance. Although the registration itself of the water source had no cost, the implication is that in the future, they will be required to pay for the actual water, further increasing the costs of production.

Description of conventional farming methods

Soil preparation consists of a first pass with a disc plough and harrow, then with the rotary cultivator. The farmers have access to three tractors on a rented basis. A fourth one was acquired late 2000 by the mayor's office through a donation from the departmental government. The low number of tractors available means that at times the waiting list can be a few weeks. Sharing tractors in such a fashion can also bring other problems, such as possibly spreading diseases, eg. club root of Brassicacea (*Plasmodiophora brassicae*) which is just beginning to become a problem in Cota.

Typically fertilisation is done with fresh chicken manure (twice a year or after three crop cycles) and occasionally with triple 18 or triple 15, and some phosphate and nitrogen complexes. These are applied without prior soil analyses 15 days before seeding.

Where crop protection is concerned, weed control is done by hand when there is a crop in or with herbicides such as atrazine (toxic level III) where compatible, for example in coriander and parsley crops. Glyphosate is used between crops to 'dry up' the remains of the previous crop. The main diseases for which control is required are anthracnose, powdery mildew, and those caused by *Alternaria* and *Fusarium*. Where insect management is concerned, prevention is not practised. The main problem is leaf miner which is controlled through the use of yellow sticky traps made available through the UMATA and commercial insecticides (See Appendix 4 for full list of pests and diseases according to crop).

Crops are harvested on average within 60 days, by hand, with a productivity of 30-40%.

3.4 Conclusion

This chapter concludes the general section that precedes the actual design and implementation of the case study project, which brings forth the farmer learning pathway that took the Cota vegetable farmers to greater technical success (Phase I), better organisation (Phase II), to sustainability on a larger scale (Phase III) and to greater autonomy (Phase IV).

PHASE I: Improving farmer production at crop level

Before intervention in the municipality of Cota, the farmers had identified a series of problems for which they could see no obvious solution at their level. They were in a state of indifference, linked to the feeling of being unable to do anything about their situation of ‘I am poor and I am dependent’. As subsistence farmers, their attitude was one of short-term oriented farm management.

As a first step out of this negative situation, meetings were held at farms in the different rural neighbourhoods to:

- Develop an inventory of problems and problem analysis
- Identify possible solutions
- Design the methodology for farm conversion
- Begin the creation of a platform for learning

On the basis of these exercises, a participatory diagnosis of the initial situation led to the participatory design of a methodology for conversion to sustainable farm management and, as this was implemented, participatory monitoring and evaluation of the improved farms.

Chapter 4 – Participatory diagnosis of farming in Cota

A first set of meetings was set up in each of the five horticultural rural neighbourhoods to take into account geographical differences and ensure ease of access by the farmers. Farmers were invited to participate through advertising by locating small posters strategically throughout the municipality, including notes in the two-page weekly municipal paper, personal invitations and circulation of a car with loud speakers. Often if the farmers do not get a personal written invitation, they do not feel addressed even if they have participated in related events previously. Until a certain level of momentum (or individual motivation to participate) was built up, this was a limitation to attracting large groups to the activities. This limitation was particularly felt where small farmers were concerned, as they especially have felt left out in the past and overcoming that barrier was one crucial aspect to the success of this project. Medium and large farmers occasionally also participated: they could attend the workshops but due to the guidelines set out by PRONATTA, could not be recipient of the team members' time on an individual basis.

The objectives of the first meetings were the introduction of the facilitators and the project as presented to PRONATTA, the construction with the farmers of a knowledge linkage map, a diagnosis of the current situation to verify and update the information collected for the PDM, prioritisation of the problems and a discussion of possible solutions.

4.1 The information linkage map

The methodology used was taken from experiences described by FAO (1995) and Ramirez (1997), based on the methods of rapid appraisal of agricultural knowledge systems (Engel and Salomon, 1994). The linkage map shows all the actors involved in an agricultural knowledge system and relationships between them and the farmers. In this case, the specific interest was where the farmers got information on new seeds, techniques, markets, and pest and disease management methods. The facilitator then brought the comments from the five rural neighbourhoods together by drawing a diagramme dividing the different sources of information according to location: rural neighbourhood, municipality or regional/national. Full lines were used when the link was considered strong by the farmers and a dotted line when weak (figure 4.1). The different people or institutions that provide information are considered actors and the synergy among them can lead to innovation. By promoting interaction among the actors, they can begin to see themselves as forming a knowledge system, from which innovation is an emergent property. The change to sustainable agriculture is a complex learning process that will require changes among all actors of the system (Röling and Jiggins, 1998). Actors within an agriculture knowledge system who go through this process are moving towards forming an ecological knowledge system. In this case, actors were divided into three groups according to their geographical influence: rural neighbourhood (elders, neighbouring farmers), municipality (local stores, schools, UMATA, marketing cooperatives, etc.) and national (supermarkets, universities, government, food terminal, etc.). The results in figure 4.1 show that farmers are reaching out to a number of different sources information, among which are spouses, neighbours and friends, organisations such as water user associations or commodity associations, and input sales people. Most of the communication channels are considered one-way, towards the farmers. Many of these channels were considered by the farmers to be weak as the information provided was very sporadic and often not updated nor a solution to their problems. The farmers also complained of a lack of continuity in the interventions of entities such as the governmental agricultural research and extension services (ICA and CORPOICA, respectively) despite the fact that personnel was continuously present (some form of identification may have been lacking). On the whole, access to reliable and continuous forms of information was poor.

4.2 Interactive diagnosis

The technique used in this activity was based on the nominal group technique (Pretty et al., 1995). First, the farmers were asked to list the general problems they had in producing vegetables, orienting them in a preliminary classification by subject area. Those problem areas were then subdivided into specific problems. The problem areas were prioritised, and within each area, so were the specific problems. Solutions were then gathered and categorised according the degree of control the farmers felt they had over each. This technique resembles that of Participatory Rural Assessment (PRA) as described by Etling and Smith (1994). Except for the first activities in which the PRA team works with community representatives instead of the farmer groups directly to determine the problems and opportunities, the remainder of the steps is very similar. The villagers are asked to discuss and rank the problems in a priority list and then the opportunities according to their feasibility and potential effect on the agroecological attributes of stability, equity, productivity and sustainability (Conway, 1985).

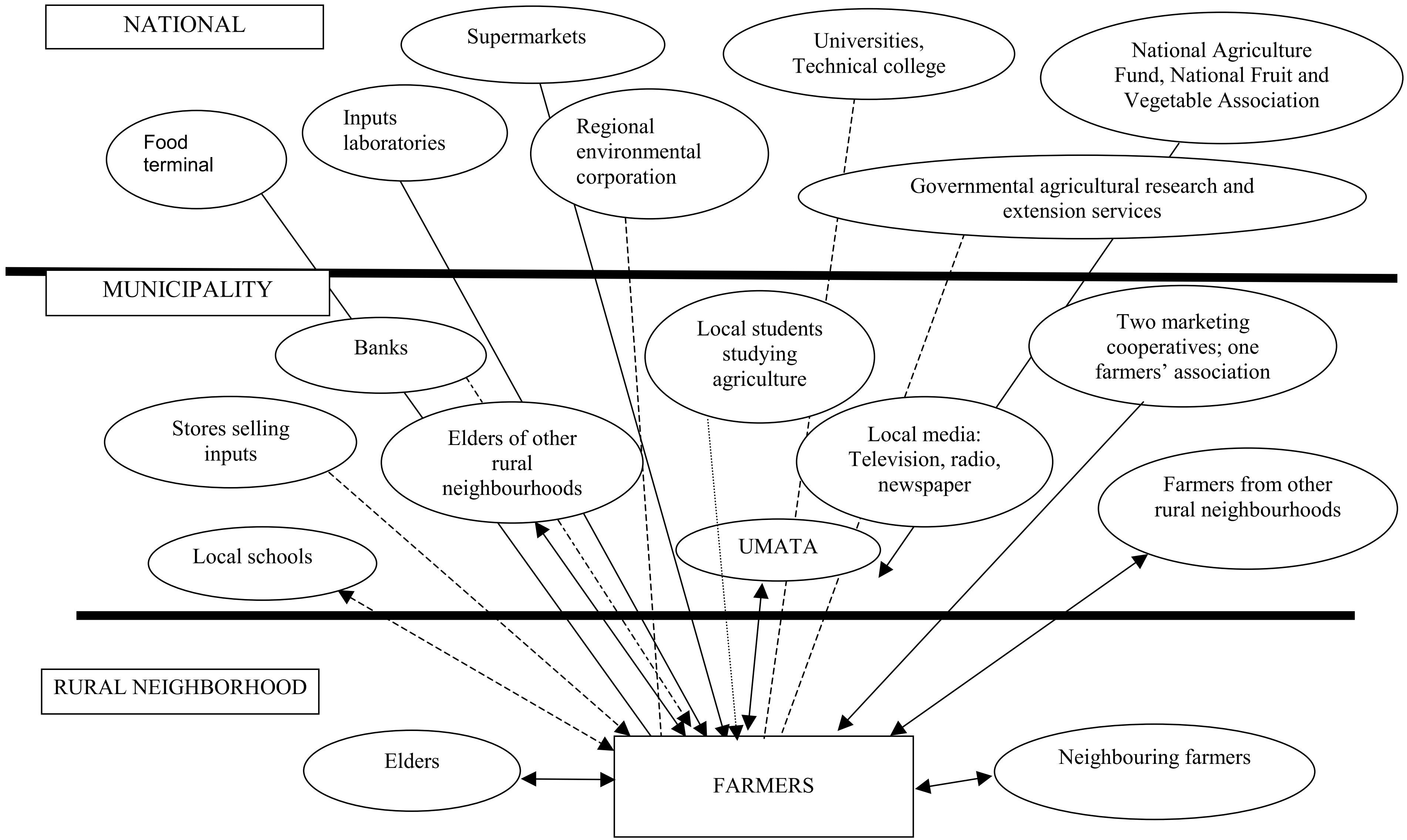

Figure 4.1 Knowledge linkage map of Cota: Knowledge community as perceived by the farmers. The map clearly shows how dependent on others the farmers feel, and that the various institutions do not seem to consider farmers as experience-based knowledge resources.

4.2.1 *Restrictions to production and marketing*

The general situation is one of reduced income due to lower profitability caused by increased pest and disease problems, increased costs for inputs[6], and vegetable prices that have been adjusted below inflation for the last three years. The main priority is therefore to acquire ways that will increase income. The farmers understand that without quality they will have difficulty marketing their produce. They therefore listed restrictions / problems dealing with plants, soil, water, technology, marketing, human resources, political context, and financial/ administrative/ economical aspects (table 4.1). The groups prioritised the restrictions differently, with the main variation being the position of marketing. For example, most groups prioritised according to the order in which they would be confronted with a problem throughout the production process: soil, water (abiotic environment), crops, market (food supply), technology, financial/administrative and finally the political context, where one particular group put marketing as number one.

4.2.2 *Solutions proposed by the farmers*

A brainstorming exercise followed to list possible solutions for each of the restrictions mentioned. These solutions, also provided in table 4.1, reflect the changes the producers feel are required to reach their 'ideal' farm and show that they recognise that they lack information in order to improve on the management of their farms. This is particularly interesting as it reinforces the results obtained in the information linkage map: the provision of information is very one-sided, and dependent on the information which the different entities decide to impart. According to the farmers, most restrictions must begin to be overcome with some form of training first. Then practical alternatives to become more sustainable can be introduced.

4.2.3 *Discussion of the results*

Röling mentions that 'Effective collective action … often requires considerable attention to creating a common perspective on problems, diagnosis and possible solutions' (in Leeuwis, 1999b). He asks whether a group of stakeholders can 'learn to act as a cognitive system in the sense that they share perceptions, intentions and agree to engage in collective or concerted action', and what the institutional implications for that would be. Answers to those questions, he points out, are fundamental to adaptive management of complex ecosystems at any level.

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[6] Many of the inputs are either imported or dependent on imported primary materials for their fabrication. Prices are based on the US dollar and therefore have increased constantly with the devaluation of the Colombian peso.

Table 4.1 Farmer identification of restrictions to production and marketing and their solutions. The items are listed in order of prioritisation by the farmers.

Item	**Description according to farmers' brainstorming exercise**	**Solution**
Soil	Lack of soil analyses and fertilisation recommendations	Training Technical support of the Umata Soil analyses Alternative fertilisers, including home preparation
	Lack of soil structure ('floury' appearance); compaction; no life in the soil	Training on how to use appropriate machinery, minimum tillage, management criteria Availability of machinery Organic fertilisation
Water	Lack of water in dry periods – few reservoirs	Dig reservoirs; build a rain water capture and distribution system Live fences as windbreaks, to reduce evaporation
	Quality not measured	Water analyses: physical, chemical, biological
	How to measure soil humidity; appropriate watering system	Training
Crops	Lack of knowledge of new varieties	Workshop on varieties Farm trials
	Indiscriminate use of pesticides; lack of information on integrated pest and disease management	Training on: pest, disease and beneficial insects identification, alternative products (allelopathy, botanicals), product compatibility and pesticide safety
	Weeds	Look for alternatives to herbicides
	Availability of seed not continuous	Contact company representatives
Marketing	No programming of crops according to demand	Get organised: at the municipal level – product availability vs demand (consult UMATA, supermarkets) at farm level – scale products, diversify
	Inadequate presentation – no value added	Look for technological options (dehydration) Training in post-harvest techniques, including packaging Increase quality
	Markets not diversified	Diversify to reduce dependence on the food terminal. Consult SIPSA (Information system on prices and volumes traded), National Agricultural Stock market
Technology and Technical assistance	Little technical assistance, extension by the Umata	Farmers to provide feedback on current technical assistance Prioritise assistance according to needs and available resources Contract consultants in groups, or through cooperatives. Also depends on the active involvement of the farmers. Combine farmers' and technicians' knowledge.

Table 4.1 (continued)

	No generation of nor access to basic climate information.	Informative fact sheets Community videos Local radio station
	Difficult to access appropriate equipment for land preparation.	Make a formal request to the Ministry of Agriculture which has funds for equipment purchases.
Human resources	Access to training difficult	Request through UMATA and National Fruit and Vegetable Association
	Lack of farmer participation	Share experiences among farmers; work together not against each other; attend meetings and training.
	Health problems due to inadequate pesticide management	Bring in speaker on appropriate application.
Financial and administrative	Ignorance as to whether they are really making money	Training in accounting
	Credit difficult to access	More workshops on credit sources; look for new sources.
	Low profits: high input costs; low product prices	Increase product quality. Farmer association for increased negotiating power.
Political context; insti-tutional support	No continuity in projects / programmes	Citizen watch groups. Support agricultural content in municipal agenda.
	Lack of association or knowledge of those existent	Become involved in the Municipal Rural Development Committee.
	Land planning must slow urban growth	State investment to maintain agricultural sector.

Although not mentioned straight out, social aspects such as health problems related to pesticide applications and consumption of toxic produce, were mentioned particularly from the viewpoint of competitiveness and marketing (the tables in Appendix 1 provide figures on pesticide use in Colombia). Landscaping per se was also not mentioned. However, the use of live fences (fences made with trees and bushes) was suggested among the solutions to cut wind and reduce water evaporation, as was the interest in their use as provider of habitat for biological control agents (the latter was prompted by a visit to the Horticulture Research Centre where research on that aspect was underway – see Chapters 9 and 10).

The main priority of the farmers was to acquire tools and methods that would increase income and reduce rural poverty, similar to situations described in Vereijken (1995). The farmers had identified better product quality as a viable option and had prioritised the restrictions to production and marketing with that in mind. They were interested in converting to sustainable practices because they had noticed resistance to pesticides, as well as crops that no longer produce as before largely due to impoverished soil quality. They also recognised that the resulting products will provide an option for new markets. However, they did not know how to go about changing, particularly to ensure a price differential to represent the effort. From the practical standpoint of prioritising problems to be solved, the farmers put the abiotic environment first (soil, water crops), similar to other situations (Vereijken,1995). Training in these different areas was seen of utmost importance for success in being more sustainable, pointing to the fact that knowledge and access to information are becoming more and more recognised as crucial production factors. Additional aspects mentioned tend to demonstrate a relatively high dependence of the farmers on outside help (local and national government, technical assistance) which does not meet their expectations. A prime example is the use principally of inputs salespeople as source of information for pest and disease management. Similar dependence has been found in India (Alam, 2000).

Röling and Jiggins (1998) discuss the need to consider five dimensions of the ecological knowledge system: sustainable (or ecologically sound) practices, learning, facilitation, support institutions and conducive policy contexts. These dimensions are all interconnected, showing the complexity of sustainable agriculture, and the need for interactive construction between the ‘hard’ biophysical system and the ‘soft’ human system. It is interesting to note that the solutions provided by the farmers fall easily into these five dimensions (table 4.2).

Table 4.2 Solutions provided by the farmers in relation to the five dimensions of an ecological knowledge system according to Röling and Jiggins (1998).

Dimension	**Solutions provided by the farmers as listed in table 4.2**
Ecologically sound practices	Home preparation of alternative fertilisers Appropriate land preparation Live fences as windbreaks and to reduce water evaporation Use of natural control agents and alternative pesticides
Learning	Training courses in: Appropriate fertiliser use, alternative fertilisers Land preparation, appropriate machinery Measuring soil humidity, appropriate watering systems Life cycles of pests, biological control agents, diseases; product compatibility and safety Post harvest techniques including packaging Basic accounting
Facilitation	Farmer feedback on existing technical assistance Contract specialists as farmer groups Dependent on farmers' active voluntary involvement
Supportive institutions	Reinforce weak linkages in the knowledge system Collaboration of inputs services; diversified market. Farmer groups exchange experiences; farmers and researchers work together. Supermarkets that offer 10% price increase for clean products
Conducive policy contexts	Financial support at municipal level through the UMATA At the national level through the Ministry of Agriculture and Rural Development as well as the National Fruit and Vegetable Growers' Association

Looking at the detail of these dimensions, the more difficult ones to influence from the point of view of the farmer are those of support institutions and conductive policy contexts. A study of the information linkage map (figure 4.1) reveals that there are many weak links among actors in the Cota agricultural system, particularly of support institutions. The UMATA in particular seems to have difficulty in meeting the expectations of the farmers, as these lie principally in the provision of technical assistance. One of the solutions proposed was that groups of farmers could contract experts directly. The UMATA could then become more of a supporting institution by providing information much like a clearinghouse on specialists and reading material to solve problems more efficiently. It could also serve to bring together commercial representatives of the different providers of inputs so the farmers can have a better idea of what is available and perhaps, by buying and selling as a group, obtain better prices and even credit in the form deferred payments on purchases. In the same line, the UMATA could continue its policy of subcontracting on specific aspects and therefore help to accompany farmers in undertaking techniques that they have wanted but not dared for lack of, if only, moral support.

Wherefore the need to involve institutions. In Colombia, most prices are based on vegetable produced conventionally. Just recently a few supermarket chains have begun to recognise a differentiated price for ecologically certified produce, ranging from 10 to 35% above the conventional. But there is nothing for ‘in between’ crops: farmers in transition, that produce food with rational use of chemicals (integrated management), or farmers who cannot be certified because their plot is too close to some undesirable factor (flower production, for example), have no way of either differentiating such produce or receiving a fair price for it. Just as in the case of the law defining ecological production systems, there should be some kind of institutional recognition of these ‘in between crops’ through a reference that would provide reliability and thereby enhance acceptance and recognition on the part of the consumers. A definition of ‘integrated farming’ must be decided on at the institutional level, and a certificate made available through national policy, as was done for ecological certification.

4.3 Conclusions

Through the participatory diagnosis of current restrictions to production and marketing undertaken in this project, the farmers have described a very complex situation of different actors and factors that can influence the final outcome. These first meetings of farmers and researchers also provided the foundation for the creation of the learning platform that would be instrumental in ensuring that the research activities remained linked to the farmers changing needs. This step in the sequence of research activities grounds the learning in a thorough understanding of the local problems and opportunities.

The eight groups of issues the farmers identified constitute the steps to be used in the design for conversion to a more sustainable production. The implementation of this design by the farmers was supported technically when required. Farmer-led research was undertaken on pilot farms to resolve specific issues as they arose. This is described in the following chapter.

Chapter 5 - Designing improved crop production strategies

5.1 Introduction

Following the participatory diagnosis, both the farmers and the project team realised that the initial methodology for farm conversion implementation laid out in the proposal to PRONATTA was not the most appropriate. The initial methodology consisted of three main full day workshops spread throughout the entire project complemented by individual visits to the pilot farms by specialists as support and monitoring of the implementation of the techniques (section 2.2.8). Since the farmers did not even have base line information on sustainable farming, a more in-depth approach to training was required. Specialists were therefore contacted to give workshops in each area defined in the diagnosis and prioritisation that could be controlled by the farmers. Parallel to the workshops, the farmers began implementing the techniques on their farms. After six months, an evaluation was done with the farmers to discuss achievements to date and whether the initial problem list and prioritisation were still current. Results from this evaluation included the need to continue with the basic training workshops to encourage new participants and the introduction of advanced level workshops for the farmers already in the programme. Other results of the evaluation included the need to emphasise marketing aspects (Chapter 7), strengthen the farmer group (Chapter 8), and have the possibility of extending the conversion process to a larger area (Chapters 9 and 10). In all, the effort to use the diagnostic exercise to create a learning platform where farmers and scientists could meet paid off in that it not only confirmed the problem situation but also made possible a revision of the initial methodology for conversion design.

5.2 Selection of pilot farms

Prerequisites for the project established by the PRONATTA included that the beneficiaries be small farmers. Additionally, the initial intention of the project was to have two farms from each of the five rural neighbourhoods that were vegetable producing, for a total of ten farms. This minimum figure was chosen in order to create a solid network for horizontal learning. As the workshops progressed, it soon became clear that one of the rural neighbourhoods, El Rozo, had in fact very few participants despite the advertising campaigns implemented. Upon investigation, it seems that that rural neighbourhood had very few small farmers, and many large dairy farmers instead. This is corroborated by the POT which describes the rural neighbourhood has not having 'stratum 1'[7] people. In fact, it mentions that while in rural neighbourhood La Moya, over 60% of the houses are within the first two strata, only 20% are at that level in rural neighbourhood El Rozo. Activities offered to that rural neighbourhood in the future were combined with one of the others.

A second rural neighbourhood, Pueblo Viejo, also had very few representatives despite the high number of small farmers there. No obvious explanation was available, nor were the farmers able to provide a reason.

Because of the low participation of farmers in those two rural neighbourhoods, the number of pilot farms from the other three had to be increased. The idea of the project was to work with farmers with a certain pre-existing degree of interest in sustainable production, in order to be able to spend the short time (30 months) to the design and on-farm implementation of the conversion design rather than to trying to change potentially reticent farmers' visions. Moreover, a successful farmer will also function as a reference for regional neighbours. Therefore, any farmer, participant in the workshops who showed interest by actually trying out the techniques, with or without adaptations, and continued to implement them, was considered a pilot farm. Five farms that had been included in a pilot project financed by the mayor's office, were automatically included in the list[8]. By May 2002, 28 farmers were involved on 21 pilot farms (some were couples or brothers), representing about 5% of the

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[7] Public services are charged according to the economic ability of the user, defined by the location and state of the housing. Stratum 1 and rural are charged the least, while stratum 6 is the most expensive.

[8] Due to a national emergency (the earthquake of 1999), the project selection process within PRONATTA was delayed. As a result, there was a wide time gap between the project approval and the first disbursement. So as not to loose the expectations created among the farmers, the mayor funded a pilot project from September to December 1999, to initiate the conversion process with a first group of five farmers identified as interested by the UMATA.

small farmers of the municipality. A complete listing of the farmers and the date they joined is provided in Appendix 4 (table A5).

5.3 Description of workshops

Initially, the producers were invited to the workshops through local advertising. Personal invitations by phone were also made for each event since numbers had been acquired during the first contact made through the participatory diagnosis meetings. The first workshops were done at the farms of the participants of the preliminary project. Then, at the end of each workshop, the farmers themselves chose the location for the next. Outside inputs required for the workshop were covered by the project budget, whereas materials available on the farm were collected by the host farmer prior to the event. The end product of the workshop (compost box, fermented tea preparation, etc.) was left for the host farmer. Often additional materials (a bin, a bag of compost, wood to make a box) would be raffled off among the other participants. Similar to what happened to Van Schoubroeck and Leeuwis (1999), the facilitators had a budget that would cover a snack at the end of each workshop. At the beginning, so it happened. However, very quickly, it somehow became the norm that the host farmers also provided drinks, an indicator of the interest in the workshops, despite the fact that the workshops were given Saturday afternoons when they would be otherwise socialising. Each rural neighbourhood was in this way exposed to the five topics over a period of six months.

Area specialists were invited to give the workshops for which the contents were basically the following.

- Issues on soil quality

This workshop covered such topics as how to take a soil sample and how to interpret the resulting soil analysis results and recommendations. Explanations on the nutrient imbalance found in many soil sample results in the Cota area were also provided. Analyses would typically show excess nitrogen and phosphorous contents, whereas secondary nutrients would be deficient, with the exception of copper which would also appear in excess. The application of fresh chicken manure on a yearly basis[9] is the main reason for the imbalances, where

[9] In a 2000 m^2 area, a farmer might apply as many as three trucks full (each of 3 m^3, with an approximate density of 0.7) every three crop cycles, which in the case of short cycle crops could mean the equivalent on an annual basis of up to 31.5 tonnes a hectare.

excessive fungicide applications may be the culprit for the excess copper. The effect in the long term of these practices was explained, both from the biological and chemical points of view. As the farmers tended to apply the chicken manure in response to reductions in crop productivity observed after a year, the latter was attributed to the unavailability of the nutrients to the plant, for whatever reason. The task was to render those nutrients available and save money on the application of the manure.

Nutrient availability is an issue in tropical and sub-tropical soils. The soil in the Cota area is silty-loam and of volcanic origin, which makes it a strong phosphorous-fixing soil. Soil analyses could show excess P in theory, but it is unavailable to the plants. P ions have a strong tendency to join with Ca and Mg in neutral or alkaline soils or with Fe and Al cations in acid soils (Lindsay, 1979). Trials done at the CIAA comparing soils from different parts of the Bogotá Plateau, showed effectively that despite increasing additions of P as fertiliser, P availability to the plant did not increase (Amparo Medina - CIAA, pers. comm., 2002). Horst et al. (2001) showed that agronomic measures such as the application of organic matter in the form of crop residues or green manure help to increase P availability to crops because they enhance soil organic matter content and biological activity. Additions of animal manure have the added advantage of contributing micronutrients to the soil (Warman, 1990), elements which have been effectively lost through crop extraction and rarely replaced as conventional fertilisers usually used provide NPK only. Deficiencies in secondary and micro nutrients observed in the samples taken in Cota are found particularly for S and Mn and to a slightly lesser degree Ca and Mg, results typically found in the Bogotá Plateau. In this case, the chicken manure does not seem to have had sufficient effect to overcome these deficiencies.

The workshop therefore looked at different options to improve on these situations. A relatively easy solution which would help in the long run was to spray the soil with a solution of molasses in water (500 g in 20 litres) which would provide carbohydrates as food to any micro-organisms that might still be alive in the soil and that would be able to work toward breaking down the nutrients to a level more easily absorbed by the plants. Additional solutions included microbial soups, and other sources of organic matter, covered in another workshop, which would speed up the process of soil health recovery.

- Rational use of water for irrigation, water quality, analyses

Methods on how to measure water volume of the irrigation system and calculate requirements according to crop, crop age and climate were taught in this workshop. Demonstrations were made of instruments that could be used to monitor the climate (maximum-minimum thermometer, rain gauge, evaporimeter, relative humidity recorder). The results of the analyses done through the CIAA for water quality were explained for their effects on the irrigation system and crop quality.

- Preparation of organic fertilisers

The reason for using organic fertilisers was first reviewed: improvement of soil structure, water absorption and retention and the provision of a better environment for micro-organisms which will help in making nutrients available to the plants, as well as help in the natural control of many insects and micro-organisms that can become a nuisance to the crops. During the workshop, the producers put together a compost box, a vermiculture box and learned how to prepare a liquid fertiliser by a fermentation process of manure and nettles, an excellent source of nitrogen for leaf crops (such as lettuce, spinach, coriander, parsley, etc).

- Allelopathy and botanical products

Allelopathy was defined as the science that studies the relationships among companion plants and those antagonistic, as well as those used as repellents in pest and disease management (Mejía, 1995). The effect is rendered by chemical compounds of the plants on the development and growth of other species, for example, intercropping lettuce with spinach at a ratio of 4:1 to improve the taste of lettuce. Specific alternatives to the most common pests and diseases of the producers' crops were provided keeping in mind the accessibility of the material to be used. Botanical products were also prepared.

- New seeds and varieties

The farmers were invited to name their requirements for crops and their current problems. Crop rotation based on plant family was reviewed and rotation based on crop type introduced (this is covered in more detail in the section on Cropping Systems Management, 5.4.4). A representative of several seed companies was invited to a workshop in order to describe the varieties currently available in the market, their advantages and disadvantages, in accordance with the local production and marketing conditions.

5.4 Methodologies and methods used in the farm conversion

The diagnostic exercise undertaken with the farmers and described in Chapter 4 showed that the farmers preferred the following order for addressing the obstacles in their farming practices: soil, water, crop, marketing, technical assistance and training, financial aspects, and political-institutional support. Many of the solutions they came up with were based on training in biophysical aspects of sustainable farming, before beginning the farm conversion process. An evaluation part way through the project revealed that the farmers felt 'marketing' required a more prominent place, and recommended that it be implemented parallel to the technical farm methods. Thus farm conversion in the case of the Cota farmers followed the design shown in figure 5.1.

Many of the methods used in the prototyping methodology outlined in Chapter 2 were also used here. Additional ones were required to complete meeting the needs of the farmers. Some of the suggestions of the farmers, such as building reservoirs for water storage, were not possible within the time and financial constraints of this particular project, but were kept in mind for the future. The overall guidelines for choice were based on the farmers' needs as per the participatory diagnosis, information available on methods successful elsewhere, and final selection based on what was appropriate according to the farmers' concept (Leeuwis, 1999b; Tekelenburg, 2001). Farmer participation was the foundation for these activities, through individual and collective decision-making, farmer learning, and negotiation among the actors who could be affected by or have an effect on change (Leeuwis, 1999b).

5.4.1 Farmer participation and organisation

The entire project is based on farmer participation. From the participatory diagnosis, a learning platform starts to be created simply because the farmers have come together to discuss and agree on what their difficulties are and in what order of importance. This continues as they discuss what a sustainable farm means to them and how to design the conversion process based on their priorities. Although at the beginning of the process participation is weak, it gradually builds up to the point where the farmers feel the need to become associated. As found in this project, farmer participation at the onset is at an individual level. Then, by getting to know each other and realising the potential of their neighbours, gradually an interest to join forces and exchange experiences grows, leading eventually to some sort of organisation different from what was started with. This methodology also allowed for taking into account the farmer preoccupation with lack of technical assistance and in general low access to new information. In effect, by becoming organised, they were able to pool information and experiences to solve each other's problems, as well as offer quantities of produce in a more stable fashion than if they had continued to market individually. It is therefore fundamental that such a method be taken into account as the effects on the success of the project can be expected to be much different from a transfer – of- technology / diffusion of innovations type project.

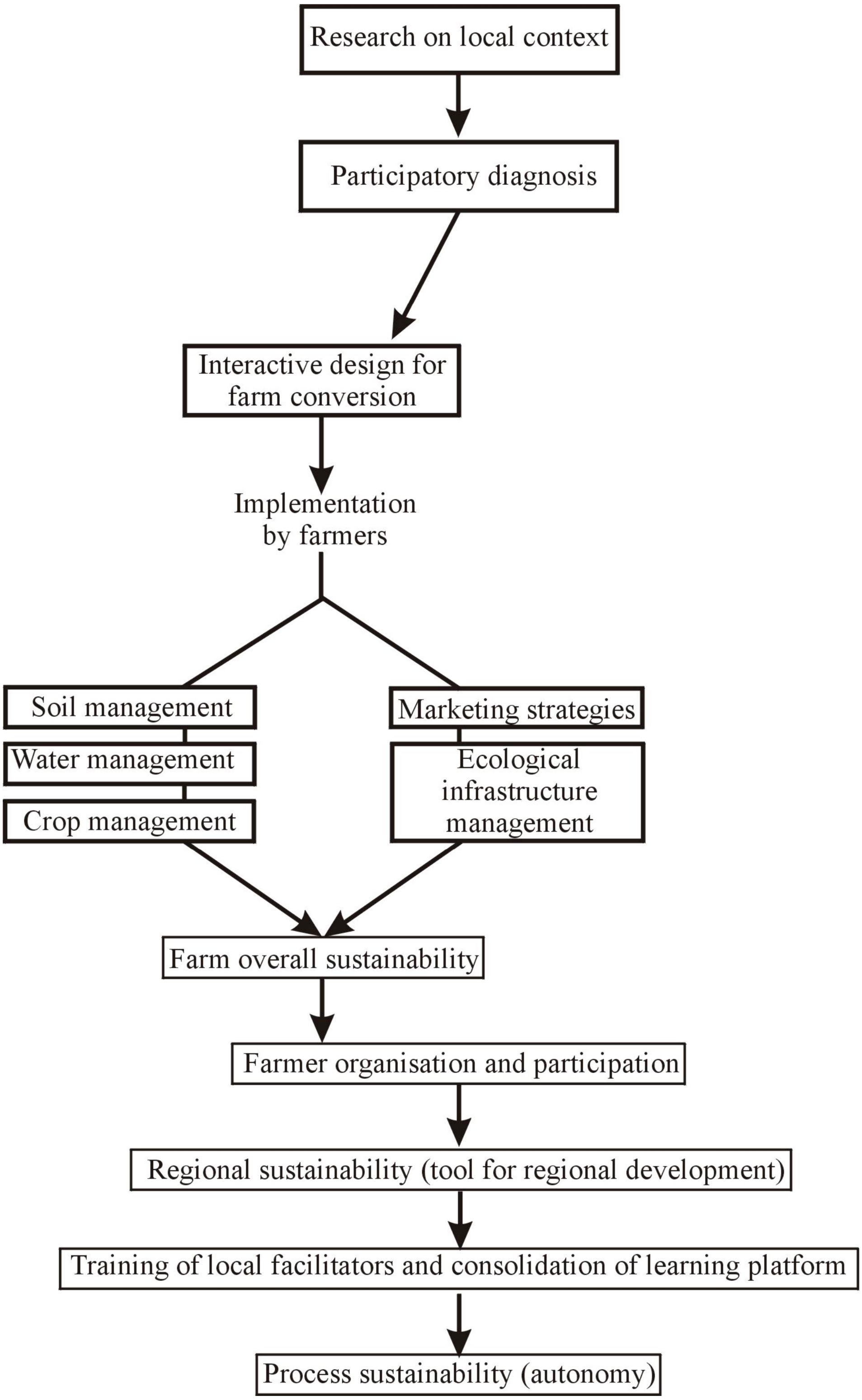

Figure 5.1 Model of the farm conversion followed by the Cota farmers

5.4.2 Soil systems management

The farmers' rationale for choosing aspects related to soil as first on their priority list was because they considered that the production process began from that point time wise. In other words, they preferred to have to look at the different issues as they arose throughout the production process. As a result, they considered that issues pertaining to water and the crops would arise after those of soil. As we have already mentioned, they later reconsidered in order to move marketing to an equal footing throughout the production process.

The methods used to address the issues brought up by the farmers in relation to the soil were training, integrated or ecological nutrient management and soil cultivation. Side effects of the other management methodologies would be taken into account, for example the results of particular crop rotations on soil compaction.

Training

All biophysical issues brought up by the farmers were addressed first through training as described in 5.3. Throughout the conversion process, additional training was provided as required. For the most part, however, accompaniment by the project team through farm visits and the exchange of experiences during the weekly meetings in the second half of the project, were sufficient.

Integrated or ecological nutrient management (I/ENM)

To promote appropriate soil management, the farmers first needed to know what they were starting off with. Complete chemical and biological soil analyses as well as water tests for aptness for irrigation were made at the beginning of the project and recommendations given to each farmer using preferably organic sources of amendments. Partial chemical soil analyses were also taken approximately every six months to monitor changes. At the end of the project, complete analyses were again made. The idea here was to reduce the use of inorganic fertilisers (mainly Triple 15) and encourage the farmers to compost the chicken manure instead of applying it fresh, if there was no other readily available source of manure. Recycling of nutrients and reducing dependency on external inputs was worked on through the implementation of compost piles, vermicompost and the use of microbial soups and fermented herb teas prepared on the farms. The materials used were either already available on the farms or easily introduced, such as promoting the growth of nettles (*Urtica* sp.) around the compost piles for future use with cow manure as a foliar applied source of nitrogen.

These techniques were intended to recover and maintain soil fertility from the chemical and biological points of view. The farmers learned how to best use inputs to that end, achieving quality production while at the same time reducing dependency and costs of external inputs.

Minimal soil cultivation

The soils of Cota are typically silty-loam, so very light in texture. However, they have been severely mistreated over the years by the use of tractors and inappropriate machinery such as the rotary cultivator, which pulverises the soil and turns over the different layers. Since most of the farmers depend on tractors available for rent to prepare their land, and therefore have very little say in the machinery to be used, efforts were made with the UMATA for the acquisition of a tractor and implements more in accordance with ecological considerations. Thus, the Secretary of Agriculture of the Department of Cundinamarca donated a tractor, with a sub-soiling cultivator and a polisher at the end of 2000.

Furthermore, as the farmers were gradually moving toward crop programming and scaled production, smaller areas of land needed preparation at a time. This justified the use of the small rototiller, a lighter weight tractor also available for rent through the UMATA, which at least reduces the degradation of the soil structure, even if it still turns the soil over.

As described in Chapter 3, the land is almost flat, with a slight slope from the mountain towards the river decreasing gradually from 12 to 3%. Water erosion from the fields is therefore almost non-existent. However, due to the powdery state of the soil and the lack of barriers, erosion due to wind is quite high at certain times of the year (especially during the month of August). Practices such as increasing the use of organic matter, implementation of mulches by depositing uprooted weeds on the beds, and planting trees as barriers were encouraged to reduce this problem. In the long term, it is hoped that by improving soil structure in these ways, soil preparation by hoe will be made more feasible (some farmers are already doing it), or even seeding and transplanting directly on the previous crop. Where the farmers continued using machinery, non-inversion tillage was encouraged.

5.4.3 Water management

Training on the use of water according to crop needs and soil and climate conditions, evaluation and selection of appropriate irrigation equipment, analyses for water quality both chemical and biological, and some activities used in other areas (mulching, addition of organic matter, enhancing live fences) were the methods used here.

5.4.4 Cropping systems management

Multi-functional cropping systems

A more ample concept is used in this study, than that by Vereijken who uses 'Multi-Functional Crop Rotation -MCR' as the method for this section (see Chapter 2). The title used here attempts to include a number of cropping systems that might help reach or complement the objectives of MCR. Combining crops whether spatially or temporally will ultimately help the agroecosystem back to a higher level of resilience, which in turn guarantees a higher sustainability of rural livelihoods (Pimbert, 1999). There are different ways this can be achieved, as described below.

- Multiple cropping systems

This method consists in having more than one type of crop in the same area at the same time. It leads to a higher efficiency in land use leading in turn to a higher land equivalent ration (LER), which translates into a higher combined yield even if individual crop production is lower (Vandermeer, 1989). The explanation for the higher yield is through the more efficient use of resources such as light, water and nutrients (Willey, 1990). It could also make use of allelopathic effects between plants.

Some multiple cropping combinations are often implemented in Colombian vegetable production (lettuce + spinach; beets + coriander) and encouraged by the project, although they were not actively included in the project process.

- Cover cropping

In order to reduce water evaporation and soil erosion, as well as help improve soil physical properties and protect soil microbiological fauna from the suns rays (and certain death), soil covers are an interesting option. Horst et al. (2001) showed that intercropping a P-mobilizing crop such as leguminous cover crops has a positive effect on P-inefficient crops as long as the two do not compete for other limiting growth factors such as water. Oberson et al. (2001) found that soil micro-organisms play an important role in maintaining P availability and efficiency of P cycling, while Magid et al. (1996) describe the role micro-organisms play in immobilising inorganic phosphorous from decomposing plant biomass, thereby protecting P from being adsorbed to soil particles. These effects were increased in areas where a cover crop was maintained. Through the Horticulture Research Centre, trials were done on some vegetable farms with a black plastic mulch, a practice that has been quite successful among producers associated with the integrated production system (Appendix 2), due to positive results where weed, pest and disease control, and water management, are concerned.

However, the practice has not been adopted to date in Cota. Rather, leaving uprooted weeds on the beds was encouraged. Trials were also initiated comparing alfalfa, red clover and white clover for their efficiency and appropriateness for intercropping, for example with broccoli.

- Crop rotations

Contrary to the studies undertaken in Europe by Vereijken, in Colombia it is difficult to prioritise the crops according to profitability as the prices vary too much. More likely, once the farmer group has become more organised and get their programming under way, each farmer will have to chose the rotation according to crops assigned to him/her as per their capacity and client demand.

At the beginning, therefore, the idea was to take the crops produced regularly by the farmers and at least to rotate them according to product types (leaf, fruit, flower and root or tuber) and plant families (as in the original prototyping methodology), so as to reduce pest and disease populations arising from continuous cultivation of crops from the same family. From the point of view pest management, this strategy is particularly interesting if one takes into account that insects disperse, among other reasons, to find new sources of food, shelter or reproduction niches. In the case of a pest situation, removing the crop it is attracted to, obligates it to disperse, and the more often a new field is created, the more often it must disperse to colonise new areas. In this sense, crops with shorter cycles are more useful, particularly if combined with the planting of live fences that create a barrier to this dispersal (Bhar and Fahrig, 1998). Regional pest populations can thus be expected to decrease over time.

In general, the purpose of this method is to increase the biodiversity of the agroecosystem, thereby increasing the complexity of the system by integrating rather than segregating system components and in turn leading to more dependable production (Vandermeer et al., 1998). The farmers must learn to understand the biological processes at different scales: temporal effects of crop rotations, spatial effects of intercropping and cover crops, processes involving the farm landscape including the trees and bushes used as live fences and the herbs grown for use as botanical pesticides, among others. Associated diversity, i.e., that which naturally arrives to the site (seeds on the wind, mammals, etc) must also be looked out for (ibid).

Integrated crop protection

Weekly visits to the participating farmers, five or six farms one day a week were established from the beginning of the project. At first, a soil specialist joined me on these visits. As the number of participants increased, I hired a technical assistant only for that purpose, whom I accompanied about half of the time. Included in the activities of the visits were monitoring of insect pests and diseases of all the crops sown, monitoring of crop quality, discussing possible solutions to problems encountered, collecting information on successful and less successful practices, promoting the exchange of information among the farmers, among others.

In this fashion, a large amount of information has accumulated which provides options for the following:

- cultural and physical management of pests and diseases
- biological and organic methods
- chemical options as a last alternative, always seeking the least toxic available on the market, and avoiding carbamates and organophosphates.

Environment exposure of the pesticides was not calculated. Among the indicators monitored, however, is one that measures the percent of kilograms of product of natural source used.

5.4.5 Marketing strategies

Marketing is usually the bottleneck in Colombia where agriculture production is concerned, and vegetables are no exception. Many of the problems listed in Chapter 3 had to do with restrictions at this level. Small farmers just do not have the lobbying power nor the know-how to access specialised distribution channels. It is difficult to be both a producer (manager of natural resources) and a salesperson. After all, large companies have separate production and marketing offices and specialists!

In this area, methods included diversifying distribution channels, aiming for direct contact with the consumers, differentiating the product, value-adding through consumer education on healthy products, training and accessing information. These will be studied more carefully under Chapter 7.

5.4.6 Ecological infrastructure management

Ecological infrastructure management (EIM) is an essential element within an agroecosystem management approach. The idea here was to work on increasing the ecological infrastructure index at farm and regional level. EIM was implemented based on the use of trees and herbs with multi-functional uses: economical return through harvesting, windbreaks, and habitat for flora and fauna.

Basic principles followed here were the encouragement of live fences around the plot of land, choosing the species according to the natural control agents they are known to harbour, including fruit tree species to diversify income source and crop type, and planting herbal species that can be used for pest and disease management and fertilisers. The methods used for EIM are described in depth under Chapters 9 and 10.

5.4.7 Farm overall sustainability

It is unlikely that the small farmers can expand to meet the probable requirements as to farm size, labour and capital in order to optimise these inputs. Therefore, in this case, rather than Farm Structure Optimisation (see section 2.2.3), farm sustainability was studied. The topic can be looked at from another viewpoint, which is how to optimise what is available. A software program was developed by a colleague specifically to this end (Pérez, 1999). Although the original program was designed for dairy farms (see Chapter 2 for more on this), he adapted it here for vegetable production. With the indicators chosen in the next section, the software was run for a sub-set of farms with data from at the beginning and the end of the project to determine progress made.

How the software works

The objective of the software is to evaluate farm sustainability in terms ecological, economical and social aspects. The software can be adapted to particular circumstances by changing the indicators used. In this case, what was evaluated were the possible changes obtained and that could be attributed to the implementation of practices and concepts by the participating farmers by comparing data before and after the project in relation to acceptable rates for each indicator according to the literature. The basis for the design of the model and the evaluation of sustainability is the Methodology for the evaluation of management systems incorporating indicators of sustainability (MESMIS) developed by Astier and Masera (1996), and modified by Pérez (1999). The indicators used were those selected as described in the next section (5.5).

The activities involved were:

- Definition of objectives of the evaluation, the study system and the limits of the evaluation
- Supply of the initial indicators by the project
- Definition of the method for measuring the indicators
- Definition of the desired values for the indicators
- Determine the information required as entry data for the model

- Design of the data entry process
- Capture of the information (trial farm)
- Verification of the information and indicators
- Structure the calculation of the indicators within model
- Structure measurement of indicators in model
- Run model for trial farm
- Prove workability, validation of data and evaluation
- Correction of information, data entry design and model structure
- Run corrected model on trial farm
- Enter data on the other farms at beginning of project
- Results of the evaluation of the farms at the beginning of the project
- Enter data of the farms at end of project
- Presentation of compared evaluation (initial state vs. final state of the farms).

The results from running this software should provide information on the values of the chosen indicators for farms in their initial state and the state at the end of the project; an evaluation of these states; and a comparative evaluation among the farms and to the desired values for the initial and final states.

5.5 Selection of indicators

The list of indicators described in Chapter 2 (table 2.3) was used as a starting point and was gradually modified to suit the specific conditions of this project. Since the idea was to design and adapt the prototype with the farmers, it would have been difficult to have had a complete pre-established list. Instead, the 'scientists' list was used in order to ensure the required rigour in the conversion process (table 5.1). Parallel to that, a second list was developed with the farmers, once they had been through the various workshops and had actually been implementing changes on their farms for about a year. As mentioned in Van Schoubroeck and Leeuwis (1999), each community or group of people 'develops its own vocabulary that reflects the settings of the group, and shares an interpretation of certain phenomena in language, thus creating a shared reality.' Therefore, in the design of this conversion design, it was considered important to have indicators of success that meant something to the farmers. We therefore established with the farmers their own list of indicators (table 5.2) for each of the prioritised items of table 4.1. These indicators were then translated to their parallel in the 'scientists' list to facilitate comparisons with previous work.

Table 5.1 The 'scientists' list of indicators of farm sustainability, including area of evaluation, system attributes, parameters, variables, desired values and area of farmer concern according to table 4.1.

Area of evaluation	System attributes	Parameter	Indicator	Variable	Desired values	Source (values)	Area according to table 4.1
BIOPHYSICAL and TECHNO-LOGICAL	Productivity	Yield	Crop production	Tonnes.year^{-1}.ha^{-1}	> 12	MAGDR (2001) Corpoica (1999)	Crops
		Energy Efficiency	Energy balance	Energy efficiency index	> 3	Gliessman (1997)	Crops, soil
		Efficiency	Productive efficiency of water	Dry matter based on crop yield (M^3 . T^{-1}. year^{-1}. ha^{-1})	> 500	Gliessman (1997)	Water
		Non-crop species diversity	Number of non crop species	Non-crop species found on the farm	> 3	This project	Crops
			Individuals per non-crop species	Number of individuals per species	> 1		
	Quality	Conservation of natural resources	Soil quality index	Soil structure	'flour', fine grains=0 granular to medium aggregates=1	This project	Soil
				Maximum resistance to penetration at 30cm	< 200000 kg.m^{-2}	CIAA Laboratory	
				Carbon / Nitrogen ratio	10-15		
				Soil salinity	<0.74 mS.cm^{-1}		
				Available phosphorous	30-60 ppm		
				Calcium+Magnesium/Potassium ratio	14-16		
				Magnesium /calcium	1-3		
				Mineral nitrogen (NH_4+NO_3)	25-50 ppm		
				Soil pH	5.8 – 6.5		
				% organic carbon	> 2.9		
	Resilience	Conservation of natural resources	Natural sources of pest and disease control vs total used	Percent of natural inputs vs. chemically synthesised products	> 50	This project	
	Stability	Self-control	Management of crop rotations	Number of botanical families represented Number of product types represented	No more than one crop from same family; no more than 2 crops of same type	This project	Crops
	Quality	Soil biological activity	Worm count	individuals. m^{-2}	> 20	This project	Soil
	Self-regulation	Efficiency	N balance: yield. ha^{-1} of N compared to N fertiliser input *	kg. farm^{-1}	> 0	Gliessman (1997)	Soil, crops
	Stability	Efficiency	Water index: received by crop compared to requirements	Rainfall.year^{-1} + irrigation volume x minutes x no of times compared to evaporation rate	= 0	Pérez, this project	Water
	Farm Self-reliance and self regulation	Efficiency	Self-supply of inputs	% of inputs produced on farm	> 20	This project	Crops
		Self-control	Internal resilience of farm system	% losses due to pests and diseases pre-harvest	< 30%	This project	Crops

Area of evaluation	**System attributes**	**Parameter**	**Indicator**	**Variable**	**Desired values**	**Source (values)**	**Area according to table 4.1**
ECONOMICAL	Productivity	Efficiency	Net annual income . ha^{-1}. $year^{-1}$	Gross income. ha^{-1}.$year^{-1}$ minus costs of production . ha^{-1}.$year^{-1}$	> $ 467,100 **	MAGDR (2001) Corpoica (1999)	Financial
			Gross annual income . ha^{-1}. $year^{-1}$	Yield in kg, losses pre and post harvest vs price per kg and quality	> $4,720,000 **	MAGDR (2001) Corpoica (1999)	
			Annual net profit	Net benefit vs production costs	> 20 %		
	Autonomy	Capacity for change	Marketing activities index	Added value	Yes = 1 ; No = 0	This project	
				Market channel diversity	Yes = 1 ; No = 0	This project	Commercialisatio n
				Product differentiation	Yes = 1 ; No = 0	This project	Commercialisatio n
SOCIO-CULTURAL	Stability		Full-time employment	Number of full-time employees per hectare	> 1 < 3	This project	Human resources
	Equity	Participation	Participation index	Membership in farm group (formal or non-formal)	Yes =1 No = 0	This project	Political context
				% participation in all workshops	≤51% participation = 1 >51% participation = 0	This project	Political context
	Adaptability	Capacity for change	Adoption of technology	% new techniques used	>50 = 1 ≤49% = 0	This project	Human resources

* Only inputs to the system and system outputs are accounted for. Recirculated materials are not included (for example compost made on farm).

** The Colombian was valued at approximately $2300 per US dollar in 2002.

Table 5.2 Farmers' indicators of sustainability.

Indicator	**Indication of …**
Presence of aggregates or not (The soil is 'grainy').*	- Soil biology: there is life in the soil. - Soil structure: it does not dry up as easily and allows water to percolate to roots.
Smell of soil: an 'earthy' smell is better than a 'cemetery smell'.	- Soil quality. The vegetables will be of better quality.
Colour of soil: a dark colour is better than yellow.*	- Soil quality. The vegetables will be of better quality.
Colour of the crop: dark green leaves are better than pale ones.	- Crop quality. The soil is well fertilised.
Plant diversity: the number of types of crops and non-crop plants on their farm.	- Income stability: diversification helps them to ensure earnings. - Input independence: they can make their own.
Plant diversity: Appearance of volunteer plants where did not grow before.	- Health of the farm is recovering.
Production increase despite reduced spraying	- The plants are 'fed' without too much work (system efficiency).
Amount of crop left in the field.	- Client interest in the produce. - Losses due to pests and diseases.
Diversity of birds: they have seen species they had not seen before.	- Since they are not spraying, biodiversity is improving.
Confidence in the food.	- Before they did not eat the vegetables they produced because they knew what they applied on them. Now they do.
Taste of the food.	- Under the new techniques, the vegetables taste better, like the vegetable in question.
Health of the participants.	- Fewer chemically synthesised pesticides used.
Number of farmers at meetings and consistency of assistance	- Participation and interest in activities.

*corroborated by Gerhardt, 1997.

The initial aim of the project had been to move towards more sustainable farming systems, primarily based on the reduction in quantity and toxicity levels of pesticides to more acceptable levels. Basically, the hope was to move the farmers from conventional to an integrated form of farming. However, the farmers themselves decided to go further for various reasons. Some, because they preferred not to depend on external inputs and salespeople; others because they believed in economic retributions because of potential new markets, or better price, or both; still others, because they realised they felt better themselves and that they could actually eat the food they were producing.

5.6 Conclusion of chapter

We have presented here which methodologies and methods were used to implement the conversion process based on the prioritisation made by the farmers in the participatory diagnosis. During this stage, my role was mainly as facilitator. However, I did need to design the link between the farmers and research. Information existed already on different methods and techniques, some through the Horticulture Research Centre, others from the literature and other research experiences nationally and internationally, and others still would have to be researched on through this project. The next chapter describes how specifically the conversion was implemented and what results were achieved.

Chapter 6 - Progress in the conversion process

The conversion design, methodologies and methods proposed for implementation under tropical high mountain conditions where small farmers produce vegetables year-round are described in the previous chapter. Here we will look at the results of the design in terms of technical effects on crop production and social effects on the farmers.

The methodologies implemented in this project for farm conversion applied methods and techniques used in other contexts, which and in many occasions required adaptation to the particular situation. As much of the work in ecological farming remains empirical, an attempt was made here to choose methods and technologies that had a demonstrated scientific basis. This was not always possible: precisely the idea of using a participatory approach to the process was to open the possibilities to alternatives that might otherwise not have been considered. In those cases, a small research project was established with the farmers to try out the new options. Basic research was limited, but served its purpose, for example, in elucidating the effect of some botanical products in the management of soil fungal diseases.

6.1 Outcomes of the conversion design and implementation

In this section, the specific methods and techniques that were used in the conversion design and implementation are described, with references to the results obtained. Details and methods (including recipes) were deemed important to report on here because they functioned as essential tools for the interaction between the research team and the farmers, and as the basis for the participatory approach to agricultural development presented.

6.1.1 *Farmer participation and organisation*

This method addresses many of the problems listed by the farmers in the participatory diagnosis for which they proposed training and organisation as potential solutions.

Five farmers started off with us through the pilot project implemented with the mayor's support. Once the full project began, the number increased gradually till a total of 28 farmers were involved on 21 pilot farms (some were couples or brothers), representing about 5% of the small farmers of the municipality by May 2002. The participation of Cota farmers in workshops provided during the first year of the conversion project is shown in Appendix 4. The most interested farmers continued as pilot farms. The gradually adherence of farmers to the project and the areas of their farms they had in conversion and under ecological practices by May 2002 is also provided in Appendix 3.

Interest has been spreading gradually throughout the municipality, especially when some of the marketing initiatives began having some impact, showing that there could be economic benefits to the effort after all! Related industries, such as manufacturers of handicrafts and goat products, have been joining as well (see Chapter 7 for more details on these marketing related aspects).

Farmer participation from the beginning of the design of the conversion process was obtained through the diagnosis of their difficulties. Their continued participation ensured that the conversion design that emerged from the diagnosis remained relevant to the changing situation. Relevance was particularly monitored at individual level by the project team through conversations and observations during the farm visits and by the farmer group by periodic group evaluations. In the software for evaluating farm sustainability, percent participation in the project based on assistance sheets, percent application of organic practices (see table A7 in Appendix 5) and membership in a farmer group were used to define level of participation. A deeper analysis of those results is provided in section 6.1.7.

Farmer autonomy was maintained by the project team with regards to the final decision of actions to be taken on the pilot farms. The training workshops, group meetings and farm visits served to provide each person with information that was expected to enable him/her to take an educated decision on resource management on their farms. As the project neared its end, both project team and the farmer group felt the growing need to put some structure in place that would maintain the flow of information and the parallel autonomy in decision-making. The result was the organisation of a group of farmer facilitators who would be trained on how to access information and transmit it to the rest of the group, and how to write project proposals for access to funding. They would also receive a more in-depth training in the more technical aspects related to the conversion process. These aspects are reviewed in more detail under Chapter 11.

6.1.2 Soil systems management

Integrated or ecological nutrient management

This method addresses the problems of soil fertilization and compaction listed by the farmers. Soil analyses were taken from the participating farmers on entering the project, a couple of times during and at the end of the project. Optimal ranges for soil fertility were based on those provided by the soil analysis laboratory of the Horticulture Research Centre (CIAA). Table 6.1 provides an example of optimal ranges as recommended by the laboratory as well as results from some of the participating farms at the onset of the project.

After the workshop on soil fertility and recommendations was given (see section 5.3), the farmers had a better understanding of the situation of their plots. Going back to the solutions they had provided in the participatory diagnosis (table 4.1), the next step was the provision of workshops on the different techniques to prepare organic sources of inputs. Emphasis was made on farmer learning of the different options available, both homemade and commercial, in the way of organic fertilisers and amendments. They also learned when which type was more appropriate to use and for what purpose, using as much as possible elements available on their farms or immediate environment. As mentioned by Deugd et al. (1998),

> *"As the limitations of transfer of technology to promote better INM become more obvious (particularly in lesser-endowed regions in the tropics), there is a need to develop new strategies, focussing on the facilitation of farmer learning to become experts at INM and at capturing the opportunities in their diverse environments".*

- Methods for the preparation of organic amendments

The following describes the new technical abilities of the farmers in the production or combination of different natural sources of fertilisers and soil amendments applied during the project.

Table 6.1 Soil analyses of some small farms of Cota taken in 1999 with optimal ranges according to the Horticulture Research Centre

				ppm													Meq.100g^{-1}
Name	R.N.	pH	EC	N-NH_4	N-NO_3	P	K	Ca	Mg	Na	Fe	Mn	Cu	Zn	B	S	CEC
optimum		5.8-6.5	<0.74	Total: 25-80		30-60	108-162	2275-4025	280-490							45-75	
JM	El Abra	6	0.48	12.4	19.5	142	636	2452	262	36	77	5.4	4.4	7.4	0.11	6.4	33.5
J&L	La Moya	5.1	6	25.8	173	1125	988	3785	407	138	43	52	9	25	0.39	13.7	42.6
J&JP	Pueblo Viejo	6.9	0.85	27.6	85.7	406	623	6394	440	87	72	9	9	46.7	0.49	9.5	46.1
M	Cetime	5.5	0.41	12.1	20.8	771	184	1755	128	39	48	8	1.8	10.2	0.28	8.1	34.8

R.N.= Rural neighbourhood; pH= level of acidity; EC (in ds.m^{-1})= electrical conductivity;

CEC= cation exchange capacity; ppm= parts per million.

Methods used: pH in water 1:1; CEC and exchange bases (K, Ca, Mg and Na) in ammonium acetate pH 7 (1:20); micro elements by DTPA (1:2); boron and EC by saturation extract; phosphorous by Bray II for pH below 6 and by Olsen for pH equal to or over 6.

- Compost piles

A site was selected within the production area of the farm so that it was central from all points of the farm, and therefore reduced energy use in moving crop residues and then moving the finished compost.

The site was cleared of grass and debris. A first layer material with a high C/N ratio such as cut grass or other source of carbon was recommended so as to restrict N leaching (Ulén, 1993). The following layers were made of crop residues, manure according to availability, some complementary nutrients according to the farm soil analysis recommendations (see table 6.3), microbial soup and molasses (found by Singh, 1987, to help speed up the rate of decomposition). Manure has been found to return nutrients to the soil more effectively than crop residues (Arden-Clarke and Hodges, 1988). The manure might come from the farm cow, chickens or rabbits or purchased chicken manure. The latter, although commercially the most easily acquired, was not recommended as most sources apply growth hormones and antibiotics which are suspected to not decompose easily and could therefore contribute to the contamination of the soil (Uriel Contreras – CCI, pers. Comm., 2001). However, it was considered less damaging if the farmer insisted on continuing with the tradition of using chicken manure as long as it went through a composting process. The final layer was to be more straw or dried grass and some kind of cover to prevent N surface losses (Ulén, 1993; Eklind et al., 1998) and to maintain the appropriate level of humidity. Furthermore, research suggests that higher straw content in composts will enhance solubility of phosphorus (Eklind et al., 1998), which is important in these soils. Some farmers prepared freestanding piles, while others made removable wooden fences at 1x1x1.5 (l x w x h) meter size. Depending on weather conditions, piles take 4 to 5 months to become adequately decomposed.

Two sources of commercial compost were also tried out in this project. This was offered to the farmers for various reasons: a. while interested farmers were waiting for their own pile to be ready, b. if farmers were not able to produce enough of their own compost to satisfy farm requirements, and c. at the end of the project, when the semester soil analyses still showed unbalances among elements.

At the beginning of the project, commercially available composts were not common at all. The easiest available one was based on chicken manure. About half of the participant farmers received some of this compost. During the last year of the project, a new compost appeared on the market, based on grasses, legumes and horse manure. The latter one was developed with the help of professionals at the Horticulture Research Centre to make sure it was a well-balanced input. The provider also inoculates it with a number of beneficial fungi such as *Verticillium* sp., *Beauveria bassiana*, *Beauveria brongniarti*, *Metarrhizum* sp., and *Paecilomyces* sp. to manage insects and nematodes, with *Trichoderma* as antagonistic to many fungal pathogens and promoter of plant growth, and micorrhizae to improve nutrient absorption. The farms received enough of this compost to cover for one application in $1000m^2$ at a rate of $4kg.m^{-2}$.

The compositions of these composts are included in table 6.2:

Table 6.2 Composition of two commercial composts used on small farms in Cota according to dry weight.

Variable	Chicken manure based *	Graminae, legume and horse manure based **
% humidity	39.2	35-40
Apparent density ($g.cc^{-3}$)	0.63	0.6 – 0.65
CIC ($meq.100g^{-1}$)	103.75	>75
C/N ratio	12.67	>12
PH	7.6	6.0 – 7.0
% organic matter	47.37	>45
% total nitrogen	1.7	2
% phosphorous (P_2O_3)	1.5	2
% potassium (K_2O)	2.6	2
Other elements in minor amounts	Ca, Mg, S, Na, Fe, Mn, Cu, Zn, B	Ca, Mg, S, Mn, Fe, Cu, Zn, B, Si

* based on an analysis done by the Horticulture Research Centre.
** based on information provided by the company, as analysed by a different laboratory.

Although the contribution of nitrogen through this compost seems to be high (approximately 800 $kg.ha^{-1}$), especially considering that most of the farms showed excess nitrogen in the laboratory analyses, we took into account various aspects when deciding to use this source, based on the recommendations of the soil scientist on our team. Mineralisation of nitrogen in compost can take up to one year and its bio-availability is low, so that in fact it is liberated quite slowly. Furthermore, the farms are coming from an altered system. Becoming more sustainable can be done two ways: abruptly or gradually. When comparing the above amount contributed by a balanced compost to the amount of nitrogen that would typically be entered into the system through conventional sources (approximately 500 kg ha^{-1} by chicken manure and Triple 15 or 18), we considered that the additional advantages outweighed the disadvantages when implementing a gradual conversion. Adding compost improves soil structure (demonstrated here by the appearance of aggregates when the soil at initiation was without structure), and increases biological activity (see next paragraph on vermicompost) which in turn helps balance soil nutrients. In the future organic matter additions will be reduced gradually as will soil amendments, according to soil analyses. In this way, the expectation was that the conversion process would not cause sudden drops in farm productivity, an expectation that was fulfilled (see section 6.1.7).

- Vermicompost

One of the indicators used to determine soil quality was the number of worms encountered in one square meter at the depth of crop roots (approximately 25cm). In some areas of Colombia, this is in fact a measure to determine the price of land by farmers (María Romero, pers. comm., 1999). Romero helped out in this project by giving workshops on how to implement and manage worm culture (with *Eisenia fetida* in this case), explaining the differences between worm and residue composts. In language understandable to the farmers, she explained that residue compost will provide structure to the soil and slow release of nutrients, while worm compost provides nutrients more quickly as well as certain plant growth hormones which have been made available through the transformation process of the worms. Before intervention, the average number of worms per square meter was registered at 12, where results after intervention showed 21 or more. The threshold used to measure sustainability in the software regarding worm presence was 20.

Not all the farmers implemented vermicompost as it requires a longer time period than regular compost (3 months of residue compost if that is to be added to the box, plus six months of worm composting, instead of the 4 to 5 months of regular compost).

- Super 4 soup

This is a fermentation process which requires that 1 kg molasses, 60 kg fresh cow manure, 1 kg dolomitic calcium, 1 kg bone meal, and 1 kg cow liver be added weekly to a large container. Additionally, each week, one of the elements (1 kg of copper, zinc, or magnesium sulphate, or boric acid) is added until all of them are used. Small experimental plots the farmers themselves did, showed a significant difference to them where plant growth and health are concerned.

- Teas

There are many ways of preparing teas: by infusion, fermentation or hydrolysis. The infusion is the easiest way and quickest, however, for the same reason, its effect is not as strong. The herb to be used is steeped in boiled water for 24 hours, then diluted for use. Fermented teas are the next easiest. Herb hydrolates require a somewhat sophisticated set-up of glassware.

However, researchers at the Tunja Pedagogical and Technological University (Colombia) devised a way to prepare a very similar product using a pressure cooker.

Fermented teas are obtained through the controlled decomposition of particular plants, chosen for their medicinal, allelopathic or nutritional properties. When they are well prepared, the biochemical and energetic principles of the plants are potentiated through the action of micro-organisms which stimulate the nutrition, growth or health of the crops, and prevent pests and disease (Ramírez, 2001).

Fermented nettle water alone or in combination with animal manure was quite popular among the farmers. It was recommended by two of the consultants brought in as a rapid source of nitrogen, with the added effect of controlling aphids when only nettles are used. The consultants particularly recommended its use on leaf crops, and since spinach, parsley and coriander are grown a lot in Cota, adoption of this practice was quite rapid. Results were quickly noted by the farmers, each of them adjusting its use according to individual experience. (For example, they noted that if the nettle and manure water was applied too concentrated, it could cause premature bolting in parsley, thereby reducing the harvesting period for the crop). Research on the effect of nettle water corroborates these results. Peterson and Jensén (1985) found that nettle water contains a high amount of nitrogen (up to 42.5mM when made with fresh nettles), especially in the form of ammonium. Storage of the water increased nitrogen content. They also found that the water provided a good source of many other nutrients such as high levels of N, P, K and low levels of Ca, Mg, and S when young plants were used, while the reverse was true for older plants. Other elements such as iron, boron, manganese, zinc, and to a lesser extent copper and molybdenum, were also found. With such results, the authors recommended the use of nettle water 'as a complete nutrient source or as an additive during conditions of mineral shortage'.

- Microbial soups

Plants growing under natural conditions excrete substances through their roots that attract micro-organisms that are beneficial to them, either because they help make nutrients available to them or protect against diseases. According to research by Ramirez (2001) some plants are more active in attracting micro-organisms, as is the case of borage (*Borrago officinalis*), nettle (*Urtica urens* and *U. dioica*), lemongrass (*Cymbopogon* sp.) and leek (*Allium porrum*). The particular microbial soup used here was developed by macerating the roots of the three first plants listed above. Legume and grass plants grown under similar conditions should also be collected. Molasses, yoghurt and a legume flour are added weekly as a source of nutrients while the microbial population builds up.

- Individual elements

To complement the organic amendments, the following elements were also distributed as mineral soil amendments among the farmers according to the fertiliser recommendations made for each farm:

Table 6.3 Inputs for 1000m² provided to participant farmers to help in balancing plot fertility.

Inputs (kg)	Dolomitic calcium	Compost No.2	$CaSO_4$	Potassium Nitrate KNO_3	$MgSO_4$	Phosphorite	$MnSO_4$	CuS	$ZnSO_4$	Boric acid
FC	50	200	0	15	20	35	3.5	0	0	0.5
JMS	50	200	0	15	10	35	2	0.5	0.5	0.5
PC	50	200	0	0	15	30	3.5	0	0	0.5
JC	50	200	0	0	15	30	3.5	0	0	0.5
JPT	50	200	20	25	30	30	3.5	0.3	0	0.5
JT							1			0.5
JA	50	200	0	25	20	30	3.5	0	0	0.5
RT	50	200	30	15	30	30	3.5	0	0	0.5
VS	50	200	0	25	25	30	2	0	0	0.5
MC	50	200	0	25	25	30	2	0	0	0.5
MP	50	200	0	25	25	30	2	0.5	0	0.5
AM	50	200	0	30	30	30	3.5	0.5	0.5	1
PB	50	200	30	30	10	30	2	0	0	0.5
C&LAC	50	200	0	0	30	30	3.5	0	0	0.5
JS	50	200	25	25	25	30	3.5	0.5	0	0.5
JS&LT	50	200	0	20	25	30	1	0	0	0.5
EG (600m²)	50	100	20	25	20	30	2	0	0	0.5
MVS (100m²)	25	50	0	20	20	20	2	0	0	0.5

The above describes how the soil systems management methodology was implemented on the farms from the point of view mineral fertilisation, mineral soil amendments and organic inputs. Neither erosion nor leaching of nutrients has been measured in these particular farming systems. However, farmers have come to recognise the loss of soil due to small whirlwinds that occur at particular times of the year. In this sense, and the information on reducing N leaching by tree root systems, the planting of hedgerows helps (improved crop-tree systems).

Table 6.4 Laboratory results showing changes in soil fertility over time for four farms in Cota

				ppm										CIC
		PS	pH	CE	%C org	N-NH4	N-NO3	N-Min	% N total	P	K	Ca	Mg	(meq.100g^{-1})
	optimum	>30	5.8-6-5	<0,74	>2.9			25-50		30-60	108-162			
Name	Date													
Cristobal Segura	Jul-01	20.7	6.5	0.84	---	61.7	14.8	---	---	366	539	4866	563	50.6
	Nov-01	60.8	7.4	0.49	4.98	16.8	27.0	43.8	0.67	469	337	3245	357	50.1
	May-02		6.3	1.4	5.56	---	---	---	0.70	137	457	5294	455	44.5
Francisco Castro	Dec-98	106	6.5	0.84		14.8				366	539	4866	563	50.6
	Aug-00	93.1	6.4	1.99		60.3				453	1237	4926	616	48.2
	Apr-01	63.4	6.6	0.97		16.8	19.5	36.3		297	441	4960	450	60.9
	Nov-01	94.8	6.6	1.69	6.91	43.8	117.8	161.5	0.82	223	425	3258	337	59.6
	May-02	---	6.7	0.84	7.45	---	---	---	1.02	196	1395	5795	632	52.8
Cano Carlos	2000	65.5	5.6	5.46		46.3	667			677	1849	4263	599	44.8
	Apr-01	88.6	6.1	4.05		42.3	444.2	486.5		289	1692	8065	609	43.8
	May-02		6.7	1.34	7.76				0.87	372	1540	6936	842	52.5

Results of E/INM

There is an almost total replacement of chemically synthesized fertilisers by organic sources (see Appendix 5 on adoption of organic practices). In effect, most farmers hardly ever buy the chemical sources, rather they rely on needs as determined by the soil analysis and use home-made organic fertilisers supplemented by natural sources of additional elements. There are a few exceptions, where the farmers still apply some chemically synthesised fertilisers. These cases correspond to farmers who have decided to follow the integrated rather than the ecological farming methods and are at least managing fertiliser applications according to analyses.

Soil structure is beginning to be recovered: where farm soils were definitively powdery, now they have more aggregates, which is one of the indicators used by farmers to monitor their progress.

In some cases, an increase in N was noted despite the fact that neither chicken manure, nor any other source of nitrogen, was applied. This can be attributed to the fact that previously unavailable N was made available by increasing microbial activity through the addition of molasses and compost as food source, increasing micro-organism populations through the application of microbial soups, and the reduction or total non-use of chemical pesticides which would reduce populations. This is corroborated by Arden-Clarke and Hodges (1988) who mention, 'as a result of the increase in microbial (and to a lesser extent soil fauna) populations, the quantity of potential mineralisable, and therefore available, N usually increases'. Most farmers implemented introduced techniques that were aimed at activating the circulation of nutrients by restructuring the farm system they were working on. This they did by working on synchronizing plant and soil processes through multiple cropping; using farm-prepared compost and other organic or botanical fertilisers; correcting mineral deficiencies or imbalances by adding products to enhance the balance of soil fertility (see table 6.3); using volunteer plants as dead ground cover, in the compost or in the many botanical products used; and finally, as shall be seen in section 6.1.6 and Chapter 10, actively managing farm ecological infrastructure.

Minimal soil cultivation

This method addressed the problems listed by the farmers in table 4.1 of soil quality and compaction, and lack of information on alternatives available due to poor technical assistance.

Early on in the project, our activities coincided with those of the UMATA in this area. Generally in the Department of Cundinamarca, there was a move among the UMATA to apply to the Secretary of Agriculture for specific machinery to be managed by them. At least 25 municipalities were awarded, among which was Cota. The machinery requested and received were a tractor, with a sub-soiling cultivator and a polisher, based on the research done by the UMATA technician as to the most appropriate equipment from the points of view of local needs (number of farmers requiring the service) and minimal damage to soil structure. This equipment is rented out to the farmers at cost, which covers maintenance, the salary of the tractor driver and gasoline.

However, for many farmers in this project, by diversifying the crops sown at a time (intercropping, etc.) and by programming crop sowings, the area actually requiring preparation at any one time ended up being quite small. On some occasions, the farmers would actually prepare those areas by hand. On others, the tractor was not necessary, rather, they used the rototiller, which is smaller and lighter weight and so therefore has less effect of compaction.

6.1.3 Water management

Cota is renowned, unfortunately, for supposedly using the Bogotá river to water the vegetables. Those farmers who do in fact use that source are few. Water used for irrigation by the farmers of this project is typically drawn from a 10-15 meter well, a drill hole of up to 25 meters or from small reservoirs that are self-replenishing. The water analyses taken showed chemical results that are acceptable for vegetable farming, although in some cases some salts were a little high. In one case where water was suspected as a possible source of plant pathogenic fungi or bacteria, results showed high levels of *Fusarium*. This was explained by the fact that the water was recycled from a vegetable-washing centre. Finally, analyses were also taken for coliform levels, in order to hopefully provide the farmers with support in the event that the Good Agriculture Practices protocol was approved. Mixed results were found. Most farms were deemed apt for vegetable irrigation. Others with levels at the limit of acceptability would require treatment.

Before intervention water was applied on a routine basis and not according to crop requirements, climatic factors or soil type. Furthermore, the irrigation equipment typically used resulted in large drops which could affect the crops at young stages. Water coverage could be in excess in some areas while deficient in others, especially the farm borders. An irrigation trial was therefore set up to compare two alternative systems: drip irrigation and micro-irrigation, each on two farms. Preliminary trials demonstrated to the farmers that much less water was used by both systems when compared to theirs. Unfortunately, more detailed data was not available when this book went to print, as the unpredictable rainy season went on much longer than expected, precluding the need to irrigate, although the farmers have shown initial interest in expanding the trial areas.

Additional activities to promote water conservation such as cover crops, mulches, addition of organic matter, and introduction or enhancement of live fences are covered in future paragraphs of this section.

6.1.4 Cropping systems management

Multi-functional cropping systems (MCS)

Crop rotation for pest and disease management was combined with rotations among types of crops or functional groups so that different nutrients are used and the land does not 'get tired' (local expression). The farmers have learned to rotate keeping those two factors into account. Tables 6.5 and 6.6 show the different crops the farmers typically sow and their categorisation according to the two factors described. Legumes are also encouraged in the rotation because they are both different family and a different type of crop, as well as an internal source of nitrogen. However, the variety of legumes of commercial value that can be grown under the local climate conditions is low; only peas and certain varieties of beans are cultivated.

Table 6.5 Crop classification by family and functional group of crops typically grown by the farmers in Cota.

CROP	FAMILY	FUNCTIONAL GROUP		
		Leaf	**Flower /fruit**	**Root**
Lettuce cultivars	Compositae	x		
Radish	Cruciferae			x
Broccoli	Cruciferae		x	
Cauliflower	Cruciferae		x	
Spinach	Chenopodiaceae	x		
Swiss chard	Chenopodiaceae	x		
Beets	Chenopodiaceae			x
Celery	Umbelliferae	x		
Coriander	Umbelliferae	x		
Parsley	Umbelliferae	x		
Carrots	Umbelliferae			x
Zucchini	Cucurbitaceae		x	
Leek	Liliaceae	x		

For their own consumption they might also have:

Table 6.6 Classification of some other crops grown for home consumption according to family and functional group.

CROP	FAMILY	FUNCTIONAL GROUP		
		Leaf	**Flower /fruit**	**Root**
Potatoes	Solanaceae			x
Cubios (*Tropaleolum tuberosum*)	Oxalidaceae			x
Corn	Graminea		x	
Peruvian carrot (*Arracacia xanthorrhiza*)	Umbelliferae			x

Other criteria for crop selection based on crop effect on soil structure and fertility, including aspects such as N off-take, transfer and needs, were considered but then discarded in this case. The reason for this was that such factors or criteria are difficult for farmers, especially in the context of small farmers in developing countries, and they would not have easy access (financial or otherwise) to such analyses or information. Rather, based on the above information, such criteria as insisting on the inclusion of leguminous crops within rotations or as cover crops, can be used as a way of ensuring N availability in the crop rotations. In this way, a MCS will be developed according to the developing country small farmer context. Overall N balance was, however, taken into account in the farm sustainability evaluation.

The MCS was instrumental in working toward the solution of several of the problems described by the farmers in the participatory diagnosis. Using the terms of the farmers, soil quality (physical, chemical and biological), crop protection, reduction of quantity and toxicity of chemical pesticides, and reduction of production costs, were addressed. In both cases, stability was sought where inputs are concerned, so that the very balance achieved by crop combinations would provide solutions to pest and disease management, soil quality improvement with least investment (efficient energy flows) while providing sufficient economic return to make farming worthwhile.

Integrated Crop Protection

There is a significant difference between the European experience and that of Colombia in this area as the percent of production costs attributed to such control in Europe is very low (Van Lenteren, 1992, mentions 2% in the case of tomatoes) where in Colombia it can be as much as 30 to 40% of costs. Applying the principles of the 'total system approach' described by Lewis et al. (1997), natural or botanical 'pesticides' and biological control agents are used here as a substitute for the chemical ones during the period of time required for the agroecosystem to recover its resilience, or the capacity to withstand 'shocks', such as an imbalance in insect populations leading to a pest situation. It is important to stress here that the strategy of input substitution is precisely used to help re-establish system resilience, and should not be the only strategy used for the farm to be considered 'sustainable' (Altieri et al., 1997). Such botanical pesticides and bio-control agents are generally not as harmful as chemical ones, are more target specific (they do not kill beneficial insects or other fauna[10]), can be effective in small quantities and do not leave residues (Alam, 2000). Hopefully, over time, and in combination with a compatible farm management system including aspects of landscape ecology, as system links are re-built, these products will be required less and less. Rather than work against nature, work with her, and while the farmers get to know her better, how she works and how they can work with her, some therapeutic or palliative measures will have to be used. These considerations are essential to the *conversion process* to ecological production.

Often the problem associated with chemical applications is that the wrong product is used. The farmers do not have the sufficient information to be able to ask for the appropriate product and it is very difficult for the salespeople, even if they had the technical knowledge, to guess what the problem is from an oral description. Basic knowledge on the cause of plant destruction was therefore necessary before the farmers could progress. They needed to understand the difference among fungi, bacteria and soil pests, and among the different types of foliar insects. Working with them on an individual basis helping them to identify the causal agent in their fields and also bringing them to the Horticulture Research Centre for training on life cycles and pests and disease identification (including stints with the stereoscopes), were critical for this. With such basic knowledge, they were then armed to be able to decide on the most appropriate control methods. Sherwood (1997) found similar results in Central America when increased access to information through training enabled farmers there to broaden the number of disease management alternatives. Trutmann et al. (1996) suggest that combining local knowledge on disease identification with basic principles of life cycles and management, could be most useful.

Emphasis here, therefore, was first on the reduction of the toxicity of pesticides used, encouraging the restriction if not total elimination of levels 1 and 2, then on the gradual substitution with natural products such as botanical and microbial controls, considered to have fewer environmental and health problems than conventional pesticides (Tripp and Ali, 2001). This process was to help the gradual reclaiming of the natural state (or resilience) of the farm where, by combining these strategies with that of ecological infrastructure management, life cycles could be restored (for example prey-predator relationships).

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[10] This is usually true, with some exceptions. For example, neem, *Tephrosia purpurea*, and tobacco have in fact been prohibited by the IFOAM due to their wide spectrum (Uriel Contreras, pers.comm., 2001).

Among the options for ICP and reducing or eliminating totally the use of chemical pesticides are antagonistic fungi. Given the appropriate conditions (climatic when applying, and existing organic matter in the soil, for example), these fungi can be used to manage pathogenic fungi. Here, we introduced *Trichoderma harzianum* for management of *Sclerotinia sclerotiorum* in lettuce particularly. We also did trials to see whether it could have an effect in balancing populations of *Fusarium*, which in the case of *F. oxysporum* were found to vary between 200 and 5600 cfu in the soil samples analysed. Some conflicting information exists as to the significance of the presence of *Fusarium* sp.: some references in the literature suggest that species richness of *Fusarium* sp. could in fact be an indicator for progress in the transition toward organic soils[11]. Here, however, *F. oxysporum* was found in soil of diseased coriander plants, so its presence was considered potentially limiting and action taken to improve population balance by using *Trichoderma* and applications of chamomile infusions (Mejía, 1995). Secondary effects of the use of *Trichoderma* have been described. Yedidia et al. (2001) observed significant increases in root area and length, also in dry weight, shoot length and leaf area when cucumber plants were inoculated. The concentration of certain nutrients (Cu, P, Fe, Zn, Mn, and Na) in the roots also increased dramatically. Of particular interest is the capacity of *Trichoderma* to solubilise P sources. By combining the use of *Trichoderma* with cultural control of *S. sclerotiorum* through removal of infected plants before attaining sclerocial stage, one farmer who previously could not get out a lettuce crop was able to harvest 80% on the first cycle this strategy was implemented. Other farmers who have kept cultural control as primary strategy and used *Trichoderma* and in some cases chamomile preparations as back up, are convinced these natural methods work.

Another microbial organism we introduced was *Bacillus thuringiensis* for management of lepidopterous pests. The procedure was in fact to spray affected areas first with a hydrolate of garlic and hot pepper and the next day, in late afternoon hours, to spray with B.t. The effect of the hydrolate was to repel the lepidopteran from the interior of the plants, ensuring that they would not die inside and cause repellence by the consumers! Subsequent feeding on the *B.t.*-sprayed leaves, ensured their final demise. Again, the farmers were very pleased with the results.

Fermented teas (discussed above) and infusions of many different plants were introduced to help in the management of various pest and diseases. A full list of those suggested is provided in table 6.7.

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[11] Elmholt (1996) found that *F. solani, F. equiseti, F. culmorum* and *F. tabacinum* are more abundant in the first years of transition to organic farming.

Table 6.7 Main plants used as infusions or fermented teas for plant protection purposes.

PLANT	FOR THE MANAGEMENT OF
Nettles (*Urtica urens*)	Aphids, many species
Fern (*Pteridium aquilinum*)	White grubs, stem borer, *Epitrix* sp.
Wormwood (*Artemisia absynthium*)	Slugs
Calendula officinalis	Bacteriosis
Horsetail (*Equisetum bogotense*)	Fungi, especially in Solanaceae
Bidens pilosa	Late blight *(Phytophthora infestans)*
Rue (*Ruda graveolens*)	Fungi, especially anthracnosis in lettuce
Chamomile (*Matricaria chamomilla*)	Fungi, especially *Fusarium*, *Pythium* and *Sclerotinia*
Garlic-Chile (*Allium sativum –Capsicum sativus*)	Insects, especially Lepidopterous

Other references corroborate our findings on the efficiency of plant extracts in managing diseases and pests. Singh and Singh (1993) mention the effects of garlic as a molluscicide, broadening its use from anti-fungal and anti-helminthic. Reyes and Rodriguez (2001) used different combinations of plant hydrolates in the management of *Sclerotium cepivorum* and *Ditylenchus dipsaci* of onion. They found that a mix of *Matricaria chamomilla* (chamomile), *Solanum nigra* and *Eucaliptus globulus* (eucaliptus) and a mix of *Tagetes* sp, (marigold), *Taraxacum officinale* (dandelion) and *Datura stramonium* were the most effective in controlling sclerotia of *S. cepivorum*, while a treatment with *Crotalaria juncela*, *Ruda graveolens* and *Malva sylvestris* provided good control of both disease and nematode incidence. Endersby and Morgan (1991) mention several plants with repellent effects on caterpillars of crops from the cabbage family: *Mentha piperita* (peppermint), *Eucalyptus* sp., *Lycopersicon esculentum* (tomato), *Sambucus nigra* (elder), *Thymus vulgaris* (thyme), *Artemisia absynthium* (wormwood), *Allium cepa* (onion), among others.

Since there is very little information on compatibility among these various natural alternatives, we implemented a small project to determine the effectiveness of three plants in the management of *S. sclerotiorum* and their effect on *Trichoderma*. At laboratory level, trials were done comparing a commercial source of hydrolate of *Ruda graveolens* (rue), *Calendula officinalis* (calendula) and *Matricaria chamomilla* (chamomile) with homemade fermented teas of the same. Chamomile is well known for its fungicidal effects (Mejía, 1995), while calendula is generally used as an anti-bacterial agent. However, in Cota, the farmers have grown used to applying both together as calendula has the added effect of augmenting the effect of other products. Rue helps in the management of other fungi such as anthracnosis particularly. These products were tested separately and in different combinations for their effect on *S. sclerotiorum* as well as their possible effect on *Trichoderma*. This small project was important as the last thing we wanted was to be applying *Trichoderma* as antagonistic fungus on the one hand and on the other killing it through the application of botanical products with fungicidal properties!

The trials consisted in determining the effect of commercial hydrolates of *R. graveolens, C. officinalis* and *M. chamomilla* on micelial growth of *Sclerotinia* sp. and *Trichoderma* sp. Sclerotinia was isolated from samples taken in lettuce crops of Cota. The main results of these trials showed that the three commercial hydrolates completely inhibited growth of *Sclerotinia* sp, either individually or mixed together. Where *Trichoderma* was concerned, a slight reduction in micelial growth was observed as compared to the control. The hydrolates of *C. officinalis* and *M. chamomilla* showed the least negative effects. Among the mixtures, the mix of *C. officinalis* and *M. chamomilla* affected Trichoderma growth the least, where as the mix *M. chamomilla* and *R. graveolens* showed the lowest growth rates among all treatments evaluated. Appendix 6 includes figures showing the effect of the different treatments on the growth of the two fungi.

Finally, also included in ICP are larger animals and birds. In this case, birds could on occasion be a problem, as they delight in getting meals from lettuce and zucchini particularly. Simple physical management techniques were used. For example, the ribbon from old cassettes is an excellent scaring device when hung around a crop. No other vertebrate pests caused significant damage to be limiting.

An advantage of many of these products is that the farmers can produce them themselves, thereby reducing their dependence on outside factors (Tripp and Ali, 2001). However, product stability and especially maintaining quality can not be ensured since each farmer may have a variation on the method of preparation, and in fact the plant source may have different contents depending on the time of harvest, as Peterson and Jensén (1985) found for nettles, and on each farms soil fertility. So, as Tripp and Ali (2001) ask: 'What is the most appropriate scale and level of production for natural pest control products in order to ensure wide-spread adoption? Should they be the subject of farm-level or village-level production, or should they be provided by commercial firms?' Some of the conclusions derived here are that although they could feasibly be produced by each farmer, that would entail more work for each. As experienced by Bentley and Andrews (1991), care must be taken not to assume that because farmers are poor, they will be willing to undertake hard, time-consuming tasks. Some farmers have more patience and interest in making such products and could therefore become a small village-level business. But such manufacturing would probably be limited to providing for other small farmers. The requirements for larger farmers would probably have to be supplied by commercial firms, which because of the overhead associated with being a firm, will also have higher prices which larger farmers can afford. However, there is still another point that must be brought up regarding products manufactured by commercial firms, which is that of registering the products. To be able to sell in a commercial inputs store, the products must be registered with the ICA, which has a price. This price is typically established for chemically synthesised products which are manufactured by large, rich multinationals. Natural products to date, at least in Colombia, are made by small businesses barely managing to stay afloat because of the innovative status of their products which have not made it yet to the larger market place[12]. Such businesses definitively do not have the financial capacity to register their products under the same conditions as chemical companies. In fact, although current legislation is the same for all, being of natural occurrence, it is quite possible that certain tests not be required, thereby bringing down the price of registration. Another current obstacle to the use of commercial bioproducts is their availability which is still quite limited.

Many of these natural products work better when used preventively. This is similar to the idea of ecological agriculture which tries to prevent rather than cure. However, although such a strategy is more cost-effective, it is also much more knowledge intensive (Trutmann et al., 1996). Bentley and Andrews (1991) provide the example of farmers in Honduras that would have to do preventative slug control three months before planting a bean crop to avoid future problems. The farmers did not see this as crucial; as one farmer remarked, 'we fetch the pill when we have a headache'. Typical of farmers worldwide, these are crisis managers (ibid). Understanding the reasons for such prevention strategies is therefore crucial to the success of this ICP method.

Another important point is the use of a combination of different methods in the management of pests and diseases, integrated into a complete management program (Endersby and Morgan, 1991), which is what is intended here.

As a result of these methods, we have observed the following:

- Considerable reduction in chemically synthesised pesticide use (choice is first on botanical and biological inputs based on the list provided by the project, then only level III or IV chemical products).
- The addition of micro-organisms has improved the capacity to grow crops that had previously serious limitations due to diseases, through use of microbial soups and addition of antagonistic fungi; crops have been harvested where before they could not be grown.

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[12] There are exceptions. Biobest and Koppert have through time become large firms for the production of biological control agents. Aventis has recently opened a biological control section.

6.1.5 Marketing strategies

A full course on marketing and a second one on post harvest technology were given in a practical way to the farmers as well as to any members of the existing commercialisation organisations of the municipality. Some of the ideas developed in these courses were put into practice. Chapter 7 covers the methods used in this methodology more fully.

6.1.6 Ecological infrastructure management

This method addresses the following solutions to problems listed by the farmers: establishment of live fences to reduce wind effect on water evaporation; also to diversify crops and have available on farm the materials required for home preparation of inputs.

Full details on how ecological infrastructure management was implemented here are provided under Chapters 9 and 10.

6.1.7 Farm overall sustainability

Calculation of production

We compared prices between the preparation and use of biopesticides and the purchase and use of commercial biopesticides and chemical pesticides. The main difficulty to be able to do the calculations was associated with prices for material available naturally on the farm, such as nettles or manure. We resolved to base the price on the time required to collect the material. Table 6.8 shows the costs of primary materials used for the various home preparations.

Table 6.8 Value assigned to primary materials used in home preparations of farm inputs (calculations prepared by Alex Mórtigo in 2001).

Item	Reference	Unit	Cost (Col pesos*)
1 day of labour in Cota	Cota farmers	Day: 9 hours 1 hour 1 minute	$ 15,000 $ 1,666 $ 27
Plant material	Time to collect: 15 minutes	1 bunch (1-7 kg)	$ 405
Molasses	Store price (Agro Punto)	1 kg	$ 405
Water	Utility service (EmserCota), stratum 1, consumption 0-20m^3	1 m^3 1 litre	$ 325 $ 0.325
Wooden planks	Local carpentry store	1 plank (5x20x300cm)	$ 4,000
Wood laths	Local carpentry store	1 (5x5x2cm)	$ 500
Nails	Local store	1 lb	$ 1,600
Machete	Local store	1	$ 7,000
5 gal. Bin	Local store	1	$ 10,000
55 gal. Bin	Local store	1	$ 30,000
Cotton veil	Local store	1 package	$ 850
Plastic string	Local store	1 roll	$ 1,700
Cow manure	Cota farmers	1 pail-full (5 kgs); 5 minutes	$ 135
Chicken manure	Local distributor	Bag of 50 kg	$ 2,500
Rabbit manure	Miguel Piza (farmer)	1 wheelbarrow-full (50kg); 10 minutes	$ 270
Gas	Price of 50 lb cylinder	1 minute of lighting	$ 2

*The Colombian peso was valued at approximately $2,300 per US dollar in June 2002.

Based on the previous price list, the following table shows how the costs to prepare a fermented tea were calculated.

Table 6.9 Calculation of cost of home production of 15 l of fermented tea.

Item	Unit	Quantity required	Unit cost (Col $)	Cost (Col $) of amount used
Plant material	Bunch	1	$ 405	$ 405
Water	Litre	15	$ 0.325	$ 5
Microbial soup	Cup	200 cc	$ 800	$ 800
Bin	5 gallons	1 (over 100 uses)	$ 10000	$ 100
Laths	Lath	1	$ 500	$ 50
Cotton veil	Package	1	$ 850	$ 85
Machete	Machete	1	$ 7000	$ 10
String	Roll	1	$ 1,700	$ 170
Preparation time	Minutes	10	$ 27	$ 270
TOTAL / 15 l				$ 1875

The price per litre is therefore $126. This concentrate is diluted 1:5 with water for applications, so that for each 20 litre application costs $505. The price goes up $54 per additional plant used in the tea.

The next tables provide the costs of production for a tea infusion, a nettle-manure fermented tea, compost and vermicompost.

Table 6.10 Calculation of costs of home production of 15 l of tea infusion.

Item	Unit	Quantity required	Unit cost (Col $)	Cost (Col $) of amount used
Plant material	Bunch	1	$ 405	$ 405
Water	Litre	15	$ 0.325	$ 5
Gas	Minutes used	15	$ 2.13	$ 31
Bin	5 gallons	1 (over 100 uses)	$ 10,000	$ 100
Cotton veil	Package	1	$ 850	$ 85
String	Roll	1	$ 1,700	$ 170
Preparation time	Minutes	10	$ 27	$ 270
TOTAL / 15 l				$ 1066

The value per litre of infusion is therefore $71, which is then diluted 1:5 in water for application, bringing the value of a 20 l application to $284.

Table 6.11 Calculation of costs of home production of nettle-manure fermented tea.

Item	Unit	Quantity required	Unit cost (Col $)	Cost (Col $) of amount used
Nettles	Bunch	1	$ 405	$ 405
Cow manure	Pail-full	5 kg	$ 135	$ 135
Water	Litre	15	$ 0.325	$ 5
Microbial soup	Cup	200 cc	$ 800	$ 800
Bin	5 gallons	1 (over 10 uses)	$ 10,000	$ 100
Pail	Pail	1	$ 5000	$ 50
Laths	Lath	1	$ 500	$ 50
Cotton veil	Package	1	$ 850	$ 85
Machete	Machete	1	$ 7000	$ 70
String	Roll	1	$ 1,700	$ 170
Preparation time	Minutes	10	$ 27	$ 270
TOTAL / 15 l				$ 2095

Thus, the litre of concentrate costs $274, leading to a cost of $1096 per 20 litre application with a 1:5 dilution.

Table 6.12 Calculation of costs of home production of a basic compost (no fertiliser added).

Item	Unit	Quantity required	Unit cost (Col $)	Cost (Col $) of amount used
Crop waste	Days to collect 2000 kg	4	$ 15,000	$ 60,000
Chicken manure	50kg bag	4	$ 2,500	$ 10,000
Water	Litre	200	$ 0.325	$ 6.5
Microbial soup	Gallon	1	$ 20,000	$ 20,000
Wood planks	Plank	11 (15 uses)	$ 4,000 ($ 44,000)	$ 2933
Wood posts	Post	4 (15 uses)	$ 4,500 ($ 18,000)	$ 1,200
Nails	Lb	1	$ 1,600	$ 160
Preparation time	Minutes	30	$ 27	$ 810
TOTAL / 750kg				$ 95109.5

Note: The time required to make the box was considered insignificant, as it was estimated at 30 minutes, which must be spread over the lifetime of the box (approximately 5 years).

Thus, the cost per kilogram of home-made compost comes to $127.

Table 6.13 Calculation of costs of home production of vermicompost

Item	Unit	Quantity required	Unit cost (Col $)	Cost (Col $) of amount used
Kitchen leftovers	Bunch	9	$ 405	$ 3,645
Compost	Kg	90	$ 128	$ 11,594
Worms	Kg	2	$ 7,000	$ 14,000
Microbial soup with water	Litre	80	$ 4005 (20 l)	$ 16,020
Wood planks	Plank	3 (15 uses)	$ 4,000	$ 800
Nails	Lb	1 (15 uses)	$ 1,600	$ 106
Cotton veil	Package	1	$ 850	$ 85
Preparation time	Minutes	15	$ 27	$ 405
TOTAL / 157 kg				$ 46655

Note: The time required to make the box was considered insignificant, as it was estimated at 20 minutes, which must be spread over the lifetime of the box (approximately 5 years).

Thus, it costs $297 to produce a kilogram of vermicompost on the farm.

With this information, we can now compare prices with commercial inputs.

Table 6.14 Price comparison of home preparation of plant production inputs. Prices based on the cost for a 20 l mixture ready for spraying in the case of liquids and the cost of one kilogram for the solids.

Chemical – commercial	Cost	Botanical – commercial	Cost	Botanical - homemade	Cost
Fungicides					
Polyram	$1,156	Chamomile hydrolate	$ 1,931	Chamomile fermented tea	$ 505
Score	$1,906	Rue hydrolate	$ 2,041	Chamomile infusion	$ 284
Kasumin	$1,071				
Validacin	$1,386				
Ridomil	$1,526				
Insecticides					
Lorsban	$636	Garlic-chilli hydrolate	$ 2,041	Garlic-chilli fermented tea	$ 559
Decis	$1,756			Nettle fermented tea	$ 505
Latigo	$1,331			Fern fermented tea	$ 252
Soil amendments					
Soil-Aid compost	$160	Triple 15	$ 840	Nettle-manure fermented tea	$ 1096
Chicken manure	$ 42			Compost	$ 127
				Vermicompost	$ 297

From these price comparisons, we can see that generally it is cheaper to produce the botanical inputs at home than to purchase them on the market. Production costs go down as a result. However, commercial biopesticides are more expensive than the chemical pesticides, which is no incentive to larger farmers.

Energy efficiency comparison

Another study was undertaken to compare energy efficiency between the conventional system and systems one year into the conversion process. The basis for this comparison is the fact that the ultimate purpose of the agricultural activity is that of converting solar energy through photosynthesis to energy in the form of food for human and animal consumption. While simple or primitive agricultural systems relied mainly on the spreading of seed and the climate to actually have a crop for harvest, modern agriculture has made use of science and technology to increase productivity. The latter depends on subsidised energy such as fossil fuels, machinery as well as chemical inputs. Since the ecological farming systems seeks to lean on natural cycles for more efficient use of internal energy, among other objectives, it was relevant to try and determine whether the effort here was or not moving in that direction.
Information on energy inputs and outputs was collected for five farms per system during five months in 2001. Energy used was converted to energetic units (kilocalories) in order to

calculate energy efficiency and determine the ratio outputs: inputs. In general terms, the system under conversion was found to be the more efficient of the two (Parrado, 2001).

Evaluation of farm sustainability

Integrating all of the methods adequately should lead to farm overall sustainability, which supports the call made by Altieri et al. (1997) for an integrated agroecosystem approach:

> *"Agroecology states that the health and performance of agroecosystems depends on how well established is a diverse assemblage of natural enemies and antagonists. By assembling a functional biodiversity, it is possible to potentiate synergisms that subsidise agroecosystem processes by providing ecological services such as the activation of soil biology, the recycling of nutrients, the enhancement of beneficial arthropods and antagonists, and so on."*

By using the software programme described in section 5.4.7, we are able to evaluate the overall farm sustainability before and after intervention. Here we report on the results of four farms (tables 6.15a through h) and also present a comparison among the farms of the results obtained before and after (table 6.16). The farms were chosen for being representative of the group of participant farmers. Each joined the project at different times (see Appendix 3). Francisco Castro was among the first five farmers of the pilot project and thus had been participating for nearly three years. Cristobal Segura was the last to join, with almost a year in the project. In general terms, an improvement is observed in the four farms. However, water remains the weakest component of the system. Different interpretations can be made from these results, depending on the weight given each indicator and component. Here, equal weight was given to each indicator.

Tables 6.15 a to h. Evaluation of the indicators by component. A total of 20 indicators were evaluated. Prices used correspond to those placed on the Ministry of Agriculture website for week 25 of 2002. Indocator values are calculated as 1 = accomplishes desired value and 0 = does not accomplish desired value. Total system sustainability is given in percentage.

Table 6.15a Evaluation of the indicators by component. Farm of Francisco Castro – 'pre'

Soil component	**Value Obtained**	**Desired Value**	**Indicator value**	**% Component**
Soil quality index	0,2	>0,6	0	
Soil biological activity (worms.m^{-1})	12	>20 individuals.m^{-2}	0	
Subtotal			0	0
Water component				
Productive efficiency of water	1.008	<500 m^{3}.tn^{-1} of DM	0	
Water index	1,34	0,95-1,05	0	
Subtotal			0	0
Plant component				
Number of non-crop species	5	>3	1	
Number of individuals of non-crop species	24	>3	1	
% losses in pre-harvest	20	< 30%	1	
Crop rotation by family and product type	4	<3	0	
Subtotal			3	75
Technological component				
Nitrogen balance	-1.184	>0 kg.farm^{-1}	0	
Energy efficiency index	0,09	>3	0	
% inputs of natural source	0	>50	0	
Average yield T.ha^{-1}.year^{-1}	90	>12	1	
% input self-sufficiency	0	>20	0	
Subtotal			1	20
Economic component				
Net income.ha^{-1}.year^{-1}	8.917.250	> 467100	1	
Gross income.ha-1.year-1	51.732.477	>4720000	1	
Net annual profitability	20,83	> 20%	1	
Marketing activities index	0	>=2	0	
Subtotal			3	75
Socio-cultural index				
Permanent employment	7,5	>1employees.ha^{-1}	1	
Participation index	1	>=1	1	
% implementation of new organic practices	0	>50%	0	
Subtotal			2	67
TOTAL FARM SYSTEM			**9**	**45**

DM = dry matter

Table 6.15b Evaluation of the indicators by component. Farm of Francisco Castro – 'post'

Soil component	Value Obtained	Desired Value	Indicator value	% Component
Soil quality index	0,2	>0,6	0	
Soil biological activity (worms.m^{-1})	22	>20 individuals.m^{-2}	1	
Subtotal			1	50
Water component				
Productive efficiency of water	926,6	<500 $m^3.tn^{-1}$ of DM	0	
Water index	1,19	0,95-1,05	0	
Subtotal			0	0
Plant component				
Number of non-crop species	11	>3	1	
Number of individuals of non-crop species	75	>3	1	
% losses in pre-harvest	22,0	< 30%	1	
Crop rotation by family and product type	4	<3	0	
Subtotal			3	75
Technological component				
Nitrogen balance	-19.840	>0 kg.$farm^{-1}$	0	
Energy efficiency index	0,11	>3	0	
% inputs of natural source	83,6	>50	1	
Average yield T.ha^{-1}.$year^{-1}$	118	>12	1	
% input self-sufficiency	7,6	>20	0	
Subtotal			2	40
Economic component				
Net income.ha^{-1}.$year^{-1}$	16.778.536	> 467.100	1	
Gross income.ha-1.year-1	70.394.020	>4.720.000	1	
Net annual profitability	31,29	> 20%	1	
Marketing activities index	1	>=2	0	
Subtotal			3	75
Socio-cultural index				
Permanent employment	7,69	>1employees.ha^{-1}	1	
Participation index	2	>=1	1	
% implementation of new organic practices	50	>50%	1	
Subtotal			3	100,0
TOTAL FARM SYSTEM			**12**	**60,0**

DM = dry matter

Table 6.15c Evaluation of the indocators by component. Farm of Pedro Calderón – 'pre'

Soil component	Value Obtained	Desired Value	Indicator value	% Component
Soil quality index	0,2	>0,6	0	
Soil biological activity (worms.m^{-1})	12	>20 individuals.m^{-2}	0	
Subtotal			0	0
Water component				
Productive efficiency of water	533	<500 $m^3.tn^{-1}$ of DM	0	
Water index	1,14	0,95-1,05	0	
Subtotal			0	0
Plant component				
Number of non-crop species	0	>3	0	
Number of individuals of non-crop species	0	>3	0	
% losses in pre-harvest	20	< 30%	1	
Crop rotation by family and product type	5	<3	0	
Subtotal			1	25
Technological component				
Nitrogen balance	-8.275	>0 kg.$farm^{-1}$	0	
Energy efficiency index	0,07	>3	0	
% inputs of natural source	0	>50	0	
Average yield T.ha^{-1}.$year^{-1}$	101	>12	1	
% input self-sufficiency	0	>20	0	
Subtotal			1	20
Economic component				
Net income.ha^{-1}.$year^{-1}$	12.420.234	> 467100	1	
Gross income.ha-1.year-1	54.031.918	>4720000	1	
Net annual profitability	29,85	> 20%	1	
Marketing activities index	0	>=2	0	
Subtotal			3	75
Socio-cultural index				
Permanent employment	3,85	>1employees.ha^{-1}	1	
Participation index	1	>=1	1	
% implementation of new organic practices	0	>50%	0	
Subtotal			2	67
TOTAL FARM SYSTEM			**7**	**35**

DM = dry matter

Table 6.15d Evaluation of the indicators by component. Farm of Pedro Calderón – 'post'

Soil component	**Value Obtained**	**Desired Value**	**Indicator value**	**% Component**
Soil quality index	0.1	>0,6	0	
Soil biological activity (worms.m^{-1})	21	>20 individuals.m^{-2}	1	
Subtotal			1	50
Water component				
Productive efficiency of water	449	<500 $m^3.tn^{-1}$ of DM	1	
Water index	1.00	0,95-1,05	1	
Subtotal			2	100
Plant component				
Number of non-crop species	3	>=3	1	
Number of individuals of non-crop species	22	>3	1	
% losses in pre-harvest	26	< 30%	1	
Crop rotation by family and product type	2	<3	1	
Subtotal			4	100
Technological component				
Nitrogen balance	-1,563	>0 kg.$farm^{-1}$	0	
Energy efficiency index	0.14	>3	0	
% inputs of natural source	93.8	>50	1	
Average yield T.ha^{-1}.$year^{-1}$	135	>12	1	
% input self-sufficiency	10	>20	0	
Subtotal			2	40
Economic component				
Net income.ha^{-1}.$year^{-1}$	20,887,176	> 467100	1	
Gross income.ha-1.year-1	71,390,927	>4720000	1	
Net annual profitability	41.36	> 20%	1	
Marketing activities index	1	>=2	0	
Subtotal			3	75
Socio-cultural index				
Permanent employment	3.84615385	>1employees.ha^{-1}	1	
Participation index	2	>=1	1	
% implementation of new organic practices	56	>50%	1	
Subtotal			3	100
TOTAL FARM SYSTEM			**15**	**75**

DM = dry matter

Table 6.15e Evaluation of the indicators by component. Farm of Carlos Cano – 'pre'

Soil component	Value Obtained	Desired Value	Indicator value	% Component
Soil quality index	0,3	>0,6	0	
Soil biological activity (worms.m^{-1})	12	>20 individuals.m^{-2}	0	
Subtotal			0	0
Water component				
Productive efficiency of water	1.212,8	<500 $m^3.tn^{-1}$ of DM	0	
Water index	1,39	0,95-1,05	0	
Subtotal			0	0
Plant component				
Number of non-crop species	9	>3	1	
Number of individuals of non-crop species	97	>3	1	
% losses in pre-harvest	23,2	< 30%	1	
Crop rotation by family and product type	4	<3	0	
Subtotal			3	75
Technological component				
Nitrogen balance	-13.061	>0 kg.$farm^{-1}$	0	
Energy efficiency index	0,14	>3	0	
% inputs of natural source	0,0	>50	0	
Average yield T.ha^{-1}.$year^{-1}$	74	>12	1	
% input self-sufficiency	14	>20	0	
Subtotal			1	20
Economic component				
Net income.ha^{-1}.$year^{-1}$	4.061.246	> 467.100	1	
Gross income.ha-1.year-1	41.032.039	>4.720.000	1	
Net annual profitability	10,99	> 20%	0	
Marketing activities index	0	>=2	0	
Subtotal			2	50
Socio-cultural index				
Permanent employment	4,76	>1employees.ha^{-1}	1	
Participation index	1	>=1	1	
% implementation of new organic practices	0	>50%	0	
Subtotal			2	66,7
TOTAL FARM SYSTEM			**8**	**40,0**

DM = dry matter

Table 6.15f Evaluation of the indicators by component. Farm of Carlos Cano – 'post'

Soil component	Value Obtained	Desired Value	Indicator value	% Component
Soil quality index	0,2	>0,6	0	
Soil biological activity (worms.m^{-1})	40	>20 individuals.m^{-2}	1	
Subtotal			1	50
Water component				
Productive efficiency of water	1.106,7	<500 $m^3.tn^{-1}$ of DM	0	
Water index	1,17	0,95-1,05	0	
Subtotal			0	0
Plant component				
Number of non-crop species	11	>3	1	
Number of individuals of non-crop species	161	>3	1	
% losses in pre-harvest	14,4	< 30%	1	
Crop rotation by family and product type	5	<3	0	
Subtotal			3	75
Technological component				
Nitrogen balance	872	>0 kg.$farm^{-1}$	1	
Energy efficiency index	0,15	>3	0	
% inputs of natural source	76,1	>50	1	
Average yield T.ha^{-1}.$year^{-1}$	70	>12	1	
% input self-sufficiency	50	>20	1	
Subtotal			4	80
Economic component				
Net income.ha^{-1}.$year^{-1}$	10.679.458	> 467.100	1	
Gross income.ha-1.year-1	37.284.603	>4.720.000	1	
Net annual profitability	40,14	> 20%	1	
Marketing activities index	3	>=2	1	
Subtotal			4	100
Socio-cultural index				
Permanent employment	2,63	>1employees.ha^{-1}	1	
Participation index	2	>=1	1	
% implementation of new organic practices	89	>50%	1	
Subtotal			3	100,0
TOTAL FARM SYSTEM			**15**	**75,0**

DM = dry matter

Table 6.15g Evaluation of the indicators by component. Farm of Cristobal Segura – 'pre'

Soil component	Value Obtained	Desired Value	Indicator value	% Component
Soil quality index	0,1	>0,6	0	
Soil biological activity (worms.m^{-1})	12	>20 individuals.m^{-2}	0	
Subtotal			0	0
Water component				
Productive efficiency of water	391,8	<500 $m^3.tn^{-1}$ of DM	1	
Water index	1,09	0,95-1,05	0	
Subtotal			1	50
Plant component				
Number of non-crop species	6	>3	1	
Number of individuals of non-crop species	27	>3	1	
% losses in pre-harvest	25,0	< 30%	1	
Crop rotation by family and product type	2	<3	1	
Subtotal			4	100
Technological component				
Nitrogen balance	305	>0 kg.$farm^{-1}$	1	
Energy efficiency index	4,09	>3	1	
% inputs of natural source	16,0	>50	0	
Average yield T.ha^{-1}.$year^{-1}$	78	>12	1	
% input self-sufficiency	0	>20	0	
Subtotal			3	60
Economic component				
Net income.ha^{-1}.$year^{-1}$	23.785.917	> 467.100	1	
Gross income.ha-1.year-1	58.528.636	>4.720.000	1	
Net annual profitability	68,46	> 20%	1	
Marketing activities index	0	>=2	0	
Subtotal			3	75
Socio-cultural index				
Permanent employment	7,50	>1employees.ha^{-1}	1	
Participation index	0	>=1	0	
% implementation of new organic practices	0	>50%	0	
Subtotal			1	33,3
TOTAL FARM SYSTEM			**12**	**60,0** %

DM = dry matter

Table 6.15h Evaluation of the indicators by component. Farm of Cristobal Segura – 'post'

Soil component	Value Obtained	Desired Value	Indicator value	% Component
Soil quality index	0,2	>0,6	0	
Soil biological activity (worms.m^{-1})	22	>20 individuals.m^{-2}	1	
Subtotal			1	50
Water component				
Productive efficiency of water	468	<500 m^{3}.tn^{-1} of DM	1	
Water index	1,02	0,95-1,05	1	
Subtotal			2	100
Plant component				
Number of non-crop species	11	>3	1	
Number of individuals of non-crop species	227	>3	1	
% losses in pre-harvest	32	< 30%	0	
Crop rotation by family and product type	4	<3	0	
Subtotal			2	50
Technological component				
Nitrogen balance	-4.858	>0 kg.farm^{-1}	0	
Energy efficiency index	0,05	>3	0	
% inputs of natural source	100,0	>50	1	
Average yield T.ha^{-1}.year^{-1}	98	>12	1	
% input self-sufficiency	86	>20	1	
Subtotal			3	60
Economic component				
Net income.ha^{-1}.year^{-1}	54.398.150	> 467100	1	
Gross income.ha-1.year-1	106.475.421	>4720000	1	
Net annual profitability	104,46	> 20%	1	
Marketing activities index	2	>=2	1	
Subtotal			4	100
Socio-cultural index				
Permanent employment	7,5	>1employees.ha^{-1}	1	
Participation index	1	>=1	1	
% implementation of new organic practices	78	>50%	1	
Subtotal			3	100
TOTAL FARM SYSTEM			**15**	**75**

DM = dry matter

Table 6.16 Comparison among farms 'pre' and 'post' of the evaluation of sustainability indicators by component. Total system sustainability values are given in percentage.

	Castro		Cano		Segura		Calderon	
Soil component	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Soil quality index	0	0	0	0	0	0	0	0
Soil biological activity (worms.m^{-1})	0	1	0	1	0	1	0	1
Subtotal	0	1	0	1	0	1	0	1
Water component								
Productive efficiency of water	0	0	0	0	1	1	0	1
Water index	0	0	0	0	0	1	0	1
Subtotal	0	0	0	0	1	2	0	2
Plant component								
Number of non-crop species	1	1	1	1	1	1	0	1
Number of individuals of non-crop species	1	1	1	1	1	1	0	1
% losses in pre-harvest	1	1	1	1	1	0	1	1
Crop rotation by family and product type	0	0	0	0	1	0	0	1
Subtotal	3	3	3	3	4	2	1	4
Technological component								
Nitrogen balance	0	0	0	1	1	0	0	0
Energy efficiency index	0	0	0	0	1	0	0	0
% inputs of natural source	0	1	0	1	0	1	0	1
Average yield T.ha^{-1}.year^{-1}	1	1	1	1	1	1	1	1
% input self-sufficiency	0	0	0	1	0	1	0	0
Subtotal	1	2	1	4	3	3	1	2
Economic component								
Net income.ha^{-1}.year^{-1}	1	1	1	1	1	1	1	1
Gross income.ha-1.year-1	1	1	1	1	1	1	1	1
Net annual profitability	1	1	0	1	1	1	1	1
Marketing activities index	0	0	0	1	0	1	0	0
Subtotal	3	3	2	4	3	4	3	3
Socio-cultural index								
Permanent employment	1	1	1	1	1	1	1	1
Participation index	1	1	1	1	0	1	1	1
% implementation of new organic practices	0	1	0	1	0	1	0	1
Subtotal	2	3	2	3	1	3	2	3
TOTAL	**9**	**12**	**8**	**15**	**12**	**15**	**7**	**15**
% indicators fulfilled over total of 20	45	60	35	75	40	75	60	75

6.2 Progress on the farmer learning pathway

Let us return to the goal of Phase I: the farmers were to progress from the situation of being poor, dependent actors in the system, hardly able to carve out a living while poisoning themselves, the consumers and the environment, to actors that could take charge of how they managed their farms, and feel comfortable socially and economically with their production practices.

In this sense, overall, the farmers have been able to move from a situation in which they were highly dependent on external inputs and biased information providers (ie. inputs salespeople) to one where they are able to prepare a good part of the required inputs and where, by rebuilding the farm landscape, gradually system resilience is recovered and inputs are less required. As described in Deugd et al. (1998) the farmers have moved away from high external input agriculture (HEIA) towards but not completely adopting low external input agriculture (LEIA). Reijntjes et al. (1995) describe HEIA as being highly dependent on chemical inputs, hybrid seeds leading to genetic uniformity, mechanisation and irrigation using high levels of fossil fuels. Monocultures dominate, and these production systems are also typically capital and science intensive. LEIA on the other hand, focuses on nutrient cycling and management and farm self-reliance, and on the multi-functionality of crops, trees and animals (serving both ecological and economical purposes). A hybrid of these two technologies is described by Deugd et al. (ibid) as Integrated Nutrient Management (INM), which is more in tune with what the Cota farmers are now doing. Indeed, rather than adding synthetic mineral fertilisers and fresh chicken manure on a yearly basis, they are now preparing organic amendments using crop residues, animal manures and specific natural fertilisers, according to soil analyses and crop requirements. They combine those amendments with microbial 'soups' that help to improve soil microbiological activity, thereby helping to make nutrients available to the plants and improving soil structure. They apply botanical and biological products in the short-term management of pests and diseases while beginning to rebuild or redesign their farms for long –term management.

In this phase, my role as project director was one of facilitating learning, providing technical information and helping the farmers to relearn a form of agriculture based on observation rather than rote application of recipe-like solutions to their problems. I based my activities on technical accompaniment rather than technology transfer or technical assistance, providing workshops for which specific specialists were brought in, some theory given and mainly the techniques were practiced directly on a farm by the farmers. By rotating farm visits so that I saw each of the participating farmers at least every 2 to 3 weeks, I was able to monitor closely how they implemented the techniques, providing advice, correcting errors and supporting them generally in their efforts to change. This built up a certain level of confidence between us that has helped to overcome one of the problems identified in Chapter 3: the lack of continuity in institutional interventions in the community.

In the process of facilitating learning, there are a number of aspects which must be taken into account (Deugd et al., 1998):

- the farmers must learn how to observe
- observation tools should be provided to them, such as resource flow mapping, participatory diagnosis, etc.
- to be able to analyse and interpret the observations, the farmers must acquire some theoretical knowledge, or at least know where to look for that knowledge. Experiential learning, as used in this project, is probably the most appropriate, rather

than introducing heavy reading material. Trainers must of course be available in the areas needed, which in most cases implies that institutional support for such training must exist.

- Ways to determine the solutions to observed problems need to be given
- Look at possibilities of developing farmer networks, for e.g. to share resources or costs of transportation of inputs, and so on.

On the whole, what must be achieved is the strengthening of the farmers' ability to own the entire learning process.

This chapter has shown that the farmers have indeed begun to move and that my steering questions were helpful in that sense. As mentioned by Lightfoot et al. (1993) the process of 'farmer-participatory skill building' has begun, and the farmers are beginning to feel confident that they have the technical means to manage their crops in a sustainable way from the point of view of economics, health and environment.

The farmers have a realistic, concrete idea about the future performance of their farms. So far their concerns dealt mainly with aspects within the boundaries of their farms. The research activities, basic, applied and adapted, were fundamental to the successful accomplishment of many of the indicators of sustainability as shown in tables 6.15a to h and 6.16. The next phase will show how the farmers began looking beyond the mere farming activity towards marketing and realising the importance of reinforcing mutual empowerment and the need for association to make an impact.

PHASE II: Team building by improving the farming system

The results obtained in the conversion process related to vegetable production (see Chapter 6) stimulated interest among the farmers to learn how to maintain the quality of their produce throughout the harvesting and post harvesting stages, and to differentiate their product in order to access new markets and price levels. For these objectives to be reached, the farmers also recognised the need to work together but because of their, also recognised, individualism, they did not know how to go about it.

On the other hand, the Municipal Development Plan (Consejo Municipal de Cota, 1998) identified post harvest management, commercialising and marketing, intermediaries that increase prices, and lack of support for small businesses as crucial among limiting aspects related to post-production.

The need was gradually being felt for increased support in marketing, and linked to that, to somehow get the participants that were beginning to feel they were a group, organised as a team. In this second phase, we shall see how these issues were addressed. Chapter 7 looks particularly at aspects related to marketing, while Chapter 8 deals with aspects of organisational strengthening.

Chapter 7 - Meeting market standards for healthy products

The farmers in Cota sell 80% of their vegetable products through Corabastos, a food terminal in Bogotá (see box 7.1), and through intermediaries. Two marketing cooperatives, CoopHortiCota and Coomagro, have been alternatives for some producers for the last four years. As described in Chapter 3, the Association of Business Farmers of Cota – AsodeCota – is the newest group formed and only in late 2001 did it start formally to market produce for its associates. Marketing difficulties identified by the producers include the fact that the cooperatives do not receive all of the produce, prices are still dependent on those of Corabastos although they are a little higher through these commercialisers, healthy and safe products do not receive a differentiated price, and the commercialisers do not have sufficient liquidity to pay the farmers rapidly, so that payments are made 30 days later at best and usually 60 days later.

With this situation, a new project was designed with the producers. The proposal was submitted jointly between the Horticulture Research Centre and the farmers, through the Junta de Acción Comunal (neighbourhood association) of Cetime rural neighbourhood, to PRONATTA for funding in October 2000. This new project addressed the specific training needs of the farmers in three areas: post harvest techniques and marketing described in this chapter and organisational strengthening described in the following chapter.

Box 7.1 Corabastos (Corporación de Abastos de Bogotá S.A.)

Founded on July 20, 1972, this is the largest food terminal of the country and second largest in South America. It is run by a mixed society: 51% is state owned, by the Ministry of Agriculture, the Government of Cundinamarca and Bogotá's mayor's office; the other 49% is privately owned. It covers an area of 420,000m^2 and 5000 tonnes of food go through it daily, 33% of which are vegetables, 29% tubers, 21% fruit, 8% grains and processed food, 5% plantain and 4% meat, eggs and dairy products. There are 150,000 visitors daily driving 10,000 vehicles. Most products come from the Departments of Cundinamarca, Boyacá and Meta. Imported products come from Ecuador, Chile, Venezuela, Peru, Canada, United States and France, among others.

7.1 Potential markets for integrated and ecological produce

A general tendency among agricultural producers in Colombia is to think of export as the solution to all ills. It is also an ideal of the Cota farmers. Thus, it is important to consider the options available to Colombia in that context.

As of 1990, the European Union conceded a preferential rate to the Andean countries of Bolivia, Colombia, Ecuador and Peru for their efforts in controlling the drug trade. This rate is called the Andean Generalized Preferential System (Andean GPS) and consists of a 100% reduction in border taxes for almost 90% of the products that are exported to the European Union, mainly with a view to favour products that are used in the campaigns for drug crop substitution (Eurocentro Colombia, 2001). This situation favours greatly Colombian products in comparison to those of other countries.

The European Union is Colombia's second business partner, after the United States, with Spain, Germany, United Kingdom, France and The Netherlands in the forefront. The advantage of course of doing business with any European country is the access through the Union to all the other member countries. On the other hand, imports from Colombia represent only 0.37% of the total to Europe, and are not very diversified, coffee, flowers and emeralds being the main products. The study done by Eurocentro Colombia (2001) mentions that food products such as non decaffeinated raw coffee, fresh flowers, fresh and frozen fruit (except banana, strawberries and lemons), fresh and frozen vegetables, fish, crustaceans and molluscs, are particularly favoured by the Andean GPS. Processed foods include dried fruit, fruit concentrates and juices, fruit and vegetable conserves, palm hearts and pickled products. Where ecologically certified products are concerned, fruit as pulp or dried, herbs and vegetables are among the list of the Andean GPS, as long as they also hold a certificate of origin. Wherefore, there is definitely some interesting opportunities on the international front for Colombia.

However, demand from the national market is still not satisfied and should be considered before looking towards international markets as there are fewer post-harvest costs implied (transportation over shorter distances, no importation paperwork is needed, etc). Furthermore, in order to be able to export, sufficient *quantity* of high *quality* produce is required, two limiting factors which are still difficult for vegetable producers in Colombia to meet. Marketing studies done by the Horticulture Research Centre for both integrated (CIAA, 2001) and organic (Castillo, 2001) produce show an increasing demand for healthy food in national markets.

Some of the conclusions reached by the study on vegetables produced using an integrated approach include the following:

- The consumers are aware that a large part of the vegetable production in the Bogotá area depends on the Bogotá river, one of the most polluted in the world, for irrigation.
- As a result, they wash the produce to be consumed fresh in salt water, vinegar, lemon and / or a few drops of hypo chloride.
- They are more and more concerned about their health and so look for produce that guarantees a lower use of pesticides.
- On average, they will eat salad three times a week. Although they show a ready awareness of some of the lettuce types (iceberg, butterhead, red and green frilled), others are less known (romaine, escarole, and rocket arugula) and they only buy one type at a time.
- Appropriate methods to promote vegetables according to the consumers are institutional videos, farm visits, recipes that can be collected and are easily prepared, and tasting sessions in the supermarkets. The sale method 'two for the price of one' is not attractive to them as that will not lead them to consume more and the extra produce just gets damaged.
- The nutritional value of vegetables needs to be promoted more.

On the other hand, the study on organic produce showed the following:

- The population segment most adequate to position organic produce is in the upper three (of six) strata, as the level of education allows for the comprehension of the concepts. A product trial in Medellín among clients of the lower strata did not give positive results. Unfortunately, the interviewees would not provide information on purchasing power, so that type of data was not available.

- The consumers would be willing to pay an extra 5 to 10% for ecological produce as compared to the mainstream price.
- A current limitation to the expansion of the market could be the confusion detected with reference to concepts such as ‘biological’, ‘ecological’ and ‘organic’. The consumers did not differentiate among them and in fact in some cases, confused them with the terms ‘hydroponic’, ‘natural’ and ‘without chemicals’. This confusion of terms was also found among the supermarket employees in charge of the store shelves, implying that the consumers would not be adequately oriented at that point either. In general, the term ‘ecological’ seemed to be the easiest identified.

These two studies reinforce the idea that there is definitively a market potential for the products of the participants of this project, particularly as they do not use the Bogotá River for irrigation and they are well on their way to ecological production.

7.1.1 Consumer expectations

Consumers are concerned about food safety, particularly where pesticides and the use of clean water for irrigation are concerned, factor which has helped toward the increase in demand for ecological produce (CCI, 1999a). Related to this concern is that for environmental protection which is orienting production systems toward the use of alternative agricultural practices. On the other hand, the agricultural market worldwide is interested in innovative product presentations that are environmentally friendly, using recyclable or recycled materials, while offering smaller sized packages to meet the ever smaller family size. At the same time, the idea is to attract the consumer by offering fresh and aesthetically attractive produce on a continuous basis, preferably with a certificate for integrated or ecological production.

Consumers have also become more aware of how to impose their choices regarding what products should be offered and how they should be presented. To guarantee successful commercialisation, it is important to know how to choose the products and the variables that will allow satisfaction of the consumers’ needs. Another factor for success is the continuous availability of the product regardless of its seasonal cycles. This makes knowing production systems a crucial factor to ensure the continuity in harvesting the product. Fresh looking produce, with the expected colour and no spots or yellowing, is more important than the type of packaging (CIAA, 2001).

A new area in Colombia in vegetable presentation is that of pre-cut, or ready, vegetables, which have existed in Europe and North America for many years already. In Colombia this area still needs development (CCI, 1999 b; CIAA, 2001). To accompany this new demand, at some point technologies such as vacuum packing with controlled atmosphere, and rapid cooling to guarantee a longer shelf-life will have to be introduced.

7.1.2 The certification process in Colombia

Indeed another option for the farmers, once they have been able to convert their farms, is to get their farms certified. Certification for ecological production in Colombia is very similar to that in Europe, in fact the local certifying body – Corporación Colombia Internacional, CCI - has based its process on European standards. The farmer must first apply to the CCI for an inspection visit. The application form includes such information as location of the farm or plots submitted, description of the surroundings, farm or plot management including time of last chemical application, the purpose of the land (vegetables, dairy, etc), water quality, etc. If the application is accepted on a preliminary basis, a fee must be paid and the inspection visit is made[13]. During the visit, the inspector verifies the information, clarifies any doubts and then presents the results to a certification committee made up of representatives of the sector (universities, agricultural associations, etc). If the farm passes this point, a communication is sent with the contract which stipulates costs and the number of inspection visits to be made per year (the number can vary from 2 to 4 depending on the level of knowledge of the farmer, the availability of a support agronomist, trust, etc). The CCI has international backing of the German accreditation company, BCS ÖKO-Garantie GMBH, which sends an inspector at least once a year to verify fulfillment of requirements; this also allows certified farms to export to Europe and the U.S.A., should they so desire.

In the context of small farmers, certification is difficult for two reasons: cost and the size of the plots. The first obstacle can eventually be overcome by creating farmer groups for certification; at least the cost per farmer will be substantially reduced. Certain aspects such as mechanisms for self-control would have to be established. However, it is quite possible that the second obstacle may be the limiting factor to ecological certification: the plots are so small that it would be difficult for the farmers to meet the requirement of an eight meter distance and / or boundary between them and a neighbour that is not interested in ecological farming, without loosing a substantial area of their farm! The only immediately obvious way out of this problem would be for the ecological farmers to convince their neighbours to join

[13] For 2002, the inscription fee was set at Col $1,410,000 pesos (approximately U$620.00) and inspection visits at Col $573,000 per day (approximately U$ 240.00).

them and thereby create 'islands' of ecological farming. Only the outer edges would need to meet the boundary requirement. This of course requires quite a lot of negotiation, convincing of recalcitrant producers and a certain level of altruism on the part of the farmers on the edge, unless some mechanism for the provision of an environmental service is implemented as compensation.

With that in mind, and looking at the broader context of Colombian agriculture, an assistant helped me develop a proposal for Good Agricultural Practices (GAP) based on the European standards (FoodPlus/EUREP, 2001). Adherence to EUREPGAP standards may be required sometime soon for any agricultural imports to Europe. It therefore only made sense to develop such standards for Colombia, based on the local conditions. For the most part, the European items were included in the proposal, with minor adaptations according to the context. One main addition was the provision for the safeguarding of zones above tree line, the 'paramo', which is prone to cultivation by potato farmers but also is the source of water for the lower areas. Before implementation of the Colombian GAP, the national norms body ICONTEC must approve it. Should this standard be approved, it would be a mechanism for these small farmers to get recognition for their efforts, even if it is not ecological certification.

7.1.3 The farmers' point of view

So far, the picture painted here is one where the farmers are dependent on third parties for the marketing and commercialisation of their produce, although the efforts involved in the formation of AsodeCota, and to a lesser degree the two cooperatives, are a step toward more autonomy. But generally, farmers, including those from Cota, are not participants in a win-win situation. Prices are determined by those of Corabastos, which are based on supply and demand and the weakness of the farmer who would have to return home with the produce, having paid to get it there in the first place, if s/he does not agree with the price offered. Supermarket and therefore the cooperatives prices are a little higher, but still based on Corabastos.

However, as mentioned in Jiggins et al. (2000), alternatives do exist that are not imposed by third parties, such as the community markets based on fixed orders found in Europe, among others. Röling and Wagemakers (1998) assert that the survivors of commercial agriculture will be those who are oriented toward the market and the consumer, with abilities in communication and acquiring information, organised in innovative networks, good at managing bureaucracies and interpreting policies, and innovative and flexible.

Within the context of Colombian agriculture and particular marketing of agricultural produce, where much of the conditions are imposed by third parties in the form of multinational (Carrefour, Makro) and local (Carulla, Cadenalco –Exito) supermarket chains, as well as the buyers in Corabastos, where the research needs are rarely decided on with the future expected users of the resulting technology, and where the producers do not sell their produce, but rather the buyers buy it from them (they lack the power of negotiation), there is a dire need to recover the capacity to determine their own future. Training in areas that the producers themselves diagnosed as weak, such as post harvest methods, marketing and strengthening farmer associations, is a step forward to that.

The experience of the Horticulture Research Centre in developing its Eurofresh® programme (see Appendix 2) provides an excellent local example of a production chain that starts with the University undertaking basic marketing research studies, variety selection trials to meet Colombian climatic and marketing requirements, and providing the principles behind crop management. The results are combined with local experience on the associated producers' farms for adjustment under their conditions and ensure that they meet the consumer requirements of uniformity, quality, continuity and productivity that are the basis for the Eurofresh programme. This experience was used and adapted to the situation of the Cota farmers.

7.2 Training programmes

Post harvest practices

A first exercise to diagnose the farmers' perceptions on their own weaknesses was used to orient the actual training. Contents included theory and practice on subject areas such as vegetable physiology (respiration, photosynthesis, transpiration), macro-elements, micro-elements, plant hormones and their functions, pre-harvest processes (contact with client, harvest programming, determination of harvest maturity, timing of harvest), post harvest processes (cleaning, selection, classification, washing, drying, disinfection), conditioning, packaging, storage and transportation. The concept of quality was also covered, and its characteristics (size, shape, dimensions, temperature, pressure, length, diameter, hardness, time), commercial definitions and requirements, norms, factors that affect quality, harvest index (based on harvest moment and susceptibility to disease), and plant maturity (physical, chemical).

To put this knowledge into practice, the farmers were required to elaborate technical sheets on two vegetable crops each. Visits were also made to the receiving warehouse of one of the main supermarket chains and to the farm of one of the producers for on site observation on how best to structure the post harvest area.

Marketing and commercialising

Again based on a diagnostic exercise, the farmers' concerns and knowledge on aspects dealing with marketing and commercialisation were established. Course subject areas subsequently covered aspects such as product, price, distribution and promotion. The participating producers were divided into groups. Each group chose two vegetable crops each to apply the information of all areas studied in the course. This basic product information was then used in the preparation of a product catalogue directed to potential clients. The products included were: iceberg lettuce, spinach, beets, Swiss chard, red radish, broccoli, curly parsley, flat-leaf parsley, cauliflower, coriander and kale. As the course went along, the amount of information to be collected for each product became quite substantial, so that each group chose one of the two products to go more in depth with. By the end, seven products (iceberg lettuce, beets, Swiss chard, spinach, curly parsley, red radish and broccoli) were fully described as to product description including nutritional content, differentiation of presentation and price according to the type of client, packaging options, bar codes and potential market. This information collected by the farmers was then used to develop a manual on vegetable marketing. Information on additional vegetables were collected by the team members to bring the total number of products to 15, thereby covering the principal crops produced in Cota.

Implementation, follow-up and evaluation

The project team provided the support during the last few months of the project to enable the producers to make sure they were implementing the post harvest techniques appropriately in their farms and smooth out difficulties in the team working aspects, particularly related to marketing.

7.3 Results of the training programmes

7.3.1 A product manual developed by the farmers

Fifteen products were fully developed so as to provide readers of the manual, expected to be farmers of a similar cultural and educational background, the basic information required for post harvest management and marketing of vegetables. Topics included:

- product description (growth requirements, nutritional information, production costs);
- product presentation (a proposal for unit size, packaging, brand name, label and bar code calculation);

- distribution channels, type of client and social stratum aimed at;
- communication mechanisms for contact with consumers;
- price calculation;
- product life cycle, harvest expectations according to quality levels.

Products covered were: Swiss chard, broccoli, cauliflower, coriander, chives, table beets, red radish, spinach, curly parsley, iceberg lettuce, 'exotic' lettuce (various types of leaf lettuce), green cabbage, red cabbage, zucchini, peas and baby carrots.

7.3.2 Eco-tourism as an alternative market opportunity[14]

Ecotourism based on the horticultural sector was considered by the farmers and project team as a very interesting marketing alternative for the small farmers of Cota. Such an endeavour would meet the tourism objectives of the municipal PDM and POT (see Chapter 3) while at the same time providing an additional income to the farmers. The attempt made here was inspired from the wine routes of Europe and North America.

Many factors must be considered in the design and implementation of an ecotourism initiative. Ashley et al. (2000) provide a list of factors that influence economic participation by the poor in tourism activities: human and financial capital of the poor, social capital and organisational strength, gender, fit with existing livelihood strategies and aspirations, location, land ownership and tenure, planning gain, regulations and bureaucracy, access to the tourist market, linkages between the formal sector and local suppliers, tourism segment and type of tourist. They also discuss tourism in relation to its economic impact, social impact and the impact on distribution of livelihood. Although these aspects were analysed by Ashley et al. from the point of view of creating a tourist industry at a national level to attract foreign tourists, most of the aspects included are valid a small scale level such as Cota. Table 7.1 provides a comparison of the factors and table 7.2 of the impacts, with a summary of the description given by Ashley et al., and their applicability to the Cota context.

[14] Special thanks is made to Alex Iván Mórtigo, an agronomy student who accepted to develop the agroecological route as his undergraduate thesis.

Table 7.1 Factors that influence economic participation by the poor in tourism according to Ashley et al. (2000) and their applicability to the Cota context.

Factor	Description according to Ashley et al. (2000)	Applicability to the Cota context
Human and financial capital of the poor	Skills in tourism, including language and tourist expectations are needed. Expansion of spin-off informal sector activities requires financial capital.	Many producers have taken a training course in ecotourism, so can serve as guides. Parallel activities will be built up slowly according to financial ability. Outside capital could be a possibility.
Social capital and organisational strength	Dynamic and flexible forms of association are needed to ensure that all members have equal access to the benefits.	The success of such an association is critical to the success of the route. Efforts in organisational capacity building and team work point in that direction.
Gender	The service nature of the tourism industry increases the accessibility of women to new jobs.	One third of the participating farmers are women. Spin-off activities such as crafts and prepared food will also increase their input.
Fit with existing livelihood strategies and aspirations	Tourism is usually an additional activity, so must not clash with the others, nor represent high risk. It must require the type of services that the people are willing to provide.	The trade-off is between time to organise the route and benefits received by the alternative market.
Location	Tourism will thrive where a number of factors combine to attract the tourists: landscapes, heritage sites, wildlife, recreational facilities.	Cota is currently an attraction for day tourists due to its proximity to Bogotá and the existence of restaurants and craft shops. The Majuy mountain and the ecological route can be used to build on the existing infrastructure.
Land ownership and tenure	Tenure over land and natural resources provide access of the poor to market power and negotiate benefits from the tourism activity.	The farmers of Cota own their land and sometimes rent additional plots to increase production area. Land tenure is therefore not an issue.
Planning gain	Government authorities can be used to promote tourism interests.	At the local level, the support of the municipal council will be required in order to convince the mayor. Work will have to be done at departmental level as well.
Regulations and bureaucracy	These requirements are often geared toward the more formal sector and could constitute barriers to a more informal initiative.	Requirements of the municipal and departmental planning and tourism offices will have to be looked into.
Linkages between the formal sector and local suppliers	Where the owners of the tourism activity are local people, they will be more likely to use local suppliers.	The owners and suppliers in this route are the farmers themselves. They are very clear on involving first those who have been participating in the sustainable agriculture project before looking for others.

Table 7.1 Continued

Factor	Description according to Ashley et al. (2000)	Applicability to the Cota context
Tourism segment and type of tourist	Domestic and regional tourists as well as backpackers are more likely to use locally run establishments, but are not likely to spend as much money. Tour groups spend more money and stay at fancy establishments that provide jobs to the local people.	Currently there are no hotel options in Cota. Tourists would come from neighbouring towns or the nearby capital city. Tourism is currently based on locally run restaurants and craft shops. The route would offer a diversification of the activities already available.

Table 7.2 Economical, social and livelihood impacts of tourism on the poor according to Ashley et al. (2000) and the applicability in the Cota context.

Impact	Description according to Ashley et al. (2000)	Applicability to the Cota context
Economic impacts	Four different sources of income can be derived from tourism: wages from formal employment, income from selling products, profits received from locally-owned businesses and collective income (from a community-run business, rent or a business partnership). Negative impacts include dominance of the business by outsiders.	Formal employment, selling local products and profits from locally-owned businesses are income sources.
Social impacts	Tourism can affect other goals of livelihood: cultural pride, a sense of control, good health, reduced vulnerability. Positive and negative impacts of tourism on these goals need to be looked at.	Such impact cannot yet be determined as it is still too early. However, by providing a venue to show off the town and the abilities of the farmers, the expectation is an increased pride in being a farmer and reduced vulnerability by creating a source for alternative income.
Distribution of livelihood impacts	The better off tend to gain more from tourism initiatives. Distribution may also differ between genders.	The even distribution of benefits will depend on the organisation and management of the route and the ability of the farmers to negotiate among themselves.

From these tables we can see that ecotourism seems to be an option for Cota. However, as Pimbert (1999) warns, often the financial benefits of such endeavours rarely return to the rural population: either they remain with the richer administrative personnel or the eco-tourism scheme is not integrated with the regional economy. Kepe et al. (2001) also found that private-sector tourism offers few local opportunities and may in fact have a negative impact on existing livelihood strategies unless efforts are made to increase the skills levels, infrastructure and access to opportunities based on local conditions. The small project described here is an effort to ensure that the benefits do stay among the farmers by having them participate in the design, implementation and management of the scheme as a form of endogenous rural development, as described in box 7.2.

Box 7.2 Objectives of the ecotourism initiative in Cota: The agroecological route

- Provide a venue for direct contact between producers and consumers, eliminating the intermediaries and so reducing transaction costs (transportation, time and earnings) and educating the consumers.
- Create opportunities for the creation of small enterprise and employment preservation and/or generation.
- Provide a marketing alternative that the farmers own, and so can manage according to their needs and capacity to answer the consumers' demand (local empowerment and reduced vulnerability to outside forces).
- Encourage spin-off initiatives such as recovery of basket weaving, hostels, etc.

The set-up of the agroecological route was coordinated by an undergraduate thesis student. He established an initial organisational procedure which was improved on by the farmers and project team by evaluating each route undertaken. This procedure can be divided into three phases: before, during and after. A lot of detail is required for the route to run smoothly, reflecting on the need for the farmers to be organised, able to negotiate and communicate, and to be strong as a group in order to withstand problems.

- Before: About 10 days before the scheduled route, a meeting is held to decide on who will play which role among the possibilities of: guide, support group for the guide, sales team and cashier. The farms to be visited must also be decided on. Initially choice was based on farms that were more advanced in terms of implementation of ecological and sustainable practices and availability of produce (the route started at a time when water was scarce, so many of the participants did not have much to show). The farmers of the chosen farms must commit themselves to maintaining their farm 'showable' and be available to explain their methods at specific times. During this meeting, farmers must also commit themselves to bring produce according to experienced demand. All farmers would have access to the tourists by providing produce for the receiving centre or shop. Different from the situation described by Kepe et al. (2001) in South Africa, there is not a land tenure issue to clear up before the agri-tourism initiative can be implemented. However, issues such as 'whose product when' and 'whose farm' do require that a decision mechanism be in place, especially when new farmers want to join when they see the route working. Logistics such as requesting the municipal bus from the mayor (which requires getting up at 4am to catch him in his office!) and purchasing receipt books and packaging materials must also be assigned.

- The day of the route, everyone hopes that all those committed to a role will actually show up and that those who are to bring produce will do so in the allotted time period. The produce must be packaged and laid out on the stand, the content of the price list adapted to the produce actually brought in, and the side-line products (desserts, juices, crafts, goat products) arranged in an orderly fashion. The guide and support group must arrive at the appointed time to meet the bus and the tourists, the tour must go according to schedule providing the necessary information on the production methods, and the sales team be ready to meet the group in the receiving centre. This team is in charge of giving the tourists additional information on nutritional value of the products and explain new items. The cashier then receives the money and gives out a bill.
- After the tourists have left, the money must be counted and distributed to the farmers. Any left over produce must be disposed of. A few attempts were made at the beginning to sell them the following day at a sauna centre in town, to make use of the Sunday tourists. However, the few interested farmers soon tired of the long day involved. Other options suggested by the farmers included using the produce for the home deliveries or donating them to one of the churches.

A number of difficulties arose with this effort, as can be imagined: jealousy among the farmers who felt that farmers were allowed to participate in the route who had not been coming to the weekly meetings and courses, disagreement about the percentage that should in the future be collected from sales to build up a fund, among others. A crisis situation gradually built up, which called for some serious negotiations before anyone could consider the route as a long-term viable alternative. These negotiations are covered in Chapter 8.

7.3.3. Additional marketing alternatives

The possibility of accessing marketing channels different from the traditional food terminal or the three commercialisers of the municipality is very tightly related to the ability of the farmers to associate themselves formally since many of the marketing channels require some degree of formality. How this issue was dealt with in the Cota context is elaborated upon in Chapter 8.

In the meantime, marketing alternatives that did not require a formal structure were looked into. Some schools that looked promising were provided with samples of the farmers' produce and an explanation of the production method and the resulting quality. Thanks to the agroecological route, some of the tourists signed up to receive home deliveries based on a standard weekly order. These orders are being delivered in returnable baskets made locally from reeds.

Even if these first orders were small, they were an incentive for the farmers to programme their crops, which should be conducive to a stronger form of association and in turn, push the farmers to making a decision on what format of association they want to adopt.

Options for the long-term promotion of the agroecological route will also have to be looked into. Depending on the contacts of the team members can only go so far. One such option is to provide information on it to local tourism boards, particularly that of Bogotá.

7.4 Conclusion

The situation here is thus one in which the different attempts at accessing new marketing channels reinforce the need of the farmers to be organised, not only to satisfy client requirements for formal association, but also to improve their selling power and withstand difficulties in the market place. Aspects such as communication, interpersonal relations, negotiation, confidence building, as individuals and as a group, will have to be addressed. Research activities in the next chapter will focus therefore on creating an organisation for concerted action, which will require more than the mere administrative formality of association.

Chapter 8 - Building organisational strength and farmer autonomy

8.1 Beginnings: Feeling the need to get organised

Isolated comments from some participating farmers surprised me: before getting involved with the projects (sustainable production and marketing), neighbouring farmers would pass each other on the street and perhaps wave. By the end of the projects, they would stop and talk to each other, helping to solve problems, keeping each other informed of events, and so on. How was such a change accomplished?

The methodology used from the very beginning of the projects, which involved participatory diagnosis of the difficulties confronting the farmers at that time, required arriving at a group consensus for the prioritisation process (see Chapter 5). From that point on, and even as they recognised the individualistic character of the Colombian 'campesino' as a limitation to progress, a group consciousness started to develop, perhaps even despite them. The need to associate started to be developed within the group of farmers starting in Phase I, which mainly sought to help develop self-reliance in the technical, production area. Having reached the point where they were able to produce good quality (almost ecological) vegetables, and then not being able to market it as such, brought on the felt need for training in marketing (Chapter 7) which in turn emphasised once again the advantages of being associated. In this chapter, initial attempts at joining an existing association ended rather quickly, leading the group to look at other alternatives that would allow them to reflect on their ecological orientation.

The form of organisation that finally results can be considered an emergent property of the process as it is an outcome of the project. The farmers feel the need to get organised as sustainable farmers, distinguishing themselves somehow from the other regular producers.

8.2 Organisational strengthening, training programme

To support the existing marketing entities in the municipality and to help others (individuals) to associate, a short course was offered to cover areas of organisational strengthening and team building. Obstacles to good performance were analysed and solutions provided through interactive workshops on management abilities, organisational environment and teamwork. By the end of this course, the producers were able to develop short, medium and long-term work plans, describing internal management and projection of the entities they belong to, particularly from the point of view of the marketing activity. They were also able to recognise, at least theoretically, the obstacles their group had to overcome to become a working team. Among other aspects was the issue of individualism, and linked to that characteristic, those of lack of commitment, back-stabbing, and so on.

This process of group strengthening, before formalising an association among individuals, is supported by Vanclay and Lawrence (1996), who stress the need to review extension knowledge, alter the form of extension and go to an approach that facilitates group interaction and problem solving at local level.

Socially sustainable farm development (autonomy, Phase IV) requires, as a precondition, that farmers are aware and can collectively reflect on their own processes. This, in turn, requires a learning platform that slowly develops into an organisation. The present chapter therefore describes a process that makes use of the growing awareness of the farmers (and the research team) of the advantages of not only working together, but creating a more solid future through joint learning and analysis.

8.3 The first efforts at working together

The first conscious efforts at working together relate back to the marketing chapter in which group efforts are key to the success of both the agroecological route and the other new marketing alternatives.

8.3.1 *Crises: An opportunity for change*

As we left off in Chapter 7, a crisis was pending in reference to certain aspects linked to the implementation of the agroecological route as an alternative marketing strategy. It was imperative that these issues be dealt with at the earliest opportunity, before they got out of hand. Accordingly, the next weekly meeting was used to do some hard-core negotiations. A prior telephone conversation with the colleague who had given the organisational strengthening workshop provided me with some ideas on how to manage the session.

We started off with a brainstorming session on what was learned from the organisational strengthening workshop. The farmers came up with the following list:

- Learn from the others
- Know how to listen in order to be listened to
- Work as a team
- Do not hide when you have something to say
- Be punctual
- Be respectful and dependable
- Listen to the leaders
- There are no limits, you must dream
- Have shared objectives
- Be humble
- Know clearly where we want to go as a group
- Do not base beliefs on suppositions
- Know how to accept criticism, without becoming defensive
- Know how to give positive criticism
- Analyse, communicate, reflect
- Provide leadership
- Believe in one's self
- Recognise one's mistakes
- Know how to negotiate so that both sides win
- Dialogue
- Seek integration

Of that list, the farmers believed they had accomplished:

- Integration, thanks to the implementation of the agroecological route
- Reaching a common interest

- Dialogue
- Acquiring confidence in the others
- Team work

Where they believed they were failing included:

- Learning from the others
- Hiding when you have something to say
- Staying committed to what they are doing
- Being punctual
- Accepting criticism without becoming defensive

They felt that positive aspects derived from the route included that it:

- is an ideal that became a purpose for change
- has helped to integrate the group
- has helped them to put knowledge into practice
- helps to promote their ecological products and sell them
- is the beginning of a micro enterprise
- helps integrate the production-marketing chain
- offers an alternative distribution channel
- creates confidence between the consumers and producers
- is a source of information for those who do not know about ecological production
- supplies the market niche for healthy food
- offers better quality of life for future generations
- allows a stronger voice of the producer within the productive system
- helps generate employment
- helps them know where they want to go
- helps the municipality become known nationally and internationally

To the question, what does working in a team mean to you, they answered:

- Everyone helps out
- Commitment is required
- Everyone is on the same side
- Sharing is fundamental
- Problems must be resolved through dialogue

Problems they have found with the route:

- There is no leader
- There is a lack of commitment
- There are discrepancies in opinion (prices, percentage of earnings that should go to a common fund, work assignments)
- It still lacks organisation
- Lack of publicity about the route is reflected in too few tourists
- More sincerity among group members is needed
- Quality norms need to be established
- Farmers are not punctual
- They need training in sales and accounting

What is their goal?

- To become known as an ecological group

The principal conclusion drawn in this meeting was that clear rules of the game were required. So a list of rules was drawn up and improved on over time. The list was divided up into two sections: rules for the group and rules for the route.

Rules for the group

- The topic to be negotiated must be clear.
- Each member must listen and respect the others.
- Know how to say things without hurting.
- Be honest and sincere.
- Be flexible.
- Fix commitments clearly.
- Decisions taken in the meetings must be accepted by everyone (anyone absent approves by their silence).
- A maximum time per intervention in a discussion must be fixed.
- When intervening, provide new information or viewpoints.
- Chose an arbitrator for the negotiation.
- There are no secrets.

Rules for the agroecological route

- Determine norms of quality.
- Any product with deficient quality will be returned.
- Producers of a same crop will rotate participation in the route.
- To have the right to sell in a route, the producers must have attended the corresponding organisation meeting the week before.
- A percentage will be charged from sales, for a fund that will help cover administrative costs of the route and in the future, be used to invest in equipment.
- The produce must be delivered within the time period stipulated. Any product received afterwards will be refused.
- Everyone must participate and rotate the different roles.
- Everyone must invite at least one person as ‘tourist’.
- Prices will be based on the list used by the certified produce at the Horticulture Research Centre. Those in charge will price any product not on the list that day.
- Those in charge the day of the route will be the only ones authorised to manage the stand.

8.3.2 Options for association

As mentioned in Chapter 7, potential clients for the vegetables produced by the participating farmers required some degree of formalisation of the farmer group. My marketing assistant found this out quite quickly, so in February 2002, we resolved to put the question to the farmers: do you want to be associated and if so, what form of association would be the most appropriate? They agreed for the most part that association was definitively important. A brainstorming exercise to list the different ways they could associate and ensuing vote came up with the results found in table 8.1:

Table 8.1 Alternatives for association as determined by the participant farmers.

Position	Option	Points
1	Join AsodeCota	9
2	Keep an informal association at first; offer the product where official status not required.	6
3	Form a group of only organic farmers, with official status.	3
4	Join AsodeCota, then subdivide into an organic section. Create two different brand names.	0

Thus, the majority felt that the first option was to join AsodeCota. The group then sent a request to the Association with that intent. Although AsodeCota showed interest initially, a number changes in the executive committee (first to a majority pro-organic, then within a month pro-conventional), led to a stalemate within the Association. About a third of the members, who were also participants in this project, began to feel that they were no longer adequately represented in marketing negotiations and were considering withdrawing as a result. The alternative originally chosen by the participant farmers seemed no longer to be an option. A choice would have to be made again.

8.3.3 The final choice

Over time, the main complaint of the farmers, despite the voiced interest by all to get organised, was the lack of commitment of their companions, which they used to explain the low assistance at meetings. Such uncertainty was causing doubts in the minds of both farmers and the project team regarding the genuine desire of the farmers to associate. However, during one of the weekly meetings to which everyone was called with an ultimatum set by the farmers: 'Attend or be left out', all of the farmers insisted on their interest in becoming formally organised. As one (young) farmer said: 'I have invested time and effort in this project for two years: I am not going to let it go to waste! We have to move on, collaborate among ourselves. We have to work toward being self-sufficient. I want my children, and hopefully my grand-children, to be able to continue this!' Another pointed out: 'Remember how we were three years ago? If it were not for this project, we would still be like that! It is time to reap the fruit of the tree we planted.' A third one concluded: 'We are going to win!'

This enthusiasm led to the decision to form their own association as sustainable to ecological farmers. As their first challenge, they set themselves tasks (table 8.2) to be accomplished within six months. An executive committee was set up, made up of the coordinators for each task. To choose the coordinators, the farmers either volunteered themselves or suggested a companion who would then accept. Everyone agreed that acceptance meant a commitment in time and effort. The rest of the farmers divided themselves among the tasks to provide support to the coordinators as sub-committee members.

Table 8.2 Tasks established by the farmers to work toward forming an association

Coordinator	Task (s)
1	• Collect information to define the type of association most appropriate to the group; • Coordinate the writing up of the statutes; • Establish internal group regulations.
2	• Coordinate the agroecological route.
3	• Coordinate crop programming.
4	• Coordinate marketing and commercialisation.
5	• Establish mechanism for internal control for production, post harvest and sales.

At this point, the farmers felt that, thanks to the various workshops, courses and farm follow-up, they had sufficient knowledge and tools at their disposal. What they needed was to put it all into practice. The project team would accompany them as far as the project timetable would allow. Thereafter, the farmers would have to look after themselves.

8.4 To what degree was organisation achieved? Results of Phase II

The end of Phase I saw the need for support to see in which way the dispersed group of farmers, then with a certain level of confidence in their ability to produce with little or no chemicals, could start to work together. In this phase, activities were implemented that would make the way for the beginnings of group strengthening. After the marketing course, the farmers had deepened their felt need for association. It was obvious to them that they would not be able to compete individually. So at the end of this Phase II, we have the following outcomes:

1. A more cohesive group of farmers who are interested in working together, among others on forming an association which would help post-project process maintenance. This is evidenced by the continued assistance at weekly meetings and courses, participation in route organisation and implementation. However, they still have far to go to consolidate themselves as a team.
2. Availability of a new protocol on Good Agricultural Practices for Colombia as a mechanism for product differentiation on the market.
3. At least two new marketing channels for their produce, based on direct sale to consumers through awareness raising (agroecological route and home deliveries) and sale to a restaurant.
4. Interest of the farmers to build up more alternative channels to reduce dependency on Corabastos and supermarkets.

As Berdegué and Escobar (1997) mention, many projects in the past have failed after the project team left because they overlooked the role of farmers' associations in the process of innovation, administration and dissemination of innovations, and instead emphasised implementation of new practices on individual farms. In this case, efforts are being made to leave some type of farmers' association in charge of the production and marketing processes once the researcher facilitator leaves. However, a consolidation phase will no doubt be required to strengthen the farmer group as a team and in certain aspects such as accounting, administration and internal control. How strong the association becomes will depend on them, on how well they work together in the long term, and on whether they see concrete benefits from being associated.

Helping the farms to obtain a cost effective product that satisfies a specific niche in the market, while at the same time reducing the negative impact on the environment and reducing the health risk associated with conventionally produced food, is not enough to guarantee that the produce will get to the consumer with that connotation. Proactive marketing and education of the consumer is also required.

In summary, some progress has been made by the farmers to work as a group and to build a team. However, some consolidating work is still required. Business skills including accounting are needed, by the farmers' specific request, before they are able to feel confident of themselves and each other in the management of the route. In this project, the route has in fact been used as a synthesis of the different elements that have been integrated throughout the three years of working with the farmers. Whether it is the most effective method will be defined by time. However, it has helped to show the farmers how the effects of sustainable farming practices combined with appropriate post harvest and marketing techniques managed as a group, can help them to access different sets of consumers willing to recognise the effort they have made financially.

The definite desire to organise themselves into a formal association, after having tried out other alternatives first (functioning non-formally, joining another association) without being pushed into such a decision by the project team or other outsiders, leads to the expectation that they will be successful in the long-term. Training local facilitators for local self-sufficiency, as will be seen in the next chapter, is another step toward that objective.

Phase II clearly shows that the emphasis of the agricultural research activities used to facilitate the farmer learning pathway moved from the beta to the gamma dimension of figure 2.5. More will be discussed about this in the final chapter.

PHASE III: Moving from farm to regional development

In previous chapters, we have discussed how the conversion process can be implemented at farm level and the importance of involving the farmers as active participants in the change process. Difficulties in marketing their produce were attributed in part to the absence of some sort of recognition of the 'integrated' practices. At the time, no intermediate certification plan existed for environmentally more friendly commodities. On the other hand, should they have attained ecological production, the farmers would have been unable to have their farms certified as such due to the prohibitive costs required to pay for the certification (see section 7.1.2). One of the options that were studied involved forming 'islands' of ecological or integrated producers that might be certified as a group, thereby reducing costs. In order to consider that as an option, a landscape view of the farming areas had to be taken and the idea of redesigning landscapes within the context of ecological farming was introduced. A socio-economic obstacle to progress is therefore being overcome through research activities in hard sciences. The final outcome will be a step closer to regional development.

Chapter 9 - Agrobiodiversity and relative abundance of arthropods in live fences

9.1 Introduction

Knowledge on ecosystems closely – and most obviously - related to human activity is generally limited to those species of economic importance as insect pests, diseases or weeds. In fact, with the exception of the growing body of information on biological control, most often any mention of insects in the literature or on the Internet makes reference to the negative aspects of their existence, from the point of view of humans. To achieve sustainability of those ecosystems requires an understanding of the multi-trophic relationships between species of the system. The so-called total system approach to agriculture (Lewis et al., 1997) pushes for more detailed knowledge of the agricultural ecosystem, which although it is more simple than natural ecosystems, may include important elements to initiate conservation programmes at regional levels. This is particularly true in cases where live fences[15] or biological corridors have been preserved within the agroecosystem, and especially where they communicate with

[15] Live fences can be divided into two basic categories; living fence posts and live barriers or hedges. Live fences are widely spaced, single lines of woody plants that are regularly pollarded and used instead of metal or wooden posts for supporting barbed wire, bamboo or other materials. Hedges are thicker, more densely spaced fences that generally include a number of different species and usually do not support barbed wire (Budowski, 1987 in Cherry and Fernandez, 1997). The International Center for Research in Agroforestry (ICRAF) currently defines live fencing as, 'a way of establishing a boundary by planting a line of trees and/or shrubs at relatively close spacing and by fixing wires to them.' (Huxley, 1997, in Cherry and Fernandez, 1997). Taken from S.D. Cherry and E.C.M. Fernández. http://ppathw3.cornell.edu/mba_project/livefence.html

forests or woods, or islands of vegetation that may have allowed the preservation of species that otherwise might have disappeared.

When considering strategies for the conservation of biodiversity the following questions arise: How can scientific knowledge be mobilised in order to obtain the best results in the preservation of biological diversity? How should change processes be managed so as to optimise the contribution of biological resources to sustainable development? What information is needed to resolve problems in the conservation of biodiversity? Which problems need to be solved first? (McNeely et al., 1990).

The landscape contributes significantly to the quality of rural life (Paine and Taylor, 1999). For that reason as well as to enhance tourism in the community, the development plan of Cota of 1998 included reforestation among its objectives. However, as in many cases, especially at the municipal level, there is little knowledge on how to go about reforestation. Where should the trees and bushes go? What species should be used based on which criteria? On the other hand, an important aspect in sustainable farming is precisely the rehabilitation of the farmscape in order to enhance populations of beneficial organisms that will help manage pests while increasing farm biodiversity (Altieri et al., 1993; Kabourakis, 1996; ATTRA, 2000). Farmers will not be interested in increasing biodiversity for merely ecological reasons: they need to know that there is an economic return to that investment (Lightfoot, 1999). The possibility of natural pest management instead of having to purchase inputs will help reduce input costs and so represent some level of economic benefit.

My interest in this area came from a different direction. An earlier study I helped with on the potential of Colombian native flora for use as ornamentals revealed a number of species that could have interesting uses as garden plants (Cavelier and Lee, 1999). Moreover, the Colombian Flower Exporters' Association (ASOCOLFLORES, 1996)) was also promoting the use of live fences to 'hide' the plastic of the greenhouses in order to improve the visual impact of the industry on the landscape. However, in both cases the question arose as to the possibility that such 'new' vegetation might also introduce or increase the presence in the crops of insects considered to be pests. Certain trees are 'known' by flower growers, for example, to be full of certain insects they assume are the same species that are pests in their crops. Examples include *Sambucus* sp. which are 'known' to be full of spider mites and Leguminosae trees that will increase the presence of thrips. Faced with this unknown factor or lack of knowledge, the growers showed a certain reticence toward the implementation of these live fences. Most work on insect populations, even as potential natural enemies, has been undertaken in weed or other herb type plants (ATTRA, 2000; Altieri and Whitcomb, 1979; Valladares and Salvo, 1999). A first study was therefore implemented to find out exactly what populations of arthropods inhabited live fences (Lee et al., 1999 and 2000; Pérez et al., forthcoming). Based on those results, a methodology was devised in a second study to design a network of live fences at the municipal level. Future projects will be considered to expand the network to a larger area.

Arthropod diversity has been correlated with plant diversity in agroecosystems (Van Emdem and Williams, 1974). Previous studies have shown that it is possible to manage insect communities through the design and construction of plant architecture that support populations of natural enemies or that might have direct effects on herbivores in a pest situation, including such aspects as ensuring a good mix of crops and varieties of crops in time and space, avoiding monocultures, reserving uncultivated spaces on the farm, and encouraging perennial crops such as fruit trees (Lawton, 1983; Andow, 1991). Many studies have also shown that the most common habitat in which beneficial populations may be found is at field edges (Dix et al., 1995; Bedford and Usher, 1994) and insects generally are more concentrated at borders between fields and woody areas (Forman and Baudry, 1984; Pasek, 1988; Bhar and Fahrig, 1998).

The potential for live fences to enhance arthropod biodiversity

The use of live fences around crops is not a new topic. They have been recommended as wind barriers (Baldwin, 1988), alternative sources of food and fibre, as well as to demarcate farms, and although farmers may actually have used them for centuries (Cherry and Fernandez, 1997), most work on the subject has been concentrated on the particular tree species used. In Colombia, recommendations exist from the point of view of how to make use of natural succession for reforestation purposes (Van der Hammen, 1998). Some studies have focused on how the presence of trees, particularly in live fences can influence the presence of natural enemies (Dix et al., 1995; Forman and Baudry, 1984; Pasek, 1988). Forman and Baudry (1984) list a number of faunal, bird and arthropod studies done in live fences, many which also show the use of the live fences as routes for movement. Summarising a review of work done on endemic natural enemies, Dix et al. (1995) found information mainly on the role of birds. They found very little information on invertebrates, and mention having encountered no information that compares the number of species and individuals of arthropods in windbreaks. However, as mentioned above, the concern for potential pest problems brought on by the implementation of live fences has restrained their implementation. Since people are the basis for the sustainable use of natural resources, if they have doubts as to the usefulness of planting native vegetation, no reforestation programme will ever be successful. Under these circumstances, scientific proof is required to quell such concerns as well as to provide information on the ecosystem that will help decide on which species are the most appropriate according to needs. Integration is required between scientific proof and human reasoning.

For these reasons, a study was undertaken in agroecosystems linked to the flower industry, an important socio-economic activity of the Bogotá plateau. The planting of live fences as windbreaks and barriers to the poor visual impact of the greenhouses has to date been implemented primarily with non-native trees such as eucalyptus, pine and acacia, with adverse effects on the soil structure, water retention capacity and biological activity (Cortés et al., 1990; Ballesteros, 1983). To be able to promote the use of less damaging tree species, particularly native ones, the growers require basic information on arthropod populations of such species that might affect their crops. Insects and spider mites (herbivores, saprophytes, parasitoids and predators) were collected in two farms from six tree species considered as native and frequently used in live fences during a twelve - month period so as to take into account phenological changes of the vegetation. Sampling methods were used that allowed in most cases to obtain information on the role of the collected organisms and their inter-relationships (Altieri et al., 1993; Botelho et al. 1994; Campos and Cure, 1993).

9.2 Materials and methods

9.2.1 Selection of tree species and farms

Insects and spider mites were collected in six tree species: *Abutilon* prob. *striatum* Dickson (Malvaceae), *Tecoma stans* (L.) Juss (Bignoniaceae), *Sambucus peruviana* Presl. Ex DC (Caprifoliaceae), *Escallonia paniculata* (R.&P.) Roem. & Schult. var. *paniculata*, *Alnus acuminata* Humboldt, Bondplant & Kunth subsp. *acuminata* (Betulaceae), *Pittosporum undulatum* (Pittosporaceae), selected on the basis of recommendations by local environmental entities, species typically used in live fences (with the exception of eucalyptus, pine and acacia) and availability of a representative number per species on each farm.

The criteria for selecting the two farms used in the study were: closeness to the research centre, interest of the owners, existence of established live fences, and the fact that climatic factors and pest incidence were being monitored. Both are flower farms producing crops such as roses, alstroemerias, aster, limonium, and gypsophila. Existing live fences are located around the greenhouses in which the crops are grown.

The first farm was located in the municipality of Chía, characterised by a predominance of small properties, producing vegetables and herbs, many with orchards. The second farm was located in the municipality of Sopó, characterised by large dairy farms, surrounded by windbreaks of mainly eucalyptus and pine. Both farms are situated at 2,600 meters altitude, with an average daily temperature of 13°C and a range between 8°C and 18°C, and average rainfall of 1000mm per year.

9.2.2 Sampling

The materials, tools and processes used in the sampling were based on methodologies used by Laroca et al. (1982), Cure et al. (1993), Botelho et al. (1994), and Steyskal et al. (1986). They are described as follows.

Each farm was visited one day from 7am to 3:30pm every two weeks for thirteen months, from January 1998 to January 1999. Each tree species was sampled in varying order three times a day for 30 minutes each at different times of the day. The three visits were made to different individuals of similar phenological development and age. Although some research suggests that there could be interesting differences in species captured at night as opposed to during the day particularly where Hymenoptera parasitoids are concerned (Brown and Schmitt, 2001), night time collections were not possible for safety reasons as well as budget restrictions.

Sampling in each tree consisted of:

- Observations on the phenological state (vegetative, flowering, fructification) of the tree;
- Capture of specimens undertaken manually, with an entomological umbrella, aspirator, net, paintbrush, or by hand. The specimens were stored and mounted as per described in Steyskal et al. (1986). Immature specimens were placed in bags or petri dishes to be reared to adulthood in the laboratory. Additional written observations on habit, location food source, were also made on site.
- Within the tree, the following sites were checked for specimens: flowers (nectaries, ovary, calyx, petals), fruit, leaves (upper and lower surfaces), branches, and trunk.

Additionally, sampling was also done by way of a Malaise trap, assembled as described by Townes (1972), located in each farm for periods of 15 to 21 days at two different times of the year. In both farms, the trap was located within the same corridor in which the manual sampling took place.

9.2.3 Organisation of arthropod species collected

The species were catalogued according to their position in the food web in relation to each other and the tree species in which they were found, based on field observations and rearing in laboratory. All species observed feeding directly on foliage were placed in the herbivore category. Among the saprophytes were included those species found to feed on organic matter in decomposition, by direct observation or on the basis of the literature. Beneficial organisms were categorised as predators or parasitoids, according to direct observation or laboratory rearing. Species observed as in transit were placed in a final category of visitors. National and international specialists identified specimens where possible to species. Due to the high number of individuals collected in the Malaise trap, these were identified to order, with the exception of those belonging to Hymenoptera which were identified to genus.

9.2.4 Organisation and analysis of results

For each tree species, a list of arthropod species was made up including date collected, location, observations on habit, and information on the order and family they belong to. In order to obtain quantitative comparisons of the species collected, the concept of species richness was used, understood as the number of species collected. This concept is considered as the most simple, least ambiguous method for satisfactory measurement of complexity and diversity (Williamson, 1972 in Van Emden and Williams, 1974).

As animals show different degrees of permanence and population density, a method used to estimate these aspects is through the use of the concepts of constancy, frequency and the degree of dominance[16]. These concepts have been used in other similar studies of insect collection involving diverse groups (Bernal and Figueroa, 1980).

Constancy provides an idea of the months in which a particular species is found. It is expressed numerically in the following formula:

Constancy $$C = \frac{100 \times m}{M}$$

Where m is the number of months in which a particular species is present, and M the total number of months sampled (in both farms this was 13 months).

With this parameter, we can establish the following insect and spider mite categories:

- Highly constant species, where C = 75 to 100%
- Constant species, where C = 50 to 75%
- Occasional species, where C = 0 to 50%

[16] Special thanks is given to María Mercedes Pérez for her work on these concepts within this project.

Frequency is merely a semi-quantitative approximation of the value of population density and provides a general view of the number of samples in which a species is present. It is expressed numerically as the percentage of samples in which each species is present.

Frequency $F = \frac{p \times 100}{P}$

Where p is the number of samples in which each species is present, and P the total number of samples taken (21 in both farms).

Again, three categories are discerned:

- Very high density species, where F = 75 to 100%
- High density species, where F = 50 to 75%
- Low density species, where F = 1 to 50%

Degree of dominance links the two previous parameters, establishing which species exercise more dominance over the community on the basis of numerical representation and permanence of each species. To each category established through the calculation of constancy is added the category of frequency, thereby obtaining the following groups:

I. Dominant species, with constancy higher than 75%, and
   a. frequency over 50%
   b. frequency under 50%

II. Species moderately dominant, with constancy between 25 and 75%, and
   a. frequency over 50%
   b. frequency under 50%

III. Secondary species, with constancy below 25%, and
   a. frequency over 50%
   b. frequency under 50%

Frequency, constancy and dominance were calculated for each species collected.

9.3 Results and discussion

Arthropod species collected are listed in table 9.1, including information on order, family, genus and species (where possible), habit, food source, the prey or host in the case of predators and parasitoids, tree species and location found at dominance of the species. From the results, the following observations can be made.

- The diversity of insects and spider mites is correlated with the architectural complexity of the plant species they are associated with (Lawton, 1983). On the one hand, trees and bushes offer a wider range of niches and food resources than do herb species and this in turn favours arthropod diversity. On the other hand, as the number of tree species increases so does the number of arthropod species encountered. The results obtained in the present study support the last affirmation. Whereas an average of 75 arthropod species per tree species was found, a total of 141 species of arthropods were collected in the six tree species of the two locations (Table 9.1).

- Diversity also showed in the number of taxonomic categories: 12 orders and 75 families were represented. Among these, the most abundant were Hymenoptera with 43 species and Diptera with 23 species. These were followed by the orders Homoptera with 22 species, Acari with 12 species, Coleoptera with 10, Lepidoptera with 9, Hemiptera with 7; Collembola, Neuroptera and Thysanoptera with 3 species each; and Psocoptera and Dermaptera with one species each. This coincides with the results obtained by Lewis (1969, in Forman and Baudry, 1984) who found the following order for number of individuals: Hymenoptera with the highest, Diptera, Homopotera, Hemiptera, Coleoptera, and Thysanoptera.

- The diversity of habitat and resources offered by the trees also favoured the richness of the fauna in terms of trophic levels. The category that contained the most richness was that of the herbivores with 48 species, followed by visitors or transitory species with 38 species, parasitoides with 29 species, predators with 13 species and saprophytes with 13 species.

- Four new species were identified by taxonomists, experts in the respective families. This discovery can be considered as an important contribution to the knowledge on biodiversity. The new species are: *Adfalconia* new sp., *Tropidosteptes* new sp. (Hemiptera: Miridae); *Illinoia* new sp. (Homoptera: Aphididae); *Argyrotaenia* new sp. (Lepidoptera : Tortricidae). *Euceraphis gilletei* (Homoptera : Aphididae) was also found and so reported as the first species of its genus observed in South America. As only half of the species collected in this study could be identified to genus and / or species despite contacts made with taxonomists worldwide, we assume that the other half may contain many other new species as well.

- The trees that made up the live fences are an important source of diversity as reflected in the average of 75 species associated with each tree in each location, as shown in table 9.2.

- A live fence made up of only one plant species does not offer as much taxonomical and trophic richness as does one with several plant species, as shown in tables 9.1 and 9.2. This aspect should be taken into account when designing and selecting species for use in live fences.

- Among the species collected were 48 herbivores, although these are not necessarily crop pests. In fact, only six of the herbivore species are considered to be of economic importance for flower crops on the Bogotá Plateau. These are the white fly *Trialeurodes vaporariorum*, the aphids, *Macrosiphum euphorbiae*, *Aphis gossypii* and *Myzus persicae*, and the spider mites, *Tetranychus urticae* and *Tetranychus cinnabarinus*. The leaf miner, *Liriomyza huidobrensis,* was found merely as visitor in the trees studied. This helps to support the research by Holland and Fahrig (2000) who also found a high level of herbivore species richness in field borders, but low population densities. Such results led those authors to assert that although woody borders provide a habitat for herbivorous species, their study did not support the concern that such a situation would lead to increased crop damage as the population densities were low.

- For each of these pest species, at least one species of predator or parasitoid was also found as its natural enemy. Furthermore, for each of these natural enemies at least one other prey or host species was available.

- Live fences made up of the species studied constitute a source of resources required by the arthropods, and particularly by the natural enemies, available at different times of the year thereby ensuring their maintenance and preventing their local extinction. Among these resources are a wide variety of prey and hosts, pollen, nectar, water, a moderate micro-climate, places for nesting, refuge and reproduction, as well as the presence of other competitors and their own natural enemies, thereby constituting a whole micro ecosystem.

- From this, we can say that within these live fences, a community of beneficial arthropods is being maintained and that they probably live off insects and spider mites carried to the trees by air currents. In this sense, the live fences can be considered a barrier to such arthropods and a source of natural enemies to control them. Because they are native species and found under natural conditions, many of these natural enemies should be considered for future studies on biological control.

- By comparing the data on richness of table 9.2, we can see that for most trees, the number of arthropod species was slightly higher in the farm located in Chía than the one in Sopó. It is possible that this may be as a result of the characteristics of the landscape in which each farm is located. In Sopó, large dairy farms with windbreaks made up of eucalyptus and pine trees predominate. On the other hand, in Chía, there are mainly ornamental and vegetable farms, a large number of which are small farms or private orchards with fruit trees and live fences of native species. By using the Malaise trap, the same tendency was confirmed, showing more richness in Chía than in Sopó. While the combination of climatic conditions, farming styles and landscape structure offers an explanation for the differences encountered between the two localities, it is difficult to extrapolate results found on one farm to an entire municipality. Further and more detailed studies are required to confirm this.
- One of the most limiting aspects for studies dealing with arthropod collections is the lack of specialists (also mentioned by Sarukhán, 1998; Dourojeanni, 1990) and the difficulty of taxonomical identification to genus and species. In the case of this study, only 50% of the specimens collected could be adequately identified.
- Another limiting factor was the difficulty in defining the habit of some hymenopterous species that are reported in the literature as parasitoids. In this case, their hosts were not always identifiable so that the adults were categorised as visitors to the trees rather than parasitoids. Any future research that includes a diversity of arthropod groups should complement trap captures with direct collection on the plants in order to better confirm the species habit and their relationship with plants and other organisms.

Table 9.1 Insects and spider mites collected, with information on taxonomical classification, habit, food source, prey or host, and level of dominance in six different tree species in two locations of the Bogotá Plateau.

ORDER FAMILY	SPECIES	Habit	Food / Prey / Host	Abutilon		Alnus		Pittosporum		Sambucus		Tecoma	Escallonia
				Chía	Sopó	Chía	Sopó	Chía	Sopó	Chía	Sopó	Chía	Sopó
ACARI													
• Eriophyidae	*Acaricalus* sp.	H	Leaves				▲						
• Phytoseiidae	*Typhlodromalus peregrinus* (Mumma, 1955)	Pr	Tetranychidae y Tydeidae	■	■	■	●	▲	▲		■	■	▲
	Amblyseius aff. *aerialis* (Mumma, 1955)	Pr	Tetranychidae y Tydeidae										
• Stigmaeidae	*Agistemus* sp.	Pr	Tydeidae										
• Tarsonemidae	*Tarsonemus* sp.	S											
• Tetranychidae	*Tetranychus urticae* Koch	H	Leaves	■	▲					■	▲		
	Eotetranychus sp.	H	Leaves			■	●						
	Tetranychus cinnabarinus Boisduval	H	Leaves										
	Tetranychus sp. 1	H	Leaves		■								
• Tydeidae	*Tydeus* aff. *mississippiensis*	H	Leaves										
• Acaridae	*Tyrophagus putrescentiae* (Schrank, 1781)	S	Fungi, senescent material	■	■	■	■	▲	■	■	■	■	■
• Oribatida	Ori No. 1	S	Fungi, senescent material		■	■			■				■
COLEOPTERA													
• Chrysomelidae	prob. *Epitrix* sp.	H	Leaves	■				■		■		■	■
• Carabidae	Tribu Platynini sp. 1	Pr	Little insects in leaf detritus			■				■			
• Coccinellidae	*Rodolia cardinalis* (Mulsant)	Pr	All stages of *Icerya* sp.					■					
• Curculionidae	*Pandeleteius regina* Howden, 1976	H	Leaves, flowers and fruits			■	●						
	Prob. ***Anypotactus morosus*** (Boheman, 1840)	H	**Leaves**		▲		■		■		■		
	Phyllotrox sp.	H	Leaves								■		
• Nosodendridae	Nos No. 1	S	Bark and debris	■	▲		■		■	▲		■	■
• Lathridiidae	Lat No. 1	S	Fungi, bark and debris	▲	●	■	▲	■	▲	▲	●	▲	▲
•Phalacridae	Pha No. 1	S	Organic material in decomposition	■	■	■	■	■	■	■	▲	■	■
•Rhyzophagidae	Rhy No. 1	S	Bark, wood in decomposition	■	▲							■	

Table 9.1 (cont.) Insects and spider mites collected, with information on taxonomical classification, habit, food source, prey or host, and level of dominance in six different tree species in two locations of the Bogotá Plateau.

				Abutilon		Alnus		Pittosporum		Sambucus		Tecoma	Escallonia
ORDER FAMILY	**SPECIES**	**Habit**	**Food / Prey / Host**	Chía	Sopó	Chía	Sopó	Chía	Sopó	Chía	Sopó	Chía	Sopó
COLLEMBOLA													
Entomobryidae	*Lepidocyrtus* sp.	S	Senescent plant material,	■	▲	■	▲		●	■	●	■	▲
	Entomobrya sp.	S	fungi, bacteria, pollen, algae,	■	▲	■	▲		●	■	●	■	▲
	Americabrya sp.	S	arthropod excrement	■	▲	■	▲		●	■	●	■	▲
DERMAPTERA													
• Forficulidae	*Forficula auricularia* L.	S	Decomposing plant material	■		■		■	■	■		■	■
DIPTERA													
• Chloropidae	Chl No. 1	V	Adults visit foliage	▲	▲	■	▲	■	▲	▲	▲	▲	▲
• Agromyzidae	prb.*Liriomyza huidobrensis*	V	Adults visit foliage	■			■				■	■	■
• Bibionidae	Bib No. 1	V	Adults visit foliage		■		■		■		▲	■	▲
• Calliphoridae	Cal No. 1	V	Adults visit foliage										▲
	Cal No. 2	V	Adults visit foliage										■
• Chironomidae	Chi No. 1	V	Adults visit foliage	●	▲	▲	▲	●	▲	●	●	●	▲
• Curtonotidae	Cur No. 1	V	Adults visit foliage	▲	▲	■	■	■	■	■	▲	■	▲
	Cur No. 2	V	Adults visit foliage	▲	▲	■	■		■	■	▲		■
• Empididae	Emp No. 1	Pr	Adults prey diptera adults	▲	▲	■	■	▲	▲	■	■	▲	▲
• Muscidae	*Musca domestica*	V	Adults visit foliage		■		■		■		■		■
	Coenosia sp.	Pr	Adults prey diptera adults		■					■	■	■	■
• Phoridea	Pho No. 1	Pt	Females of *Icerya* sp.					■					
• Psychodidae	Psy No. 1	V	Adults visit foliage	●	●	■	■	▲	●	▲	▲	▲	▲
• Piophilidae	Pio No. 1	V	Adults visit foliage	▲	■								
• Sarcophagidae	Sar No. 1	V	Adults visit foliage	■	■	■	■	■	▲	■	■	▲	■
	Sar No. 2	V	Adults visit foliage										■
• Sepsidae	Sep No. 1	V	Adults visit foliage	■	▲	■	▲	■	▲	▲	●	▲	●
• Scatopsidae	Sca No. 1	V	Adults visit foliage	▲	■	■	▲	▲	●	▲	▲	▲	●
• Sciaridae	Sci No. 1	V	Adults visit foliage	●	●	▲	●	●	●	●	●	▲	●
	Sci No. 2	V	Adults visit foliage	▲	▲	▲	■	▲	▲	▲	▲	▲	■
• Syrphidae	Syr No. 1	Pr	Larvae prey aphids and scales	▲	▲	■	▲	▲	■	▲	■	●	▲
	Syr No. 2	V	Adults visit foliage and flowers	■			■		■	■	■		■
• Tipulidae	Tip No. 1	V	Adults visit foliage		■		■	■	■	▲	▲	▲	■
• Trixoscelidae	Tri No. 1	V	Adults visit foliage				■	■	■		■		■
• Ephydridae	Eph No. 1	V	Adults visit foliage	■		■				■		■	■
• Muscoidea	Mus No. 1	Pt	Females of *Icerya* sp.					■					

Table 9.1 (cont.) Insects and spider mites collected, with information on taxonomical classification, habit, food source, prey or host, and level of dominance in six different tree species in two locations of the Bogotá Plateau.

				Abutilon		Alnus		Pittosporum		Sambucus		Tecoma	Escallonia
ORDER FAMILY	**SPECIES**	**Habit**	**Food / Prey / Host**	Chía	Sopó	Chía	Sopó	Chía	Sopó	Chía	Sopó	Chía	Sopó
•HEMIPTERA													
•Anthocoridae	prob. *Orius* sp. 1	Pr	Aleyrodidae nymphs, Aphididae	■	■	●	●	■	■	▲	▲	▲	▲
•	prob. *Orius* sp. 2	Pr	Pseudococcidae, Thripidae	▲	■	■	■	▲	■	▲	■	■	▲
•	prob. *Orius* sp. 3	V	Adults visit foliage		■			■	■		■	■	
•													
• Miridae	*Adfalconia* nueva sp.	H	Leaves	●	●	●	▲	■	■	●	▲	●	■
	Tropidosteptes nueva sp.	H	Leaves	■	■	●		▲	■	▲	▲	●	
	Tropidosteptes hirsutus (Distant, 1884)	H	Leaves	▲	▲	▲		▲		▲	▲	▲	
	Tropidosteptes chapingoensis Carvalho & Rosas, 1965	H	Leaves	■	▲	▲		■	▲	■	■	▲	■
HOMOPTERA													
• Aphididae	*Euceraphis gillettei* Davidson, 1915	H	Leaves and young shoots			●	▲						
	Macrosiphum euphorbiae Thomas	H	Leaves and young shoots	●	●			●	▲	●	▲	●	
	Illinoia nueva sp.	H	Leaves and young shoots										●
	Aphis gossypii Glover	H	Leaves and young shoots	▲	▲			■	■	■	■	■	
	Myzus persicae Sulzer	H	Leaves and young shoots									▲	
• Cicadellidae	Cic No. 1	H	Leaves and young shoots	■							▲		
	Cic No. 2	H	Leaves and young shoots		■						▲		
	Cic No. 3	H	Leaves and young shoots	■		■	■						
• Coccidae	Coc No. 1	H	Leaves	■		■		▲	■				●
	Coccus hesperidium L.	H	Leaves		■		■	▲	▲				■
• Pseudococcidae	*Pseudococcus calceolariae* Maskell	H	Leaves	▲		▲	■	▲	▲	■		▲	▲
• Membracidae	*Aconophora* prb. *elongatiformis* Dietrich	H	Young stems					■		■		▲	▲
	Heranice miltoglypta (Fairmaire)	H	Young stems				■				■		
• Margarodidae	*Icerya* sp.	H	Leaves					●	▲				
• Psyllidae	Psyll No. 1	H	Leaves and young shoots	▲		■	■	■		▲		■	
	Psyll No. 2	H	Leaves and young shoots	■		■		■	■	■		■	
	prb. *Ctenarytaina eucalypti* Maskell	H	Leaves and young shoots	▲	■	▲	▲	■	■	■	■	■	■
	Psyll No. 4	H	Leaves and young shoots				■		■	■			■

Table 9.1 (cont.) Insects and spider mites collected, with information on taxonomical classification, habit, food source, prey or host, and level of dominance in six different tree species in two locations of the Bogotá Plateau.

ORDER FAMILY	SPECIES	Habit	Food/Prey/Host	*Abutilon* Chia	*Abutilon* Sopó	*Alnus* Chia	*Alnus* Sopó	*Pittosporum* Chia	*Pittosporum* Sopó	*Sambucus* Chia	*Sambucus* Sopó	*Tecoma* Chia	*Escallonia* Sopó
• Aleyrodidae	*Trialeurodes vaporariorum* Westwood	H	Leaves		●		●	■	■	▲	■		●
	Trialeurodes prb. *abatiloneus*	H	Leaves	●									
	Trialeurodes sp. 1	H	Leaves			●							
	Trialeurodes sp. 2	H	Leaves									●	
HYMENOPTERA													
• Anthophoridae	*Thygater aethiops* (Smith, 1854)	V	Adults visit flowers	▲				■				▲	
• Aphelinidae	*Aphelinus* sp.	Pt	Aphididae	▲	■	■		■	■	▲	▲	▲	■
	Aph No. 1	Pt	Coccidae Coc No. 1					■	■				▲
	Encarsia sp. 1	Pt	Aleyrodidae	▲	■	▲	■					■	▲
	Eretmocerus californicus Howard	Pt	*T. vaporariorum* y *T. abatiloneus*	▲	▲								■
• Apidae	*Apis mellifera*	V	Adults visit flowers	●	●			▲	▲		▲	■	■
	prob. *Bombus atratus*	V	Adults visit flowers		■								
	prob. *Bombus pullatus*	V	Adults visit flowers	▲						■		■	
• Braconidae	*Aphidius* sp. 1	Pt	Aphididae	▲	■	▲	■	▲	■	▲	▲	▲	▲
	Aphidius sp. 2	Pt	Aphididae									■	
	Chelonus sp.	Pt	*Argyrotaenia* sp. larvae			▲		■		▲	■	■	
	Phaenocarpa sp.	V	Adults visit foliage	■		■	■		■	■	■		■
	Pholetesor sp.	Pt	*Argyrotaenia* sp. larvae			▲		■			▲		■
	Praon sp.	Pt	Aphididae	▲	■	▲	■	■		■	▲	▲	▲
• Eucolidae	Euc No. 1	V	Adults visit foliage	■	■	■	▲		■	■	●	■	■
	Euc No. 2	V	Adults visit foliage	■	■		■	■		■	■	■	■
• Cynipidae	Cyn No. 1	Pt	Hyperparasitoid of *Praon* sp.							■			
• Diapriidae	Dia No. 1	V	Adults visit foliage	■	■		■	■			■	■	■
• Eulophidae	prob. *Diglyphus* sp.	V	Adults visit foliage	■	■	■	■	■	■	▲	■	▲	■
	Eul No. 3	Pt	*Argyrotaenia* sp. larvae					■			■		■
	Eul No. 4	Pt	*Argyrotaenia* sp. larvae			■		■	■	▲		■	
	Eul No. 5	Pt	*Argyrotaenia* sp. larvae			■	■			■			
	Eul No. 6	V	Adults visit foliage		■	■	■		■	■	■		■
	Eul No. 7	Pt	*Argyrotaenia* sp. larvae							■			
• Eupelmidae	Eupelminae No. 1	Pt	prob. *Ceraeochrysa* sp.							■			
• Ichneumonidae	Ich No. 3	V	Adults visit foliage	■	■	■	■	■	■	▲	▲	■	▲
	Ich No. 3a	V	Adults visit foliage		■	■	■	■	▲	▲	▲	■	▲
	Ich No. 12	V	Adults visit foliage	▲	■	■	■	▲	▲	■	▲	■	▲
	Ich No. 6	V	Adults visit foliage							■	■		

Table 9.1 (cont.) Insects and spider mites collected, with information on taxonomical classification, habit, food source, prey or host, and level of dominance in six different tree species in two locations of the Bogotá Plateau.

				Abtilon		Alnus		Pittosporum		Sambucus		Tecoma	Escallonia
•ORDER •FAMILY	SPECIES	Habit	Food/Prey/Host	Chia	Sopó	Chia	Sopó	Chia	Sopó	Chia	Sopó	Chia	Sopó
	Ich No. 8	Pt	Lepidoptera larvae			■						■	
	Ich No. 9	Pt	Syrphidae larvae									■	
	Ich No. 15	Pt	*Argyrotaenia* sp. larvae			■	■	■		■	■	■	
	Ich No. 16	Pt	*Argyrotaenia* sp. larvae							■			
	Ich No. 17	Pt	Lepidoptera larvae					■					
	Ich No. 18	Pt	Syrphidae larvae		■		■			■	■		
	Ich No. 19	Pt	*Argyrotaenia* sp. larvae			■		■	■			■	
HYMENOPTERA													
• Megaspilidae	prob. *Dendrocerus* sp.	Pt	Hyperparasitoid of *Aphidius* and *Praon*	▲		■	■			■	■	■	▲
• Platygasteridae	*Amitus fuscipennis* Macgow & Nebeker	Pt	Aleyrodidae	▲			■					▲	
• Proctotrupidae	prob. *Pseudoserphus* sp.	V	Adults visit foliage	■			■		■		■	■	■
• Pteromalidae	*Pachyneuron* sp.	V	Adults visit foliage	▲		■				■		■	
	Asaphes sp.	Pt	Hyperparasitoid of *Aphidius* and *Praon*	■		■	■		■	▲	■	■	■
	Pte No. 1	Pt	Hyperparasitoid of *Aphidius* and *Praon*		■	■					■	■	■
• Scelionidae	Sce No. 1	Pt	Lepidoptera eggs								■		
LEPIDOPTERA													
• Arctiidae	*Halisidota texta* (Hernich - Schaeffer)	H	Larvae feed on leaves			▲		■					
• Drepanidae	Dre No. 1	H	Larvae feed on leaves						■				
• Gracillaridae	Gra No. 1	H	Larvae feed on leaves			●	▲						
• Noctuidae	Noc No. 1	H	Larvae feed on leaves					■					
	Noc No. 2	H	Larvae feed on leaves									■	
	Noc No. 3	H	Larvae feed on leaves										■
• Geometridae	Geo No. 1	H	Larvae feed on leaves	■									
• Tortricidae	*Argyrotaenia* sp.	H	Larvae feed on leaves	▲		▲	■	●	■	▲	▲	▲	■
	Bonagota sp.	H	Larvae feed on leaves			■		■		■			
NEUROPTERA													
• Coniopterygidae	*Coniopteryx* sp.	Pr	Tydeidae						■				■
• Chrysopidae	prob. *Ceraeochrysa* sp.	Pr	Aphididae, Aleyrodidae,	▲		▲		●	■	▲		▲	▲
• Hemerobiidae	*Hemerobius solidarius* Monserrat	Pr	Tetranychidae, Tydeidae, Entomobryidae	●	▲	■	■	●	▲	●	▲	▲	▲

Table 9.1 (cont.) Insects and spider mites collected, with information on taxonomical classification, habit, food source, prey or host, and level of dominance in six different tree species in two locations of the Bogotá Plateau.

				Abutilon		Alnus		Pittosporum		Sambucus		Tecoma	Escallonia
•ORDER •FAMILY	SPECIES	Habit	Food/Prey/Host	Chia	Sopó	Chia	Sopó	Chia	Sopó	Chia	Sopó	Chia	Sopó
PSOCOPTERA			Decomposing plant material,										
• Caecillidae	Cae No. 1	S	fungi, lichen, pollen, algae,	▲	▲	●	■	●	▲	▲	▲	●	▲
• Elipsocidae	Eli No. 1	S	dead arthropods	▲	▲	●	■	●	▲	▲	▲	●	▲
THYSANOPTERA													
• Thripidae	*Frankliniella auripes* Hood	H	Flowers and fruits	■			■		■			▲	
	Frankliniella panamensis Hood	H	Flowers and fruits	■		■		■	■	■	■	▲	
	Psectrothrips delostomae Hood	H	Flowers and fruits	■								●	

Habit of the species : H. Herbivour Pr. Predator Pt. Parasitoid S. Saprophagous V. Visitor of leaves and/or flowers
Level of dominance of the species: ● : Dominant species ▲ : Moderately dominant species ■ : Secondary species

Table 9.2 Comparison of arthropod groups present in the two municipalities of Chía and Sopó, as collected during a 12 –month period between January 1998 and January 1999.

	Abutilon		*Alnus*		*Pittosporum*		*Sambucus*		*Tecoma*	*Escallonia*	
	Chía	Sopó	Chía	Sopó	Chía	Sopó	Chía	Sopó	Chía	Sopó	Average
Herbivoures	22	15	20	18	21	19	20	17	20	14	19
Parasitoids	8	8	14	10	15	6	16	12	15	11	12
Predators	10	8	10	8	10	10	10	8	9	10	11
Saprophagous	12	12	11	10	7	12	11	9	12	12	9
Visitors	25	25	19	26	19	25	24	29	25	31	25
Total	77	68	74	72	72	72	81	75	81	78	75

9.4 Conclusions

Live fences composed of the tree species studied here are elements that contribute to the augmentation and conservation of the richness of flora and arthropods both at the level of the agroecosystems studied as well as the regional landscape. This richness was observed in terms of the total number of species collected, the number of orders and families identified, the different trophic levels represented, the average number of arthropod species associated with each tree species and the discovery of new species.

The diversity of arthropods found in the live fences suggests a resilient ecosystem that can include both crop pests and their natural enemies. When the crop is renewed or replaced, the pest might re-enter the greenhouse or field, however it is quite likely that its natural enemies will accompany it. De Vis and Van Lenteren (1999) found that this occurred for aphids in tomato greenhouse crops in the Bogotá Plateau. Equilibrium can thus be established quickly in the greenhouse and the live fence becomes a provider for a system in equilibrium. Without the live fence, the pest will most likely arrive attracted by the crop, but the likelihood of it arriving with its natural enemies is low.

This type of research contributes to the knowledge of the composition as well as of some of the more important relationships among arthropods inhabiting live fences around flower crops particularly from the point of view of biological control. It is hoped therefore that these results might help promote the use of trees of Andean origin.

From these results and especially due to the tendency shown for some insect and spider mite species to associate themselves with particular tree species, came the idea for the following study.

Chapter 10 - Conditioning of biodiversity in farm surroundings: design of a network of live fences

10.1 Introduction

Knowing which pests are predominant in an agricultural production system, accumulating information on parasitoids and predators of these pests and determining the habitat required by these and other natural controllers, can help decide on which plant species are the most appropriate components of a live fence in a particular context. Additional indicators can be used to determine how much area should be covered in vegetation, such as the ecological infrastructure index (Vereijken, 1995; Kabourakis, 1996).

The fulfilment of the objective of designing a live fence network was based not only on the need for a habitat for natural pest control, but also on the Territorial Organization Plan - POT - requirement for reforestation and increasing biodiversity, as well as the visual impact which it is hoped will increase the attractiveness of the area for tourism. Integration of design needs and expectations was required (Hidding, 1999). Hence the multi-functionality. People from Bogotá will consider Cota as a place to get away from the big city, enjoy nature and perhaps purchase some safe and healthy vegetables. The Cota farmers have for the most part always lived there, so have ownership over it as well as get their living from the land. The town planners will view it as a requirement to reforest based on municipal and regional law. These different values attributed to the same landscape are similar to those of a checklist, collected in an European Union concerted action (1993 to 1997), described in Stobbelaar and van Mansvelt (2000) and grouped into abiotic, social and cultural categories.

10.2 Materials and methods

The method followed in this study for insect collection was the same as in the previous one. Additional plant species were chosen so as to expand the knowledge base on arthropods inhabiting them. Fruit and herbs species were also studied as it is expected that by including such species in a live fence, the farmers would be more likely to look after the portion on their property, particularly in the case of small farmers. Five collecting points were chosen within the horticultural area of the municipality of Cota. A map of current vegetation was elaborated based on an existing digitalised municipal map and recent 1:10 000 colour air photographs.
The plant species chosen here were:

a. Native trees: *Polymnia pyrimidalis* Triana (Compositae), *Brugmansia* sp. (Solanaceae), *Xylosma spiculiferum* (Tulasne) Tr.&Pl. (Flacourtiaceae), *Rapanea* guianensis Aublet (Myrsinaceae), Salix humboldtiana Willdenow (Salicaceae),
b. Herbs: *Calendula officinalis* L. (Compositae), *Aloysia triphylla* Britt. (Verbenaceae), *Myrica parvifolia* Benth.Pl.Hartw. (Myricaceae), *Matricaria chamomilla* L. (Compositae), *Ruta graveolens* L. (Rutaceae), *Nicotiana tabacum* L. (Solanaceae) , and
c. Fruit trees: *Prunus serotina* (Cav.) Mc.Vaug (Rosaceae), *Feijoa sellowiana* Berg. (Myrtaceae), *Rubus floribundus* H.B.K.(Rosaceae), *Carica pubescens* Lenne & Koch (Caricaceae), and *Cyphomandra betacea* (Cavanilles) Sendtner (Solanaceae).

A list of pests according to crop was drawn up (see Appendix 4), emphasising the fact that those living in the soil would not be likely to have natural enemies in the trees, and therefore would not be contemplated in the study.

10.3 Ecological infrastructure index

The Ecological Infrastructure Index (EII) is a figure that expresses the amount of area kept as habitat for fauna and flora, including linear (live fences, biological corridors) and non-linear (islands of vegetation) elements of the landscape. In this case, the EII for the strictly horticultural areas of the municipality was calculated. The same can also be done at farm level. The EII was calculated based on the formula in Kabourakis (1996):

EII = ecological infrastructure (EI) achieved / desired EI

The horticultural area of the municipality covers a surface area of 1232 hectares, while the existing vegetation accounts for 98 of that. This information was obtained by adding the polygons representing the current vegetation from the digitalised map. The current EI is therefore:

$$98 / 1232 \times 100 = 7.95$$

This amount is very close to the figures found in Kabourakis for Crete, where it was recommended that 4% in flat areas and 8% in slope areas be dedicated as conservation area. Of these, 15% should consist of non-linear elements while 85% of linear elements such as live fences.

10.4 Network design

The digitalised map of current vegetation was studied for existing tendencies in live fences. How to decide on the ideal distance between corridors was a problem. Some information was available as to the effect of live fences on air and soil temperatures, evaporation and wind speed. Forman and Baudry (1984) mention that wind is the most important factor, on which the effect of the others depends: day temperature, soil and atmospheric moisture are increased near the live fences, while wind speed, evaporation and night temperatures decrease. The reduction in evaporation is felt as far as 16 times the height of the live fences and 28 times for wind speed. Ideally, the distance between fences should be determined by the distance natural enemies will travel into the field to find their prey. Crop quality, such as a higher sugar content of beets or number of pods on bean plants, and crop yields have reportedly increased where field windbreaks have been used in vegetable production (Baldwin, 1988). References have been made to the fact that predators living in such a fence may forage in adjacent crops (Dix et al., 1995), and that arthropod populations are more concentrated up to 10 times the height of the live fence downwind possibly because they follow the air-flow patterns (Forman and Baudry, 1984). Dispersal, defined by Den Boer (1990) as 'the undirected movement away from the habitat of origin' is calculated by Pasek (1988) for insects on the basis of the height of release, wind speed and settling rate (which in turn is subject to factors such as insect physiology, including the existence of threads, for example in the case of some larvae). She mentions that most larvae are not likely to disperse more than 200m, while scale insects have been reported to disperse up to 5km. In reference to beneficial insects, Lewis (1969) found higher concentrations of Miridae, Syrphidae within 4 times the height of the live fence and Hymenoptera within 10 times. Otherwise, few exact figures on distances of insect movements in open fields were found in the literature, none in tropical contexts, and few particularly dealing with the distance a control agent might travel to seek its prey. Generally, however, the authors consulted concur on the fact that there is a greater concentration of insects nearer to live fences, especially on the leeward side, from one to 12 times the height of the fence

(Forman and Baudry, 1984; Pasek, 1988) and that this distance tends to increase with the permeability of the fence (Pasek, 1988).

Due to the scarcity of specific information relevant to this particular case, from the first 'line' of live fence, the following ones were calculated at distances of approximately 500 meters, making use of existing tendencies. This resulted in a network of 13 lines width wise and 5 lines lengthwise throughout the horticultural areas of the municipality. Although optimally each farm should be planted with a live fence all around it, that is obviously not an option first for financial reasons, as that would be quite costly, and second because since the plots are all quite small, a significant area normally dedicated to farming would have to be given up. The proposed network would ensure that at least every 3 to 4 farms, there would be a line of trees linking the mountain to the river. From conversations with Van der Hammen, we agreed that should the municipality manage to implement this 'primary' network of live fences, a significant step would have been made in the right direction toward obtaining biological corridors at a local level.

The length of trees in the existing lines was calculated, as well as the total length of the line, in order to determine linear meters lacking, and therefore the number of trees required to fill in the primary network.

As is shown in table 10.1, the total length of live fence requiring completion in the horticultural area of the municipality is 18300 meters. Another 1230 meters at least are required in order to ensure linkage with the river. In other words 19530 meters of trees are required. Planted at a distance of 3 meters, that would mean that 6510 trees are needed for the primary network to be complete.

Table 10.1 Calculation of the linear meters lacking in the proposed live fences network.

Line No.	Distance in the horticultural area (linear meters)	Additional meters recommended *	Current area in vegetation (ha)**	Current linear meters in the horticultural area	Linear meters lacking in the horticultural area	Additional linear meters lacking
1	1350	300	0.8347	930	420	80
2	1850	375	0.6946	1230	620	-
3	2300	1000	0.6346	1220	1080	-
4	2900	800	1.5495	1550	1350	-
5	1550	450	0.8407	890	660	450
6	2650	0	1.0794	1740	910	0
7	1480	0	0.9717	980	500	0
8	1200	200	1.1314	980	220	200
9	1200	0	1.0323	1040	160	0
10	1650	180	1.8140	1150	500	20
10A	650	250	0.9542	250	400	0
11	1250	850	2.1828	1120	130	250
12	1100	500	1.2471	940	160	-
13	600	300	1.0700	600	0	230
A	7300	0	6.4096	5260	2040	0
B	3500	0	1.4266	2010	1490	0
C	5400	0	5.2624	3020	2380	0
D	4700	0	1.0081	460	4240	0
E	4850 (157(	0	1.000	2050(470)	2800 (104(	0
Total	44200	5205	31.1437	25900	18300	1230 (minimum)

*in order to complete the live fence all the way to the river.

** includes islands of vegetation.

E – 'peripheral' live fence, of which 1040 meters are new; the rest overlaps with the other fences. This was taken into account in the calculation of the total.

10.5 Selection of plant species for the network

In order to choose the species most appropriate for each live fence, the information on arthropods inhabiting the various tree species studied in both projects was compiled (table 10.2). The design should include plants of varying size and uses in order to fulfil the following criteria:

- promote the presence of natural enemies of crop pests;
- avoid causing a disturbance to the crops by causing shade (choose low trees or bushes);
- help as windbreaks in order to reduce water evaporation in the plots and thereby reduce the need for irrigation (choose taller tree species);

- help in the control of crop pests coming from neighbouring fields (choose taller tree species, densely planted – Bhar and Fahrig, 1998);
- provide the farmers with a visible reason to look after the trees – species of economic importance should be included, such as fruit trees and while these grow, species of herbs.

In this way, three groupings of the plant species were formed.

- Tall trees, over four meters height: these should be used as wind breaks, where there are no telephone or electricity cable, and where there is no risk that they cause shade to crops.
- Medium sized trees (up to four meters height): for sites where cables could cause trouble or taller trees might shade crops (recommended for more public sections).
- Medium sized species mixed with fruit trees and herbs: for sites where cables could cause trouble or taller trees might shade crops, and in cases where they surround crops.

This and additional information on the aptitude of the trees and bushes according to criteria such as attracting pollinators, controlling erosion, water conservation among others, although far from complete, is summarised in table 10.3.

10.6 Some final thoughts on the use of live fences in landscape design

The roles live fences play are diverse and many have economical and social, as well as the more obvious ecological, benefits. They provide windbreaks, thereby reducing soil erosion and crop evapotranspiration, keep grazing animals in or out of the field, provide property limits and private areas, habitat for flora and fauna, alternative sustenance when fruit trees are included and offer an agreeable sight to the people who live there as well as passers-by. The link between humans and their agricultural activities, and the landscape, has always been strong. A better understanding of this link should help us to maintain and promote it, and put us a step further ahead in the aims of sustainable agriculture. To have 5% of the farm in natural habitat for the enhancement of flora and fauna is a minimum suggested to this end (van Elsen, 2000), but this same author urges an integration rather than a segregation of areas within the farm.

Table 10.2 Summary of information on trees inhabited by natural enemies.

	Inhabited by natural enemies of:					
Plant species	Aphids	Leaf miners	White fly	Caterpillars	Spider mites	Thrips
Cyphmandra betacea	x	x	x	x	x	x
Carica pubescens	x	x	x	x	x	x
Feijoa sellowiana		x		x		
Rubus floribundus	x	x	x	x	x	x
Prunus serotina	x	x	x		x	x
Xylosma spiculiferum	x	x	x			x
Rapanea guianensis	x	x	x	x	x	x
Alnus acuminata	x		x		x	
Pittosporum undulatum	x				x	x
Abutilon prob. *striatum*	x		x		x	
Sambucus mexicana	x		x			
Tecoma stans	x		x			
Escallonia paniculata			x			
Polimnia pyrimidalis	x	x	x	x	x	x
Brugmansia sp.		x		x		
Salix humboldtiana	x	x		x		x
Lippia citriodon	x	x	x	x		
Ruda graveolens	x	x				
Nicotiana tabacum	x	x				
Myrica parvifolia	x	x	x	x	x	x
Matricaria chamomilla	x		x		x	x
Calendula officinalis						

Further research in many of the aspects brought up in these projects is required. There is a need for more observation of a span over several years, especially comparing fields with and without live fences, expanding the number of tree and shrub species involved. Although information on dispersal by wind is available, distances traveled by natural enemies in search of their prey or host in open fields is still a virtually untouched area of research. Details on the trophic relationships of the insects collected, the usefulness of the beneficial insects collected in biological control strategies, further studies to deepen the knowledge of the landscape effect on farm biodiversity and similar studies in other agricultural sectors (animal husbandry, for example) are required. Research on the maintenance of established live fences is also needed, as is the optimal amount of area required for EII in tropical conditions.

In the meantime, the data collected here were shared with the farmers in Cota and other communities, with the hope that their interest would awaken as to the benefits of enhancing biodiversity on their individual farms and the importance of integrating individual farms within a regional context. In Cota, an insect collection with representatives of the different insect groups collected was given to the UMATA so the farmers could easily compare any specimen they might find and thus determine whether in fact it is a potential pest, natural enemy or harmless. An average of 20 native trees was also given to each farmer or couple participating in the project in order to begin the implementation of the live fence network.

The information collected in these two projects have already begun to cause interest among flower and vegetable producers alike. Some municipalities in the region have voiced an interest in a regional project that would consider the design and implementation of live fences on a larger scale. This shows how scientific study can provide constructive support to a socio-ecological change process. The challenge here will be to bring the different entities together and negotiate a deal which will satisfy all.

Table 10.3 Classification of trees and bushes according to their use in live fences

Scientific name	Native	Height	Growth	Riversides	Wood	Medicinal	Fruit	Nat. Control	Birds	Polinators	Bats	Erosion
Abutilon prob. *striatum*	x	medium	rapid					x		x		
Senna viarum	no def.	tall	moderate			x				x		
Adipera o Casia tomentosa	no def.	medium	moderate									
Alnus acuminata	x	tall	moderate	x				x				
Polimnia pyramidalis		tall	rapid	x		x		x	x			
Brugmansia sp.	x	medium	rapid	x		x		x				
Prunus serotina	x	tall	moderate			x	x	x	x	x		
Tecoma stans	(E.U.)	medium	moderate			x		x		x		
Baccharis bogotensis	x	tall	rapid							x		x
Piper bogotense	x	medium	moderate			x			x		x	
Xylosma spiculiferum	x	medium	slow					x	x	x		x
Rapanea guianensis	x	medium	slow	x				x	x			
Feijoa sellowiana	no	medium	moderate				x	x	x			
Inga codonantha	x	tall	moderate	x	x	x			x	x		x
Lafoensia speciosa	x	tall	moderate	x	x					x		
Pyracantha coccinea	(E.U.)	medium	slow									
undulatum	(Australia)	medium	rapid							x		
Escallonia pendulatum		Medium	Rapid									
Oreopanax floribundum	x	tall	moderate	x	x				x			
Streptosolen jamesonii	(Ecuador)	low	rapid					x	x	x		
Rubus floribunus		low	rapid				x	x	x			
Carica pubescens	x	medium	rapid				x	x				
Vallea stipularis	x	tall	moderate		x					x		
Croton funckianus	x	tall	rapid	x	x				x			x
Salix humboldtiana	x	tall	moderate	x	x	x		x				
Sambucus mexicana		medium	moderate	x		x						
Escallonia paniculata	x	tall	moderate	x	x			x				
Tilia sp.	no	medium	moderate			x						
Cyphomandra betacea		medium	rapid				x	x				

Phase IV Consolidating future group autonomy

By now, the farmers have gone through three phases of the learning pathway. Phase I covered the beginnings of the conversion process which involved a participatory diagnosis of the farmers' situation at that time, a design drawn up with the farmers as to how to go about solving the problems identified, and implementation of the solutions. These solutions consisted mainly of methods to help them convert their farms gradually from being unproductive, ecologically unfriendly plots to ones with higher productivity, more self-reliant where inputs were concerned and more ecological. Phase II saw the farmers move towards a group consciousness, which incited them to look at how to join forces for marketing and then study different options to become formally organised. Phase III showed how this group consciousness has created a need to consider conversion on a larger scale, requiring regional plans for aspects such as the implementation of biological corridors to re-establish biological diversity and help recover farm resilience as well. Regional development became an issue.

This last phase corresponds to the time period in which the farmers are on their own, after project closure. At this point, the farmers' role is strongest, and the expectation is that the researcher-facilitator and project team are no longer in the picture. To ensure continuity of the process in this phase, the research was oriented toward activities that would strengthen the farmers capacity to stand on their own. Training of local facilitators was considered to be a way to achieving this. How this was done is described in Chapter 11.

Chapter 11 - Training of local facilitators for group support

11.1 Background

To help ensure continuity of the process initiated here, the farmers and project team agreed that it would be necessary to train some of the participants as local facilitators. These people would receive more in-depth training on technical aspects of the conversion process, reviewing particularly those parts where they felt weakest, as well as training on how to provide knowledge to their neighbours. They would be focal points of information, and so for that, also needed to know where to look for any information they lacked. The idea was to help this group become self-sufficient in information management so that a reversal to original dependency on input salespeople and other actors with different agendas would not occur. This point was also considered important by Berdegué and Escobar (1997) who emphasised the need to help the farmers to build strategic partnerships if they are to compete in national and international markets.

Access to information only, however, is not sufficient to ensure that it is understood, adequately used, adapted or otherwise put to use. The ability to analyse, reflect, to then use or discard the information according to its appropriateness to local conditions, must also be developed in these future local facilitators. They must, as it were, learn how to turn information into knowledge. In this sense, Stiglitz (1999) lists three points that must be considered when discussing knowledge:

- The complexity and variation among societies requires localisation of knowledge;
- Practical experience or tacit knowledge must be exchanged through horizontal learning; and
- Each society must take charge of the local learning process, adapting it to fit local conditions.

Thus, for knowledge to be useful, it must be adapted to local circumstances, and for that to happen, active participation of those who know the conditions is necessary. 'It is by the local selection, assimilation, and adaptation of knowledge that local doers 'make it on their own'' (Stiglitz, 1999). The ability to be open to new forms of knowledge and to use it selectively or by adapting it also reinforces local autonomy, instead of increasing dependence on external sources.

11.2 How to train local facilitators

Three phases were involved in training the local facilitators over a time period of six months nearing the end of the project:

- Diagnosis of the advances of the project. This part involved all of the project participants and required that they review everything that had been done and study to what extent change had occurred on their individual farms. One of the main exercises was in fact, the presentation of before and after drawings of their farms. A list of limitations to continuity was drawn up and suggestions made to overcome them. Finally, digitalised municipal maps were used to show where the existing participating farms were located and the estimated degree of likelihood that their neighbours might be convinced to change. These allowed both farmers and project team members to appreciate the real effect the project had had to date as well as the extent of understanding, recognition and appropriation the farmers had of the process. The organisational aspects were seen to be the weakest component of the project.

- Selection and training of the facilitators. The farmers elected twelve people of the group by confidential vote to be trained as facilitators. A plan of action was then drawn up by the facilitators-in-training with their training needs and strategies to ensure process continuity. The group of facilitators was divided in two for better coverage of the topics requiring work. Group 1 was to look specifically at agricultural techniques and organisation, by strengthening their knowledge on technical aspects so as to guarantee the necessary support and technical assistance to the other farmers. Group 2 concentrated on marketing and project management, and was specifically involved in elaborating the action plan by following a method used for preparing project proposals.

- Implementation of the action plan, adjusting it where needed. The action plan was made of objectives, activities and quantified indicators of achievement with specific time frames. For example, a programme was designed to meet market demand for particular vegetables. This programme was to be in place by a certain date in order to meet the deadlines set by the marketing assistant for the beginning of deliveries.

The particular training of the facilitators as facilitators involved having the two groups answer the following questions:

a. What is the image you have of a facilitator?
b. What information do you need to do the job of facilitation?
c. What would you expect if you had to go to a facilitator for help?
d. What are the advantages of being a facilitator?
e. What are the most important aspects of the topics to be dealt with by each group?
f. What must be included to adequately monitor progress and farm accounts?
g. How can we overcome the limiting conditions to continuity?
h. What is organisation and planning and what use do they have?
i. How do we imagine this farmer group organised?
j. Is organisation important?
k. How can we work on preparing the organisation of the participating producers?

Answers to these questions included the prerequisite for being a facilitator that the person have hands-on experience so as to be a model for the others. The person need not know everything, but s/he must be open to learning. S/he must know how to access information and keep up-to-date. S/he must be able to identify errors in farm implementation of the ecological practices and to help look for solutions. The person must get along well with the others, know how to transmit knowledge and how to generate change in thinking and attitude toward new processes. S/he must generate confidence and credibility, and be committed.

Other than a list of technical courses they felt they needed to improve their current level of knowledge, they also suggested that a manual for ecological production should be prepared based on their experience and that more support was needed in communication especially from the point of view of facilitation. They also emphasised the need to know where they can get information from and how to go about doing it (internet, libraries, research stations, consultants) and how to register information on farm progress, including accounting. From the marketing point of view, the facilitators stressed the need to educate the consumer as well as the other producers on the implications of safe and healthy food. They also voiced the need to define a logo and label for their group to be able to generate recognition for their efforts.

For the farmers, advantages to being a facilitator include access to the extra learning, the possibility of influencing objectives of the municipality or of other projects, and of being in a position to make sure that was started here does not get lost. Other points made included the opportunity of applying the knowledge acquired to specific cases that will help produce positive changes.

Specific training provided

- Internet access. Internet has only recently been considered as accessible to the rural poor. As Stiglitz (1999) comments, Internet has helped the users realise that knowledge is a global public good. As long as the hardware and communication infrastructure is available, access to information by the poor can be increased dramatically. There are some attempts in Colombia to establish Internet outlets in remote places, however, due to the size, topographical difficulties and insecurity, progress is slow. In this project, it was acknowledged that much information found on the Internet could be useful to the Cota farmers, including the SIPSA, a website established by the Ministry of Agriculture (MAGDR) to provide up-to-date information on agriculture prices. So one of the two local facilitator groups was trained at a local Internet café on aspects as basic as computer parts, through doing searches and how to print a file. The information that they were able to download after a very short period of training, even when some of them had not even used a computer before, shows that Internet offers farmers an interesting source of information beyond the boundaries of their municipality or even country.

- Allelopathy and compost. This time, the workshop was given by one of the producers considered by all to be the most knowledgeable on the subject. This producer had prepared the workshop before hand very well, and provided the facilitators with the basic principles and techniques involved in preparing fermented tea, compost piles and vermicompost. This workshop was used as an example of horizontal learning, in which the farmers learned to value the knowledge built up locally before looking outside their municipality.

- Live fences. Although most of the farmers were familiar with the idea of live fences, they were less clear on how to choose the trees particularly to combine economic use with environmental services. The information provided in this workshop covered the contents of Chapters 9 and 10.

- Identification of pests and diseases. This course was given at the Horticulture Research Centre for the entire farmer group. Personnel from the Integrated Pest Management research group, including those from the Plant Clinic helped give this course, making use of the practical experience they have gathered attending clients. Emphasis was made on visual aids and practical identification by stereoscope.

- Preparation of a project proposal. Problem definition, general objective, specific objectives, strategies, aims with measurable indicators, activities were defined and applied to a proposal on how to solve some of the difficulties of commercialisation, in particular regarding the programming of crops to ensure continuous availability of the produce.

- Social processes. A course on communication, interpersonal skills, negotiation, and so on, was given (see Chapter 8). This will have to be reinforced particularly to help the farmers learn to analyse situations so they can progress individually and as a group, learn to overcome problems and deal with them appropriately, and so forth.

The two facilitator groups were thus trained in technical aspects as well as in some soft elements to enable them to access information and build up an agriculture information network to suit their particular needs. This is one step closer to helping the group of farmers of this project to become more self-reliant. Mechanisms will have to be established to offer this 'service' to the other farmers so that some compensation is received for their investment in time. Such decisions will need to be made by the whole group, as all are concerned to one degree or another.

11.3 Is the farmer group self-supporting enough?

While the project team can do what both they and the farmers agree is required to help the farmer group toward autonomy and self-reliance for long-term continuity of the process, ultimately the level of interest and commitment of the farmers will be the determining factor. What they decide to do as a group, and even more importantly, what they consider that the group format can do for them, will influence and be influenced by their view of this project.

It cannot be expected that association is the solution to all their problems (Stringfellow et al., 1997), nor necessarily the path to success where sustainable vegetable production is concerned. Cooperativism has in fact acquired a bad name in Colombia because it has been misused (Margarita Ramirez, Pontificia Universidad Javeriana, 2001, pers. comm.). What is important is that as a group they define objectives that do not 'exceed their current management skills' (Stringfellow et al., 1997) and, by slowly strengthening the group and themselves as cooperating members, work gradually towards those objectives.

Building on what has been initiated here, some immediate activities this group could undertake in the future are:

- Decide on a mechanism for problem identification and priority setting that everyone feels comfortable with. Many exercises were done in this area during the project so that they should already have an idea of the most appropriate procedure for them.
- Make use of the information network to access consultants to solve particular problems they may encounter.
- Maintain themselves up-to-date on available technology, including new seed varieties, sources of inputs, new packaging materials, etc. This they can do by staying in contact with the members of the project team, surfing the Internet, keeping aware of and attending educational events, and so on.
- Slowly get involved in the management of activities such as marketing which will generate income to members (Bebbington et al., 1994).
- Build up a group 'resume': they should begin to put into practice what they have learned on project proposal writing, by presenting small projects at first. This will provide them with practice on generating and managing funds as a group, which over time will enable them to grow.
- Confidence in themselves as a group must be constructed as well, since success attracts and the association could be politicised easily if it does not have its own strong personality.

The experience of visiting other farmer groups has shown them that working together is possible, but it requires motivation and dedication of time to create what they want, and to do that, they must first know what they want. Creating facilitator groups is a tool that if well used could ensure that the farmers build and maintain their self-reliance as a group. Just as with the conclusions drawn at the end of Chapter 8 on organisational learning, the local facilitators will also require more strengthening before they are looked on as reliable information sources by their fellow farmers.

11.4 Conclusion

Chapter 11 concludes the phases of the learning path that evolved throughout the case study project in collaboration between farmers and researchers. Learning is an iterative process that will see the farmers continuing around the four phases as shown on figure 2.5. However, as they build up their degree of self-reliance, the curve will move up through the third dimension that represents autonomy, preventing in such a way that they might return to their initial situation.

In the following, final chapter, we return to the research activities on which we set out in Chapter 1, and attempt to draw systematic conclusions about agriculture development research.

Chapter 12 - Discussion and conclusions

12.1 A review of the research questions

At the beginning of my study, I set off with the intention of providing a methodology that would help realise change and facilitate learning processes for successful innovation at individual, group and institutional levels. I also promised some guidelines for policy making focussed at improving family farming in Colombia.

The research is grounded in a societal problem of small vegetable farmers located in the high Andes. These farmers were characterised by their very low income, high dependence on external inputs and biased sources of information, land severely degraded due to excess mechanisation and pesticide applications, and poor negotiating power in the market.

I therefore identified two research problems to be resolved, specifically:

- What kind of learning trajectory can be designed to help small farmers in the high Andean Bogotá Plateau move toward more sustainable forms of production, that would also be useful on a larger scale and be replicable? and
- How can agricultural research help and what set of research activities are required to facilitate the farmer learning pathway?

To orient the solving of these two problems, a case study approach was proposed and two general research questions introduced:

- What is the nature of the elements and their relationships in the sequence of respectively the research activities, and the farmer learning pathway?
- What is the nature of the interface between the sequence of research activities and the farmer learning pathway?

In other words, the present research project is of interest because it looks at (1) the farmers' learning pathway, (2) the agricultural research activities designed to elicit this learning pathway, and (3) their interface. To the extent that they are described in this book, the three are empirical outcomes of an emergent, adaptive, interactive process between scientists and farmers. They were not planned or hypothesised. They emerged as fieldwork progressed. The justification for the claims made in this book rest on the recorded satisfaction of farmers and concrete changes observed in a subset of the participating farms. In all, the research can be classified as a 'one shot' evaluation of a single intervention, with all the shortcomings thereof. It used a case study approach with a vengeance. Its contribution lies in the greater insight in farmer learning and the role of agricultural science in this learning. The outcomes are indicative. They become significant within the total set of studies with similar objectives and results (e.g., Tekelenburg, 2001).

The two general research questions were elaborated on as follows:

What research methodology can be used to facilitate the conversion of farmers to more sustainable agriculture in a developing country under continuous cultivation? We can distinguish research activities associated with:

1. Designing, under such conditions, a farming system that gives higher yields at lower costs, economically and ecologically, so that productivity as a whole is improved (β dimension, Phase I).

2. Facilitating small farmer group formation and organisation so as to ensure emergence of concerted action (γ dimension, Phase II).

3. Designing landscape level elements at a higher scale (region) to support the new farming system, moving from small farm management to applications at a regional level (β dimension, Phase III).

4. Facilitating ownership of the process that will ensure continuity after the researcher – facilitator has left. We can call this the 'facilitation of self-facilitation' (third dimension, Phase IV).

To answer these questions, this final chapter pulls together the results of the work. It starts off with the learning points about the farmer learning pathway that actually emerged during the course of the project (12.2). This overview is followed by a set of learning points with respect to science-linkage derived from the experience (12.3). Initially, the project did not seem to need to give much attention to policy and institutional conditions. However, these proved increasingly important. Section 12.4 provides an overview of the issues that emerged at the institutional and policy levels. Finally, section 12.5 offers some suggestions as to future research needs.

12.2 Summary of the farmer learning pathway that emerged

In this section, I focus on those outcomes that actually emerged during the work with the farmers.

12.2.1 Main elements of a farmer learning pathway for farm conversion

The set of elements in the learning process that evolved during the project and that seem to be essential in designing a learning path for small farmers includes:

- participatory diagnostic exploration (partly based on an analysis of the context by the research, to which we shall turn below);
- building a learning platform that evolves from meetings and training sessions, to collective decision-making, to association and organisation;

- a farm conversion process designed with farmers that mobilises expert knowledge at farm level;
- expanding the conversion to include a wider area (landscape);
- building a marketing organisation; and
- creating capacity for self-facilitation to access new knowledge and build resilience (autonomy).

12.2.2 Dimensions of the learning pathway

Using hindsight, it seemed that the learning pathway of the farmers moved along three dimensions. The first, dealing with 'hard' ('beta') issues, took the farmers from the situation of high reliance on external chemical inputs with no guarantee of recovering their costs, much less of making a profit, to one where they are able to choose and combine production methods most appropriate to their conditions and expectations of economic return. The second opened opportunities for the hitherto atomistic self-centred farmers to join forces with fellow farmers so as to achieve recognition and bargaining power. The third moved the farmers from a situation where they were highly dependent on others for their information, for acquiring inputs and for selling their produce, to one where they were more self-reliant, able to make informed decisions, seek information and make their own inputs should they so desire. In sum, they became more autonomous. Figure 2.5 brings these three dimensions together in a spiral that moves around and up. The spiral suggests that the farmers went through different phases during the process of conversion to sustainable farming. But the notion of sequential phases is only adequate to a limited extent.

12.2.3 The dimensions of the learning process occur parallel to each other

The elements do not make a neat set of phases as portrayed in figure 2.5. In fact, the technical conversion ('beta'), and the building of a learning capacity ('gamma') are really parallel processes that mutually influence and reinforce each other. Leeuwis (1999b) has earlier made a plea for much greater attention to the participatory nature of effective prototyping. But the importance of a parallel stream of beta and gamma activity, i.e., of designing systems that work and systems that are acceptable *at the same time* (see also Tekelenburg, 2001) requires the mutual interweaving of the two processes, as they mutually reinforce each other. For example, the participatory diagnosis allowed both priority setting of 'hard' issues that farmers wanted to tackle, *and* the emergence of a learning platform (see 12.2.5).

12.2.4 Participatory diagnosis leads to learning platform

Through the information map and the list of obstacles to vegetable production and marketing, the farmers described a complex situation in which a wide variety of actors and factors were involved. The farmers organised the list of obstacles according to general areas and then prioritised these areas for problem solving. Although many of the problems enunciated had been included in the context description, this diagnostic exercise served to confirm and elaborate on the problems. At this point, I also realised that the initial methodology for the conversion process proposed to the financing agency would have to be changed, precisely in order to better answer the farmers' needs. This original methodology was heavily inspired by Vereijken's work on prototyping, successfully implemented in Europe. I left this methodology to incorporate priority setting by farmers, also with respect to the substantial technical problems they wanted to deal with. From the prioritisation, I was able to give the research activities an order that made sense to the farmers rather than using an imposed agenda. This was fundamental to the farmers' learning process as they felt that the time they were spending in the project actually was helping to answer their own questions.

This is a very important result of the project. As facilitator of the project used as case study here, I had started off with the idea of using the prototyping methodology, albeit at a more participatory level, for the conversion of small farms in Colombia to more sustainable practices. In fact, it turned out that what was required went much beyond prototyping with its emphasis on the beta dimension of learning. Many aspects dealing with the gamma dimension needed to be included, leading to a very interactive learning platform as a meeting point for farmers and researchers that led to a conversion design that was appropriate and acceptable to the farmers.

The participatory diagnosis thus proved to be a very important phase. It was during this participatory diagnosis that a platform began to emerge on which farmers and researchers could interact to engage in joint learning. This proved crucial for the rest of the project.

12.2.5 Interactive design of farm conversion

The eight prioritised areas provided the order in which the farmers preferred to begin resolving their problems. A basic framework was drawn up (figure 5.1) that would permit coverage of the different areas in the defined order. Methods for the implementation of each step would be chosen together with the farmers as their learning and needs evolved. However, the first activity for each of the areas was practical and theoretical training. A multi-disciplinary project team was definitely essential to meeting these needs. In other words, during the interactive design of farm conversion, intensive science-linkage occurred.

Specialists were drawn in to give courses. Specialist knowledge was obtained from the University. But farmers played a key role in systematically trying out new ideas on their farms. We followed discovery learning principles as much as possible. Sometimes some farmers would volunteer trials when others were not yet ready. During this phase farmers were eager for information.

12.2.6 The need to learn to work with nature

Learning to work with nature required the development of the capacity of observation. In the context of pest and disease management, the farmers learned to identify reasons for the appearance of such problems. Perhaps the soil has an excess amount of nitrogen. It is said that plants in that situation 'call' certain insects to practice what amounts to 'bleeding' of the plant. In fact, the more luxurious the plant, the more it attracts insects. This can often explain, for example, the presence of aphids in broccoli crops. Perhaps, on the other hand, the tri-trophic relationship formed by the plant, pest and natural enemy, has been broken or become unbalanced. Valladares and Salvo corroborate this when recommending a food web approach to pest management for such cases to study feeding interactions, an approach that is just beginning to be used in an agricultural context (1999).

An additional learning aspect for the farmers was patience: micro organisms take longer to have an effect than do chemical pesticides and the idea is not to cause a disruption even by the application of natural inputs (Lewis et al., 1997).

Most importantly, in order to be able to do all the above, the farmers had to learn how to observe and understand nature, implementing the strategy most appropriate to the particular circumstance based on an understanding of nutrient and life cycles. 'The realisation dawns that agriculture cannot be developed without banking on the intelligence, creativity and competence of farmers. Instead of adoption, the emphasis is now on learning. Farmers become experts, not by adopting science-based technologies, but by becoming better learners' (Deugd et al., 1998).

12.2.7 Implementation of the conversion process

The various methods used by the participating farmers in the management of the soil system led to the replacement of chemically synthesised fertilisers by most of them. Where they still used chicken manure, they first composted it. They understood the importance of soil analyses in order to provide the soil with nutrients according to crop needs rather than basing fertiliser applications on the calendar. Many of the soil amendments (compost, microbial soups, teas) were being prepared on the farm, while supplementary sources of nutrients were acquired from external sources. In one case, a farmer began a small business to provide the other farmers with the amendments, which could be time-consuming in their preparation. Based on the farmers' own observations, the soil, which had started off as floury looking, was beginning to form aggregates once more. 'Cuando la tierra va cogiendo grano' (when the soil begins to form grains) was an indication to them that the soil was starting to recover its health.

Where water management is concerned, the farmers are now more aware of how to calculate water requirements based on crop needs, climate and soil structure. They understand the importance of water quality not only from the chemical point of view but especially for health. They have been exposed to new more efficient irrigation systems. In the future, more work will be required for this area, particularly to prepare the farmers for drought periods.

In the cropping systems management area, the farmers know now how to plan their crop rotations based on type of crop and the botanical family it belongs to, as well as incorporating the factor of market demand. Integrated crop protection methods, including botanical and biological sources of pesticides, have been introduced with positive results for the management of pests and diseases.

With time, management of farm vegetation including live fences is expected to help in the recovery of farm system resilience, reducing the need for pesticides of any kind. The effects of rotations and friendlier methods of pest and disease management on the soil and the farm surroundings will be visible in the longer term. However, the farmers do insist that they have had to spray less since they joined the project and have noticed a larger number of bird species, some of which they had never seen before.

By the end of Phase I of the farmer learning pathway, the farmers had progressed along the first dimension from a high dependence on external inputs and biased information providers to a situation in which they had knowledge of choices available and the know-how to prepare the inputs themselves. The results described in Chapter 6 demonstrate as much. Their cropping systems were no longer based on monocultures, they implement sustainable practices for soil and water conservation, undertake better plant and disease management strategies and as a result have achieved better farm productivity overall.

In what we called 'Phase II' of the learning pathway, the horizons of the farmers widened. Their focus moved from the farm to the market place. They learned about post harvesting techniques to maintain product quality throughout the distribution channels. They applied marketing strategies new to them to the implementation of an agroecological tourist route, home distribution of their produce and the supplying of some restaurants. Differentiation of their product remains a problem that will require dealing with in the future. Some options include the use of a Good Agricultural Practices protocol or convincing neighbours to join them and acquire ecological certification as a group. The role of research here was through the application of results obtained elsewhere. The result was specifically a set of farmer-owned marketing strategies that signified better market control.

The farmers gradually realised that working on their own multiplied the amount of effort required to keep updated on production techniques, market their produce, obtain fair prices, and so on. Forming a group seemed to be an interesting option. Once again, training was instrumental in providing information and techniques for group formation, leaving the farmers with sufficient space to decide themselves what they would do. In facilitating the process at this stage, it was very important not to take that decision for the farmers, since that could have resulted in them associating themselves for the wrong reasons leading potentially to failure of the association.

Having reached a certain technical ability that permitted them to feel more comfortable about the productivity of their individual farms, in Phase III the farmers began to realise the importance of looking at conversion processes in a larger area. They came to understand the importance of recovering biodiversity for farm resilience, and particularly in order to enhance natural control of potential pests. They began to apply the principles of live fences by planting trees and herbs round their plots. And they started to look at their neighbours to see who might be susceptible to change so that the region as a whole might become more sustainable. Basic and applied research activities played an important role here to support empirical knowledge on diversity particularly where natural control with arthropods was concerned, providing hard data on plant species that would be most useful.

To bring together the phases of the farmer learning pathway so that the effort of the whole process would not be lost as soon as the researcher – facilitator and team left, a final phase (IV) was used to build the capacity of representatives of the participating farmers. These local facilitators were given additional training in the technical aspects of converting farms to sustainable practices, as well as in how to be facilitators. By forming the facilitator groups, platforms for sustainable social learning have been created, which allow the community to learn together in the absence of external support.

As I said before, the learning pathway was not pre-planned, rather it was an adaptive emergent process. This was achieved by being responsive to the farmers and being grounded in the interaction of the research team with the farmers. The learning process was led by the interaction between the learning about a particular item and the real effects on the ground: these mutually reinforced each other and also provided hard evidence that the learning process was working.

12. 3 Learning points with respect to science-linkage

The farmers' learning path was the outcome of a set of strategic agricultural research activities. These were not planned or designed in detail before hand. As was the case of the farmers' learning path, the research activities emerged from the experience. It is, therefore, good to report on what was learned, although I do not claim that this is the only thing that could have been learned, nor the best or optimal thing that could have been learned. This study hopefully provides greater insight into the matter.

12.3.1 Resource mobilisation

A crucial function in the research process was the mobilisation of funds from PRONATTA. This is not a very surprising statement. But the nature of resource mobilisation proved important in many respects. It circumscribed the scale and scope of the work, as well as the number and type of farmers involved. Since it was a research and not a development project, the mobilisation of special funds could, for example, lead to an isolated island of privileged farmers who pre-empt the opportunities for others, who may not have the opportunity to access funds for their own development. Designing development research projects is therefore fraught with questions of social justice, the opportunities for replication and for out-scaling.

12.3.2 Context description

A crucial element in the set of research activities was the analysis of the context. At this stage, farmers were not involved. But it is a crucial phase for the design of the strategy of the development research. It hopefully grounds the whole effort in a thorough understanding of the context, the macro problems and issues that need to be resolved. Important aspects of the contextual analysis are an understanding of the intended partners or beneficiaries in the larger societal framework (e.g., conflicts, competitors, support networks, other stakeholders, etc.), an understanding of the opportunities and threats with respect to the intended beneficiaries, and some ideas about the options and resources available for development.

The description of the context was based on secondary information, part of which was a diagnostic study carried out by the municipality of Cota. It served to ground the research in the real situation of small farmers of the municipality, located just outside of Bogotá, the capital of Colombia. This provided me as researcher with a basis from which to begin working with the farmers. I went in with an overall view of the problems they faced as well as a fairly good idea of the objectives of the municipality.

Although I had lived and worked as a researcher and professional in horticulture in the same area as the project for a number of years, the context analysis proved crucial for me to understand what was going on with the respect to the development project. Also I was very lucky in being able to draw on a good survey by the Municipality. The experience underlines the importance of this research phase especially, not only for outsiders, such as foreign researchers, but also for insiders.

12.3.3 The researcher as a facilitator

Learning here has been achieved in various ways. The main one, cross-training (Stiglitz, 1999), was done by having local specialists who knew by personal experience how to implement a particular practice. Horizontal learning was encouraged by having farmers particularly knowledgeable in an area teach the others in the techniques they were using. A third type, also mentioned by Stiglitz, and a very popular method in Colombia, is the study tour. Here, a study tour was arranged near the end of the project to visit three experiences in other parts of Colombia. A group of twenty-five farmers, students and facilitators went off on a two-day trip in a rented bus. Three organisations were visited which had 22, 10 and 9 years of experience of working in rural areas, the first two managing large farms organically and the third with a very interesting organisational experience. The main conclusions drawn by the farmers were that technically they were doing quite well, and that they still had far to go on the organisational front. However, they had seen that it was possible for small farmers to organise themselves and they came away with a number of ideas for strengthening their own group.

It is important to realise that change does not happen from one day to the next. An attitude change is required in the farmers who have been used to immediate solutions to their problems. The facilitator must help them to realise that what is involved is a long-term process, one that is adapted as different issues come up along the way. The conversion design used here evolved throughout the project while the farmers progressed along the learning pathway. How and when each aspect is dealt with is determined by the situational context. It is a method that can therefore be used in other contexts, as long as the flexibility is ingrained and adaptive management used to progress.

As a source of information, the facilitator must also provide knowledge on how to understand the situation reached and why. Training in observation skills is therefore a necessity as is the capacity to make decisions from a basket of alternatives. However, excess information can also cause trouble, as the farmers need the training to be able to absorb it: the best way would probably be to provide small amounts of new information in each training session, building the next one on the previous one. In this line of thoughts, Tripp and Ali (2001) suggest that in order to promote more widespread use of IPM strategies, for example, understanding how the IPM strategies work is necessary and that that is not provided through farmer-to-farmer diffusion. They suggest that small quantities of the new products should be given out to farmers for them to do their own testing, with follow-up demonstrations on how to use the products.

Crucial to the conversion process was the introduction when and where required of research results that were appropriate to the situation. In this respect, such a linkage with science was facilitated here at different levels. The Horticulture Research Centre provided results on basic and applied research undertaken in Colombian conditions. The multi-disciplinary team brought its own experience as well as information on what was going on nationally and internationally. Some research was also required specifically for problems encountered or questions asked due to the project. This led to farmer comparisons of different products for pest and disease management and for soil amendment. Input production costs were calculated to compare homemade products with those commercially acquired. Irrigation systems were compared. Laboratory efficacy trials on botanical disease control products were implemented. And so on. But the 'package approach' to agricultural extension definitively does not apply. Rather the facilitator at the beginning of the process must be a source of information on the different possibilities available to solve a particular problem, allowing the farmer to chose that or those most suitable to his/her context.

Very important for the success of this project was the mutual respect that developed over time. Regular visits by me induced the farmers to overcome the barrier created by successive visits by outsiders and government or private agencies who stayed long enough only to serve their own purposes. Additionally, my insistence from the very beginning that I did not have all the answers but that I was willing to work with those wanted to try out new options, building knowledge together, was also crucial. Trutmann et al. (1996) comment on the importance of respect and reciprocity to successfully work with farmers, joining local and scientific knowledge to complement each others strengths and weaknesses. They also suggest that 'building on present knowledge systems would discourage building up a dependency on exogenous inputs'. This mutual respect grew to the point where at least some of the farmers felt they could talk openly and honestly with me. The barrier caused by social, cultural and educational differences was overcome gradually, an aspect that Bentley and Andrews (1991) also found important to work on.

An understanding of the 'localness' of knowledge management and learning is crucial to being a successful facilitator. As a knowledge and information broker, the facilitator must also help the people s/he is working with to learn how to analyse, reflect on and choose whether the information is useful, whether it should be discarded or adapted. A balance must be reached between the security these people want to feel by being recommended solutions to difficult problems by an expert (essentially, the role the facilitator would play at the beginning of the process which would achieve short-term results necessary for continued motivation) and the need to develop local autonomy for decision-making (long-term social goal of learning how to learn).

As the role of the facilitator changes throughout the conversion process, from provider of information as technical assistant to a gradual withdrawal as the farmers slowly are able to take over and become more autonomous, there are dangers that such process be done too quickly. Bentley and Andrew (1991) give the example of a situation where in an IPM project in Honduras, the researchers gave in to the farmers desires for pesticide efficacy trials: 'Farmer participation in research means more than simply reacting to farmers' whims or desires based on incomplete information. It requires establishing a real dialogue between the client and the change agent'. Within a conversion process it is important to establish short-term answers while building up the long-term ones.

In reference to a measurement of progress, indicators can certainly be used, and many regional and global projects have been implemented to do just that. However, the indicators that are finally chosen must be flexible enough to take into account the fact that sustainability is a moving objective. It changes, evolves, and adapts over time as the context changes, as the farmers make changes to their production and farm management strategies, and as their farm ecosystems become more healthy and resilient.

On the whole, I believe that the type of facilitation used in this project was most conducive to helping build the learning pathway of the farmers. By facilitating experiences and the space for interaction with other farmers and the project team, the farmers are encouraged to learn actively, leading to a better understanding of the complex situation that is small farmer agriculture and a stronger capacity to take control of that situation. Emphasising process ('facilitate learning') rather than providing immediate solutions to problems, also helps to strengthen the farmers ability to learn individually and as a group. Groot and Maarleveld (2000) link this approach of facilitation to 'communicative rationality' which tends to be associated with particular styles of facilitation: reflective ('highlights reflection so that individual's learning can be on-going and sustainable….building people's capacity for problem solving, adaptation, negotiation and conflict resolution') and integrative (a win-win situation is sought 'serving the interests of all parties'). The way in which the learning pathway was built is a reflection of the reflective and integrative style of facilitation used in this case.

12.3.4 The role of basic and applied research in the project

The incorporation of research at various levels and from varied sources was fundamental to successfully building the learning pathway. Sources included experiences from the Horticulture Research Centre, from professionals in related disciplines nationally and internationally for application and adaptation of existing results and information. New research was also needed to answer questions along the way, and for that applied and basic science were used to support technology requirements.

As an example of the use of basic science, the Plant Clinic of the Horticulture Research Centre was contracted by the project to do efficacy trials of botanical controls. Hydrolates from three different plants (*Ruda graveolens, Matricaria chamomilla* and *Calendula officinalis*) were tested on *Sclerotinia* and *Trichoderma*, showing that they all completely controlled the plant pathogenic fungus *Sclerotinia* in these laboratory trials. *Trichoderma,* an antagonistic fungus used to manage *Botrytis*, *Sclerotinia* and *Fusarium* among other fungi, was not immune to the hydrolates (especially when *Matricaria* and *Ruda* were combined); however, it still maintained colonies, suggesting that the use of these hydrolates did not exclude the use of *Trichoderma*, or vice versa.

A second example of basic research was the collection and identification of arthropods inhabiting live fences, a topic that is quite underdeveloped worldwide and novel in Colombia. From this study new knowledge was acquired on the potential of live fences for harbouring both potential pests and natural control agents. Although more studies are required not only to increase the number of vegetation species looked at, but also to establish whether there is in fact a link live fence arthropod populations and those in crops, the results here showed in

principle that there were few species considered pests and that those species were surrounded by their natural controls.
These results led me and my colleagues to believe that establishing live fences so as to enhance natural control would help recover system resilience. Basic and applied research were combined to increase the information on arthropod populations in existing live fences, as well as to design a live fence network based on the plants and trees that would be most useful to the farming system. Knowledge was obtained on how to increase the ecological infrastructure at farm level, but was also applied (at least in theory) at regional level, showing how the conversion to ecological practices can be gradually scaled up.

Applied and adaptive research methods were integrated into the process in the trials implemented in the farm conversion. Information on ecological practices and methods were gleaned from the literature, colleagues of ecological agriculture disciplines, and local knowledge. This 'basket' of options was sifted through for the best alternatives, which were then tried out with the farmers. Information on market tendencies was examined from market research studies done through the Horticulture Research Centre in order to ensure that the new products of the farmers would have an outlet.

A final example of applied research was the adaptation of the software programme for use in small farm vegetable production. Initially designed to evaluate farm sustainability for dairy production, the indicators used had to be changed to include those most appropriate to vegetable farming, and the appropriate variables and their values included. On the surface of it, that sounded quite straightforward. However, for many of the new indicators (for example, how to define whether the appropriate combination of crop rotations is being used according to botanical family and product type), new variables and values had to be established. Values for the indicators that remained the same had to be researched, in some case for each crop. Entering the data and ensuring that the results made sense through verifications with the farmers and rectification of the software required iterative fitting until finally we could be sure that the software was analysing the information adequately. The software is a useful tool to evaluate productive, ecological, social and economic sustainability of the system. Work still is required to make it more agile.

12.3.5 The mix of research activities in conversion: creating science linkage

As Kline and Rosenberg (1986) point out, there are two sets of forces that work with each other and that are determinant in the final outcome of innovation processes: commercial forces and technological forces. These authors also link research throughout the innovation process: 'science can be visualised as lying alongside development processes, to be used when needed'. Here, the commercial aspects include whether the technology is acceptable and appropriate to the farmers, as well as whether the end product can be sold. The technological forces include the information that is available or possible new research that can be undertaken to obtain the acceptable and appropriate technology. The mix of research activities described in section 12.3.4 were used at different points in the farmer learning pathway according to the needs of the farmers at that time. We can visualise this process in the following figure, which is an adaptation of Kline and Rosenberg (1986).

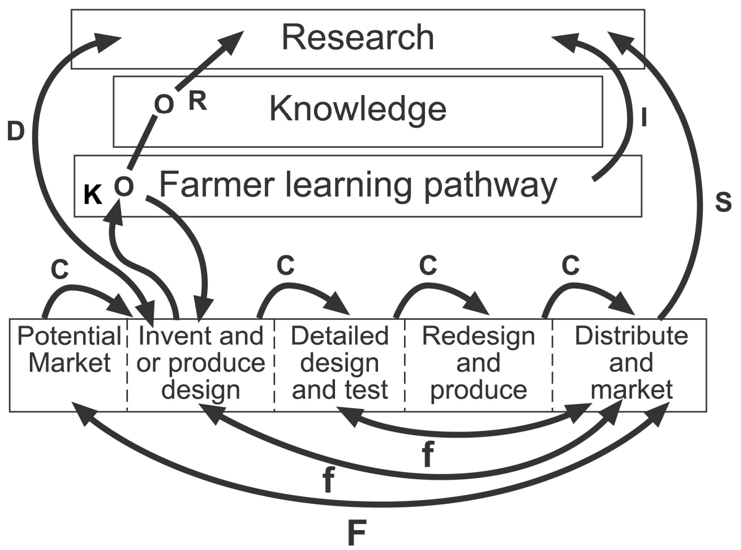

Figure 12.1 Chain-linked model showing flow paths of information and co-operation, adapted from Kline and Rosenberg, 1986.
Symbols on arrows: C = central chain-of-innovation; f = feedback loops; F = important feedback loop; K – R = links between research and problems in design, through knowledge and farmer learning pathway (this occurs at the different levels of the chain); D = direct link between research and farmer learning pathway; I = support of scientific research by techniques, tools, and methods of technology; S = support of research in sciences of the product area to gain information directly and by monitoring outside work.

12.3.6 A research methodology for the facilitation of farm conversion

In this situation, the case study approach is considered to have been successful in that it provided a rich picture on how the farmer learning pathway and the design of farm conversion evolved. Moving as facilitator between being participant observer, working closely with the farmers, and objective observer when stepping back to analyse what was happening, proved to be a very good way to both help the farmers in the conversion process (farm level) and analyse the direction the project was taking (project level). It also allowed me as researcher to understand the link between the various research activities and the farmer learning pathway.

As discussed earlier in this chapter, both beta and gamma issues brought up in the project were given solutions that were acceptable to the farmers and appropriate to their situation. Drawing up research questions and acquiring information on the context prior to initiating the case study helped to locate the case study in reality. This also allows for the conclusions on the process in this chapter to be founded on reality and not suppositions.

Crucial to the farm conversion design and implementation and to the farmer learning pathway, however, was the creation of a learning platform for interaction among the farmers as well as between farmers and researchers. Thus the figure 5.1 can be complemented in this final chapter with the addition of the creation of the learning pathway, that begins during the participatory diagnosis and continues, gradually building itself up, throughout the whole process. This is shown in figure 12.2.

12.3.7 Research activities required to improve farm productivity, economically and ecologically

Applied and adaptive research activities were most used in this project. In many cases, the information required already exists albeit in a form not accessible to the farmers. In such cases, the researcher – facilitator must make that information available to the farmers, helping them to learn how to choose what is useful to them, or to adapt the results to their particular circumstances. When information is not available on a specific issue, then new research may be required to provide answers. Rather than defining and measuring sustainability, research should be oriented toward analysing the cause of the current situation so as to propose management strategies to change the current pathway. Providing information on the context, linkage mapping and participatory diagnosis helps in that way, by providing an understanding of the current situation that exists among the actors of the area to be studied.

12.3.8 A research methodology for scaling up ecological production

Scaling up is definitely an issue. Biological control cannot happen efficiently on one farm alone. Future emphasis must definitely be in trying to get the neighbours involved, which some farmers have been trying to do already by giving free of charge some samples of bio-products for them to see how they work (i.e. the same strategy used in the project on them!). The same methodology can be used: adapting results already available and supplementing them where required with new research. However, in order to expand the area under ecological or integrated production, abilities in negotiation will also be needed. The farmers here qualified their different neighbours according to how easily they might be convinced to join the conversion process. Qualifications went mostly from medium to highly difficult.

Where regional landscaping is concerned, negotiations will be required at different levels as the landscape to be affected is enlarged. The proposal for a network of live fences included in Chapter 10, for example, extends only to the horticultural area of the municipality of Cota. Although interest in the concept of live fences networks is taking off in many municipalities in the region, as is the conversion design process, the interest has been voiced at the levels of municipal and departmental administration. Farmer interest has yet to be confirmed.

12.3.9 Research activities required to facilitate small farmer organisation

The farmers must first feel that need to be organised. The research activities must therefore feed into the learning process of the farmers. The interaction between research and learning must be carefully looked at here, so that the research does not end up directing the farmers' progress according to the research team's criteria.

12.3.10 Research activities required to facilitate ownership by farmers

In order to ensure that the farmers felt ownership of the research activities in this case, from the very beginning as facilitator I insisted to the farmers that I did not have all the answers and that decisions as to the orientation of the conversion design and implementation would be made by them. At first, the research team gave guidance on specific research, and provided the link to the Research Centre for laboratory work. However, all research activities should in fact gradually be taken over entirely by the farmers, from the identification of a problem, discussion of possible solutions, implementation or contracting out of the research, evaluation of results, to the final decision on what works.

12.3.11 Research activities to build the capacity for self-facilitation

Through out the entire conversion process, research activities have been used to feed into the farmer learning pathway to provide answers when required. The farmers learned how to acquire information, analyse its usefulness, choose what was appropriate for them, from the point of view of their own objectives. Thus, from the very beginning, the researcher must help the farmers to recover confidence in themselves. Ownership of the process is part of that. Seeing that their decisions in fact produce positive results in the form of reduced pesticide use, better health, food that tastes good, higher farm productivity, and feeling better about themselves, also helps. Once they are able to recognise their needs and know how to look for solutions that they know will help improve their lives, the confidence to depend on themselves will grow.

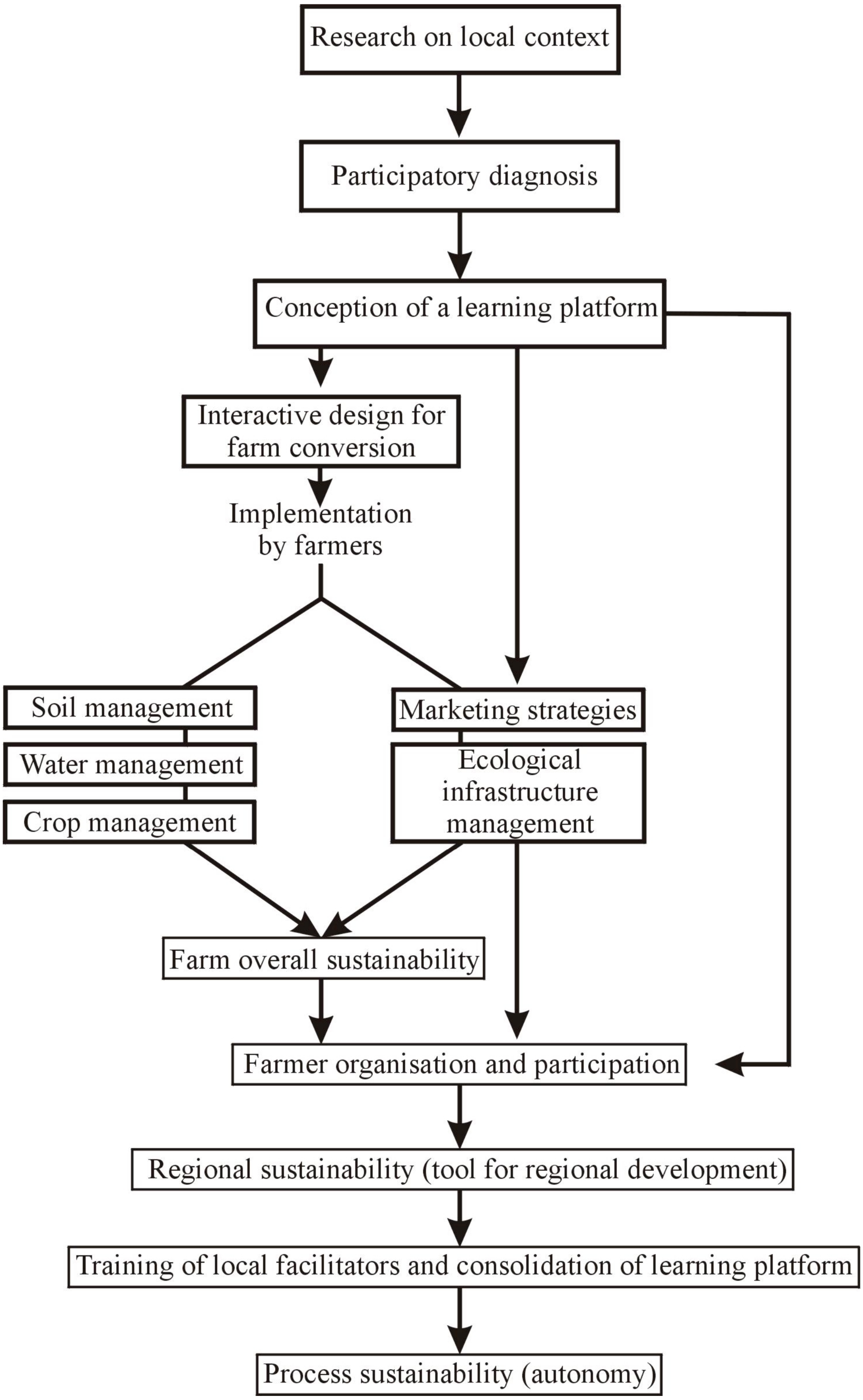

Figure 12.2 Methodology for design of farm conversion and implementation used with farmers in the municipality of Cota, Colombia. Arrows infer conditionality, where simple lines represent a link. The learning platform is included here showing its influence throughout the entire conversion process.

12.3.12 Additional conclusions for research: the integration of β and γ sciences

The outcomes of hard research (insect collecting and identification, efficacy trials, irrigation trials, etc) are essential to feed into the farming system we are trying to reconstruct, which is also part of adaptive management. The complexity of the farming situation studied here (small farms, year-round production in high mountain climate conditions, integration of production, quality control, marketing aspects, integration of different forms of learning: formal classroom, practical group work involving researching information, on-farm workshops with hands-on activities, regular follow-up with the farmers; integration of hard research at lab level with participatory forms, etc) would only be possible by taking a systems thinking point of view. Systems thinking explores things as a whole, taking into account their interconnectedness (Flood, 1998) where reductionists try to take things apart to understand them, and expect to get the original whole when they put the pieces together again, which inevitably does not happen. Because of the complexity, there are also many variables to take into account, especially when time is factored in as well (dynamic complexity). Dynamic complexity must be taken into account especially from the point of view of the above-mentioned change in the objective of sustainability.

12.4 Implications at the institutional level

One aspect that the conversion project did not explicitly address is the institutional and policy context. The project operated in a supportive environment (aided by the municipality, PRONATTA and the university). However, while implementing the project, important implications arose for the institutional and policy levels, in ways similar to Groot's (2002) experience that local facilitation and learning are crucially conditioned by higher system levels and thus facilitation must take these into account. Some of the implications found in this study are included here.

As Lightfoot and Noble (1999) observe, enabling a learning process is not sufficient for long term sustainability of the effort. Networking is very important to build up so that the various actors involved continue to work (and learn) together. Research and development must continue to come up with appropriate solutions by involving researchers, farmers and other actors alike. A stronger relationship with research and development institutions should be established to ensure a sustained development through an evolutionary process adapted to changing circumstances with the capacity of renewal of the people.

Quality control and norms for bio-products must be established. These norms should be such that they are applicable at farm level, while still ensuring quality on the larger commercial scale. The national certifying body, ICONTEC, has been working on norms for compost, but it must move quickly to other areas. The other alternative is subscription by manufacturers to a voluntary quality control regime, as suggested by Tripp and Ali (2001), that exists already for soil analyses laboratories nationally and internationally.

Product registration must be made more accessible so that smaller manufacturers may also register their products. To be able to sell in a commercial inputs store, the products must be registered with the ICA, which has a price. This price is typically established for chemically synthesised products that are manufactured by large, rich multinationals. Natural products to date, at least in Colombia, are made by small businesses barely able to survive.

Availability of bio-products must be encouraged. If they are not available at a crucial moment, the farmers will purchase what ever is available, which could lead them to fall back easily to the use of synthesised chemicals.

Support of local small enterprises should be on the priority list of the different government levels. Small enterprise leads not only to more autonomy of the person involved but also to the area s/he works in: whatever s/he produces is available locally as a result.

Publicity and marketing strategies at national level are required to promote consumption of fruit and vegetables in general, but especially of environmentally friendly and health safe products.

Follow-up mechanisms for Decree 544 (on ecological certification) should be implemented more actively in the field and in supermarkets as well as through national policies aimed at promoting ecological production, instead of reducing taxes on chemically synthesised pesticides and fertilisers.

Support should be provided to spread information on these ‘new’ technologies through the preparation and spread of pamphlets easily read by farmers.

Agricultural educational institutions must incorporate ways to ensure that the students are taught not only by professionals, but also by farmers. That would open up the students’ eyes to other visions, and give them a better understanding of the ‘real’ world they are about to go out to. It would also prepare them to interact better with the farmers so that science caters more to real needs and participatory research can really be participatory.

Agricultural institutions must include alternative management strategies for integrated crop protection and nutrient management in the training of future agronomists, biologists and extension agents, corroborated by the work done by Alam (2000) in India. In this way, such professionals will be able to function as providers of information on the different possibilities that exist, allowing for the farmers to decide on which s/he thinks is the most appropriate under her/his conditions.

An integrated attitude must also be cultivated, instead of the reductionist one still prevalent. While students continue to be trained in an area per area basis rather than multi-disciplinary, problem solving will remain restricted to looking at one aspect rather than the whole picture. In fact, there is an increasing need for development institutions to work in the facilitating and brokering of information and knowledge rather than be involved directly in their transfer.

Internet access by farmers as a source of information should be facilitated even in the most distant locations so that the knowledge gap between advanced industrialised countries and the lesser-developed countries does not continue to increase.

The establishment of new institutions or farmer organisations is a slow process and requires ‘high maintenance’ support (Stiglitz, 1999) before they are solid enough to work on their own. Therefore, financial support should be made available for follow-up projects for farmer groups that have promise.

12.5 Future research needs

The needs proposed here are general in scope. The reader is referred back to each chapter for specifics.

To support the beta dimension

Although often the farmers have used their own experimental methods to prove worthiness before adopting new technology, a lot of information on ecological production methods remains empirical from a hard scientist’s point of view. More hard data to explain the results obtained in sustainable and particularly ecological farming would be useful.

Studies on the functions of agricultural biodiversity, the relationships among the different components of the system, the effects of planned biodiversity on associated biodiversity require more work.

To support the gamma dimension

Studies on the most appropriate form of farmer association. Co-operatives have acquired a bad name due to misuse. Other alternatives exist legally, however, they may not match the type of organisation that would be acceptable socially. Such customary organisation is based on relationships that are ingrained into the organisation of rural life (Bebbington et al., 1994). It is possible that organisations created with different structure to that of the customary one will not survive. Future work in this area would help orient the formation of successful farmer groups.

From the autonomy point of view

Although references are made in the literature to the importance of building farmer autonomy into the development processes, in practice it is a complex objective and in fact achieved under few circumstances. Work such as that of Groot (2002) and the experiences described here should be used toward ensuring that autonomy building is included in development projects successfully.

From the research on agricultural development research viewpoint

The research study here attempted to move on from the results obtained by Van Schoubroek (1999) and Tekelenburg (2001) within the new research methodology on agricultural research. This is one case study that has shown more of the methodological path that should be followed to successfully influence agriculture research. Further studies in this area are definitively required to make sure that this methodology is appropriate and to continue improving on it.

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Acronymes

AKIS	:	Agriculture Knowledge and Information System
ASOCOLFLORES	:	Colombian Flower Exporter´s Association
CCI	:	Corporación Colombia Internacional
CIAA	:	Centro de Investigaciones y Asesorías Agroindustriales – Horticulture Research Centre
FFS	:	Farmer Field School
IFOAM	:	International Federation of Organic Agriculture Movements
INDAP	:	Instituto Nacional para el Desarrollo Agropecuario (Chile)
IPM	:	Integrated Pest Management
MAGDR	:	Colombian Ministry of Agriculture and Rural Development
PAM	:	Programa Agropecuario Municipal - Agricultural Municipal Programme
PDM	:	Plan de Desarrollo Municipal – Municipal Development Plan
POT	:	Plan de Ordenamiento Territorial
PRONATTA	:	Programa Nacional de Transferencia de Tecnología Agropecuaria
RAAKS	:	Rapid Appraisal of Agriculture Knowledge Systems
TOT	:	Transfer of Technology
UJTL	:	Universidad de Bogotá Jorge Tadeo Lozano

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Appendices

Appendix 1

Table A1 Pesticides produced and sold in Colombia by active ingredient and group (in kilograms) for 1997 and 1998

	Production 1997	% total	Sales 1997	% total	Production 1998	% total	Sales 1998	% total	Variation 98/97	
									Production	Sales
FUNGICIDES										
Inorganic compounds	838,472	4.4	770,519	11	982,226	7.6	852,53	10.4	17.1%	0.11
Dithiocarbamates	16,956,068	89.2	5,309,288	76.4	10,594,075	82	6,428,473	78.6	-37.5%	0.21
Benzimidazoles	148,405	0.8	175,393	2.5	185,634	1.4	158,74	1.8	25%	-0.1
Triazoles & Diazoles	288,159	1.5	123,857	1.8	323,558	2.5	155,55	1.9	12.3%	0.3
Diazinas & Morfolinas	12,727	0.1	19,678	0.3	----	----	7,322	0.1	-100%	-0.6
Others	768,824	4	551,447	7.9	832,793	6.4	578,252	7	8.3%	0.05
Additives	276	0	244	0	235	0	228	0	-14.7%	-0.06
TOTAL GROUP	19,012,934	100	6,950,429	100	12,918,524	99.9	8,191,098	99.8	-32.1%	17.9%
INSECTICIDES										
Organochlorines*	181,936	4.8	220,617	8	382,351	9.2	282,351	10.3	110.3%	0.3
Organophosphates	2,986,972	78.8	1,700,289	61.2	3,008,069	72.2	1,885,265	68.5	0.7%	0.11
Carbamates	387,586	10.2	406,417	14.8	475,662	11.4	405,460	14.7	22.7%	0.0
Pirethroides	73,510	1.9	41,147	1.5	89,124	2.1	38,108	1.4	21.2%	0.07
Biological products	6,271	0.2	6,582	0.24	30,299	0.73	24,389	0.89	383%	2.7
Others	124,902	3.3	350,398	12.7	132,374	3.2	87,825	3.2	6.0%	0.75
Mineral oil	30,464	0.8	17,487	0.64	46,384	1.1	29,871	1.1	52.3%	0.7
TOTAL GROUP	3,791,643	100	2,742,940	100	4,164,491	100	2,753,270	100	9.8%	0.4%
BIOLOGICAL PRODUCTS										
Bacillus thuringiensis	4,871	0.13	5,375	0.2	14,382	0.35	9,559	0.35	195.2%	0.78
Beauveria bassiana	15	0.0	10	0.0	1,592	0.04	1,442	0.05	511.7%	141.77
Entomophthora virulenta	1,350	0.04	1,166	0.04	14,11	0.34	13,188	0.48	945.2%	10.3
Metarhizium anisopliae	20	0.0	18	0.0	72	0.0	67	0.0	258.8%	2.65
Phacelomyces lillacinus					143	0.0	133	0.0	100%	1.0
Verticillium lecanii	15	0.0	11	0.0					-100%	-1.0
TOTAL	6,271	0.2	6,582	0.24	30,299	0.73	24,389	0.89	383%	2.7

**Endosulfan - authorized by the Ministry of Health - Resolution 10255/93*

Adapted from Instituto Colombiano Agropecuario and División de Insumos Agrícolas, 2000. Comercialización de plaguicidas 1998. Bogotá: Produmedios.

Table A2 Pesticides imported into Colombia by active ingredient and group (in kilograms) for 1997 and 1998

FUNGICIDES	1997				1998				
	Active ingredient	Prim.Mat.	Total	% total	Active ingredient	Prim.Mat.	Total	% total	Var.98/97
Inorganic compounds	159.438	30,000	189.438	1.65	63.141	---	63.141	0.37	-66.7%
Dithiocarbamates	2,098,868	---	2,098,868	18.29	752.102	---	752.102	4.41	-64.2%
Benzimidazoles	229,085	9,800	238.885	2.08	97.029	6,370	103.399	0.61	-56.7%
Triazoles & diazoles	236,870	---	236,870	2.06	347.751	---	347.751	2.04	46.8%
Diazinas	120.327	---	120.327	1.05	3,960	---	3,960	0.02	-96.7%
Others	1,310,062	---	1,310,062	11.42	682.945	30,240	713.185	4.18	-45.6%
Additives	6,604,819	675.305	7,280,125	63.45	5,462,368	9,595,786	15,058,154	88.36	106.8%
TOTAL	10,759,471	715.105	11,474,577	100	7,409,298	9,632,396	17,041,694	100	48.5%
INSECTICIDES	1997				1998				
Organochlorines	309.017	---	309.017	6.98	447,840	---	447,840	10.1	44.9%
Organophosphates	2,189,258	8,190	2,197,448	49.66	2,516,107	4,200	2,520,307	56.81	14.7%
Carbamates	436,730	---	436,730	9.87	409.395	---	409.395	9.23	-6.3%
Pirethroids	84.731	---	84.731	1.91	49.582	---	49.582	1.12	-41.5%
Biological products*	3.428	---	3.428	0.08	---	---	---	---	-100%
Others	395.383	---	395.383	8.93	95.917	---	95.917	2.16	-75.7%
Mineral oil	14.563	---	14.563	0.33	---	---	---	---	-100%
Other additives	737.061	246.874	983.935	22.23	715.237	197.872	913.109	20.58	-7.2%
TOTAL	4,170,173	255.064	4,425,238	100	4,234,079	202.072	4,436,152	100	0.2%

**Bacillus thuringiensis*

Adapted from Instituto Colombiano Agropecuario and División de Insumos Agrícolas, 2000.
Comercialización de plaguicidas 1998. Bogotá: Produmedios.

Table A3 Pesticides exported from Colombia by active ingredient and group (in kilograms) for 1997 and 1998

FUNGICIDES	1997				1998				
	Active ingredient	Prim.Mat.	Total	% total	Active ingredient	Prim.Mat.	Total	% total	Var.98/97
Inorganic compounds	75.894	---	75.894	0.64	96.875	---	96.875	0.78	27.6%
Dithiocarbamates	11,259,530	---	11,259,530	94.73	11,816,125	---	11,816,125	94.77	4.9%
Benzimidazoles	47.607	---	47.607	0.4	47.868	---	47.868	0.38	0.5%
Triazoles & diazoles	164.817	---	164.817	1.39	184.236	---	184.236	1.48	11.8%
Diazinas	14.435	---	14.435	0.12	900	---	900	0.01	-9.38%
Others	323,100	600	323,700	2.72	321.887	---	321.887	2.58	-0.6%
TOTAL	11,885,386	600	11,885,986	100	12,467,893	---	12,467,893	100	0.6%
INSECTICIDES									
Organochlorines	89.491	---	89.491	5.48	134.822	---	134.822	11.9	50.7%
Organophosphates	1,275,530	55.555	1,331,085	81.57	750,140	43.839	793,980	70.09	-40.4%
Carbamates	80.012	15.932	95.944	5.88	80.116	---	80.116	7.07	-16.5%
Pirethroids	50.163	---	50.163	3.07	77.139	---	77.139	6.81	53.8%
Biological products	---	---	---	---	6.041	---	6.041	0.53	100%
Others	40.512	---	40.512	2.48	32,270	---	32,270	2.85	-20.3%
Mineral oil	24.613	---	24.613	1.51	8.368	---	8.368	0.74	-66%
TOTAL	1,560,323	71.487	1,631,810	100	1,088,899	43.839	1,132,738	100	-30.6%
Biological products									
Bacillus thuringiensis	---	---	---	---	4.975	---	4.975	0.44	100%
Beauveria bassiana	---	---	---	---	144	---	144	0.01	100%
Entomophthora virulenta	---	---	---	---	922	---	922	0.08	100%

Adapted from Instituto Colombiano Agropecuario and División de Insumos Agrícolas, 2000.
Comercialización de plaguicidas 1998. Bogotá: Produmedios.

Appendix 2 Horticulture Research Centre, University of Bogotá Jorge Tadeo Lozano

The Horticulture Research Centre (Centro de Investigaciones y Asesorías Agroindustriales – CIAA) was established in 1991 by the University of Bogotá Jorge Tadeo Lozano through an agreement with the Catholic University of Leuven, Belgium, in order to provide support to the Colombian horticultural sector through research, training and extension programmes.

There are currently five research programmes: Climate control, Integrated pest management emphasising biological control, Soils and plant nutrition, Sustainable agriculture, and Participatory research. These are backed by three laboratories: Phytopathology, Entomology and Soils. The programmes often overlap in their projects, leading to an interdisciplinary approach to their implementation. Research in the CIAA has thus led to the establishment of the 'Eurofresh®' farming system which has brought together research, production and marketing of vegetables under one roof. According to market demand, 'delicatessen' type crops are chosen. The research centre does a trial to filter out varieties that do not work under Colombian climatic conditions, have too serious plant protection problems or undesirable physiological traits, or do not meet market requirements as to taste, colour, and so on. The resulting varieties are tried out with the producers on their farms for the final choice. Recommended production procedures are worked out in a similar way. These procedures are based on four principals: continuity (availability 365 days a year to the supermarkets and the end consumers), uniformity (based on weight per unit), quality (low pesticide use through IPM, no chemical residues, clean water, no plant protection problems), and productivity (starting with high quality seed, production managed on a per meter basis). Interested farmers join the research centre through formal association (a cooperative) which is in charge of programming scaled production and the marketing.

These standards have led to being able to market lettuce by the unit rather than by weight and to negotiate a minimum price per unit for relatively long periods of time. However, the quantities that can be sold, and therefore produced, are subject to market demand, thereby limits the number of farmers who can join. This has led the CIAA to diversify the products available through Eurofresh: from Boston lettuce it has now included romaine lettuce, curly red and curly green lettuce, rocket arugula, cocktail type carrots, and tomatoes. Products tried

and discarded, mainly for market related reasons include: scarola, radicchio, brussels sprouts and mache.
The emphasis throughout all of the programmes of the CIAA is on how to reduce the use of chemically synthesised inputs in order that producers can offer ‘environmentally friendly’ produce, if not organic. Use of chemical fertilisers of artificial synthesis has thus been reduced by 50% through the application of compost made from recycling crop wastes. Only pesticides of toxicology categories III and IV are allowed. ‘Natural’ and botanical pesticides, as well as cultural control (pest life cycle management) and allelopathy , are also worked although to a lesser degree.

A strength of the CIAA is definitely its biological control programme in which successful trials have used *Phytoseiulus persimilis* for the control of *Tetranychus urticae* in roses and two parasitic wasps are being studied in great detail from their life cycle through their parasitic / searching habits to their compatibility with each other and other biological control agents for more on this, see De Vis, 2001). These wasps, *Encarsia formosa* and *Amitus fuscipennis* control the greenhouse whitefly, *Trialeurodes vaporariorum*, a serious pest of tomato and other warm climate crops, and for which Colombian producers currently spray two to three times a week right up to harvest.

The various aspects related to organic farming in the different programmes were brought together in 2000 in the Sustainable Agriculture programme., The national entity in charge of the certification of organic farmers, Corporación Colombia Internacional, accepted to certify an informal ‘associative’ farmer group. The certification is in this case given to the production system which is guided by technical support from the CIAA, leading to the approval of several farmers at a significantly lower cost than as individuals. This group also functions according to market demand, although as there are still very few nationally certified producers (others are certified by international certifiers, which allows them to export those goods, but those certificates are not valid in Colombia), the competition is still low. Produce has been marketed since January, 2001, under the brand name Ecosecha®.

Appendix 3

Table A4 Attendance at workshops organised in 2000, in the five rural neighbourhoods of Cota

R.N.	Total	Diagnosis	Design	Soil	Org.fert.	Water	Alelopathy	Seeds	6-mo eval.	Integration	Concepts	Soil microb.	Visit1	Visit 2	Plugs
Cetime	24	15	6	13	4	11	11	7	4	5	3	4	6	4	1
El Abra	29	10	14	11	8	8	9	7	4	3	2	6	3	3	1
La Moya	37	22	11	11	13	5	13	6	2	5	3	7	5	0	2
P.V.	21	8	3	1	4	3	8	10	2	0	0	2	0	0	2
El Rozo	18	11	0	3	0	9	0	2	0	0	0	0	0	0	0
Centro	4	3	1	0	1	1	1	2	0	0	0	1	0	0	0
other	41	5	1	2	4	0	10	7	6	2	0	6	3	0	0
Total	174	74	36	41	34	37	52	41	18	15	8	26	17	7	6

R.N. Rural Neighbourhood; P.V.: Pueblo Viejo

Table A5 Pilot farmers, dates they joined the project and areas defined for farming, area under conversion and area under ecological. Figures taken as of May 2002. None of the farmers had area under conversion or under ecological production prior to joining the project, except for M. Piza in Cetime whose area could be considered as in conversion at that time. Farmers' names are included by their own request.

FARMER	DATE JOINED	RURAL NEIGHBOUR-HOOD	FARM AREA (m^2)	AREA UNDER CONVERSION	AREA UNDER ECOLOGICAL
Miguel Piza	Sept. 1999	Cetime	1650	---	1650
Francisco Castro & Beatríz Quevedo	Oct. 1999	El Abra	16000	16000	----
Etelvina Balcero	Nov. 1999	Cetime	800	N.A. (built a house on the lot)	---
Jaime Segura & Lilia Tibaquichá	Sept. 1999	La Moya	19200	19200	---
José Tauta &Juan Pablo Tauta	Oct. 1999	Pueblo Viejo	5000	---	5000
Amanda Martinez	Jan. 2000	Cetime	1000	---	1600
Esther Guitarrero	Jan. 2000	El Abra	600	50	550
José Eugenio Segura	Jan. 2000	La Moya	850	---	850
José Alba	Jan 2000	La Moya	900 + 5400 in partnership	5400	900
Eduardo Calderón	Jan. 2000	Pueblo Viejo	2000	2000	N.A. (died Sept 2000)
Jorge Calderón	Jan. 2000	La Moya	3000	1000	2000
Pedro Calderón	Jan. 2000	La Moya	3000	1000	2000
Stella Duarte	Jan.2000	El Abra	1000 (plugs)	1000	---
Luís Alberto Cano & Carlos Cano	Mar. 2000	La Moya	5500	3000	1200
Rosa Tauta & Pedro Cantor	July 2000	Cetime	3000	---	3000
José Manuel Segura & Martha Montenegro	June 2000	El Abra	1500	---	1500
Primitivo Balcero	Sep. 2000	Cetime	9600	8100	1500
Alex Mórtigo	Jan. 2001	Cetime	80	---	80
Victor Segura	Jan 2001	El Abra	3000	3000	---
Cristobal Segura & Sandra Yaneth Gonzalez	July 2001	La Moya	1200	---	1200
Martin Castañeda	July 2001	El Abra	3500	3500	---
TOTAL					

Appendix 4

Table A6 Pests and diseases most common to vegetable crops in Cota

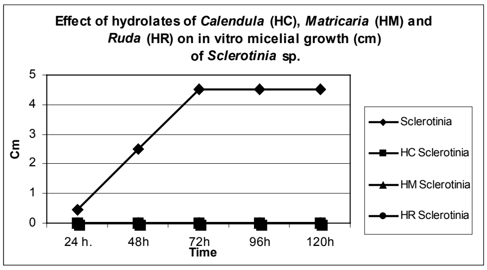
Name used by farmers	Pest arthropod	Crops affected
Leaf miner	*Liryomiza* spp.	Swiss chard, spinach, beets
Stem miner	*Melanogromyza lini*	Peas
Slugs	*Deroceras veticulatum*	Most crops
Caterpillars	*Agrotis spp.*	Lettuce, Brassicaceae
Leaf eaters	*Spodoptera* spp.	Most crops
White grubs	*Ancognata scarabaeoides*	Most crops
Small flea	*Epitrix* sp.	Potato
White fly	*Trialeurodes vaporariorum*	Tomato
Large flea	*Myzus persicae, Brevicovyne brassicae*	Lettuce
Not identified by farmers	*Frankliniella panamensis, Thrips tabaci*	Swiss chard, spinach, beets
Small spiders	*Tetranychus urticae, T. cinnabarinus*	Tomato, cucumber
Name used by farmers	**Causal agent**	**Crops affected**
Grey fungus	*Botrytis* sp.	Lettuce
White fungus	*Sclerotinia* sp.	Lettuce
White dust	*Erysiphe polygoni*	Herbs, tomato
Ashes	*Peronospora effusa*	Swiss chard, spinach, beets
Black spot	*Gloeosporium* spp.	Coriander
Not identified by farmers	*Fusarium* sp.	Coriander
Drop	*Phytophthora infestans*	Potato, tomato
Root rot	*Pseudomonas* sp.	Parsley

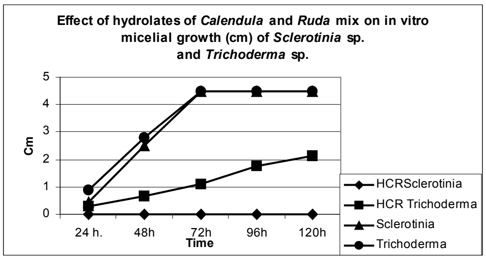
Appendix 5 Organic practices implemented by participating farmers

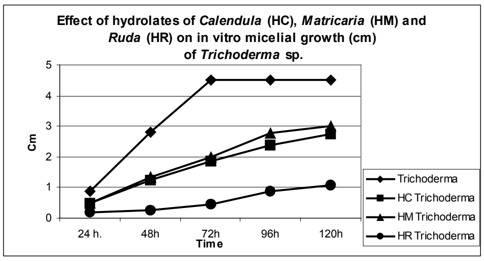
Table A7 Organic practices implemented by participating farmers. A total over 50% (>8 over 17) was considered sustainable

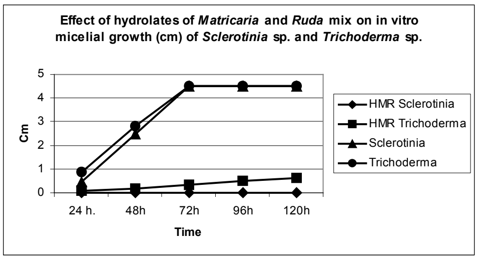
			Pest and disease management											**Fertilisers and amendments**						Total
Producer		**Vereda**	**Chamo-mille**	**Calen-dula**	**Chipaca'**	**Garlic-chile**	**Fern**	**Nettle**	**Alelo-pathy**	**Plant oils**	***Tricho-derma***	**Traps**	***B.t.***	**M&N**	**Compost**	**Compost tea**	**Vermic.**	**Micro-bial soup**	**S4**	
Alba	Jose Alba	La Moya	X	X		X	X			X	X		X	X	X			X		10
Balsero	Etelvina	Cetime									X				X					2
Balsero	Primitivo	Cetime					X		X				X	X	X			X		6
Calderón	Jorge	La Moya	X	X		X				X	X		X		X				X	8
Calderón	Pedro	La Moya	X	X		X	X	X	X	X	X		X	X	X			X	X	13
Cano	Carlos /Luís	La Moya	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	16
Casteñeda	Martin	El Abra	X	X		X			X	X	X		X		X					8
Castro	Francisco	El Abra	X	X		X			X	X	X	X	X		X			X		10
Duarte	Stella (Plugs)	El Abra									X				X					2
Guitarrero	Esther	El Abra	X	X		X			X	X	X		X	X	X		X			10
Martinez	Amanda	Cetime	X	X		X	X		X	X	X		X	X	X			X	X	12
Mortigo	Alex	Cetime							X	X	X		X		X			X		6
Piza	Miguel	Cetime	X	X	X	X	X		X	X	X	X	X	X	X		X	X	X	15
Segura	Constantino y José	La Moya	X	X		X			X	X	X		X	X	X		X	X		11
Segura	Cristobal	La Moya	X	X		X			X	X	X		X	X	X		X	X	X	12
Segura	Jaime Segura	La Moya	X	X		X			X	X	X	X	X		X					9
Segura	Jose Manuel	El Abra	X	X		X	X	X	X	X	X		X	X	X		X	X		13
Segura	Victor	El Abra	X	X		X			X	X	X		X	X	X					9
Tauta	José /Juan Pablo	Pueblo Viejo	X	X		X	X		X	X	X		X	X	X		X	X		12
Tauta	Rosa	Cetime	X	X		X	X		X	X	X		X	X	X		X	X		12

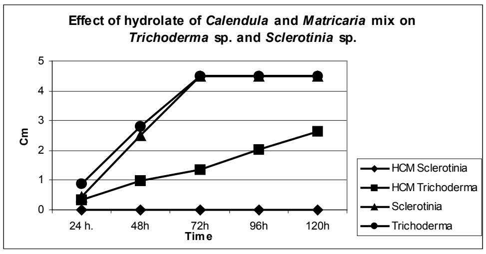
Appendix 6 Effect of botanical hydrolates on micelial growth of *Sclerotinia* sp. and *Trichoderma* sp.

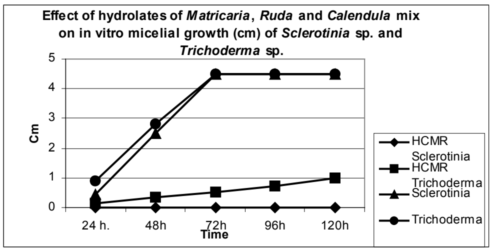












Samenvatting

Dit onderzoek gaat over een maatschappelijk probleem dat zich onder kleinschalige groententelers op de hoogvlakte van de Andes voordoet. Deze boeren worden gekenmerkt door zeer lage inkomens, hoge afhankelijkheid van externe *inputs* en niet-onafhankelijke informatiebronnen. Hun productiegrond is uitgeput geraakt als gevolg van overmatige mechanisatie en pesticiden gebruik. Op de markt hebben de boeren een slechte concurrentie-positie.

We concentreerden ons op twee probleemstellingen:

- Is het mogelijk om de boeren op de hoogvlakte van het Andes Bogota Plateau duurzamer te laten produceren. De randvoorwaarde daarbij is dat de boeren volstrekt zelfstandig worden in hun streven naar meer duurzaamheid en dat het leerproces dat hieronder verscholen zit, beschikbaar komt voor toepassingen elders.
- Kan het landbouwkundig onderzoek aan dat proces bijdragen en welk soort van onderzoek is dan noodzakelijk om de leerweg voor boeren operationeel te maken?

Beide probleemstellingen werden bekeken in het kader van een welomschreven casus. Daaruit volgden twee onderzoeksvragen:

- welke onderzoeksactiviteiten moeten er achtereenvolgens worden ondernomen om de tuinders in de casus te laten leren en
- wat is de aard van het raakvlak tussen die reeks van onderzoeksactiviteiten en het leerproces door boeren en tuinders in het algemeen?

Deze vragen waren vertrekpunt voor ons onderzoek. Het ging erom dat wij wilden weten hoe boeren in onze casus leren, welke soort van onderzoeksactiviteiten er moeten worden verricht om boeren daadwerkelijk te kunnen laten leren en welke wisselwerking tussen onderzoek doen noodzakelijk is voor leerprocessen bij boeren. We zijn er in ons onderzoek daarom niet a priori uitgegaan van een bepaalde planning of hypothese. We wilden het proces bestuderen dat onder boeren ontstaat wanneer zij leren. De alledaagse praktijk bepaalde dus, al naar gelang de behoeften en actuele situaties van boeren, welke planning of processen noodzakelijk waren om onderzoekers en boeren te laten interacteren. De resultaten ontstonden dus naarmate het veldwerk voortging.

Het leerproces dat zich tijdens het project ontwikkelde omvatte aspecten die ook belangrijk bleken te zijn voor het ontwerpen van leerprocessen voor kleinschalige boeren. Die aspecten zijn:

- participatief diagnostisch onderzoek (voor een deel gebaseerd op een analyse van de context behorende bij het onderzoek);
- de vorming van een leerschool die zich ontwikkelde uit de vergaderingen en trainingsbijeenkomsten die voor gezamenlijke besluitvorming, vergroting van onderlinge cohesie en organisatievermogen noodzakelijk waren;
- het omschakelingsproces dat tezamen met boeren werd ontworpen en dat expertise op bedrijfsniveau beschikbaar maakte;
- opschaling van de bedrijfsomschakeling naar een groter gebied (landschapsniveau);
- de vorming van een vermarktingsorganisatie en
- het ontstaan van voorzieningen die de toegang tot nieuwe kennis mogelijk maakt en veerkracht schept (bevordering van de autonomie van de boeren).

Terugkijkend op het proces blijkt dat de leerweg van de boeren zich in drie richtingen bewoog. De eerste richting die betrekking had op ‘harde’ (bèta-achtige) onderwerpen, voerde boeren uit een situatie van hoge afhankelijkheid van externe chemische *inputs*, zonder de garantie dat de kosten daarvan goed gemaakt zouden worden en met weinig bedrijfsrentabiliteit, naar een situatie waarin zij keuzes konden maken en de meest geschikt bevonden productiemethoden met elkaar konden combineren afhankelijk van hun eigen bedrijfssituatie en verwachtingen ten aanzien van economische voordelen.
De tweede richting voerde boeren uit een situatie van tot dusver zeer solitair en op overleving gerichte manieren van werken, naar een situatie die mogelijkheden opende om samen met collega-boeren de krachten gebundeld te krijgen om wille van een betere onderhandelingspositie. De derde richting voerde boeren uit een situatie waarin zij voor wat betreft hun informatie, verkrijging van *inputs* en verkoop van hun productie, erg afhankelijk waren van anderen naar een situatie waarin zij meer vanuit zelfvertrouwen werkten, waarin zij gewogen beslissingen konden nemen en waarin zij hun eigen *inputs*, zo zij die nodig hadden, konden maken. Kortom, zij werden autonomer.
Wanneer alle drie ontwikkelingsrichtingen in hun samenhang worden bekeken, dan zien we dat het proces richting duurzamer produceren zich in vier fasen voltrok. Die fasen verliepen evenwel niet in vier achter na elkaar volgende stappen. Eerder is het zo dat de bedrijfstransformatie met technologisch (bèta) karakter en de bedrijfstransformatie met het karakter van leren (gamma) in feite twee parallel lopende processen bleken te zijn, die elkaar over en weer beïnvloedden en versterkten.

Het eerste hoofdstuk van het boek biedt een inleiding op het onderzoek en op de maatschappelijke problemen die daarmee tegemoet werden getreden. De context van de studie is kort van omvang en geeft een overzicht van de hoofdstukken die aan de orde komen.

Het tweede hoofdstuk biedt een overzicht van de theorie waarop het onderzoek en het gehele project werden gebaseerd, alsmede van de vragen die uit beide voortkomen. De theorie van ontwikkeling gericht onderzoek wordt kort naar voren gebracht. Daarbij wordt stil gestaan bij paradigmata, theorieën en methoden die te maken hebben met biologische landbouw en werken met boeren. De onderzoeksmethode, die gebaseerd is op beschrijving van wat er in een casus, gericht op de ontwikkeling van een leerweg voor boeren, is gebeurd, wordt expliciet gemaakt.

Hoofdstuk 3 beschrijft de situatie waarin de project casus zich aanvankelijk bevond. De locatie, de gemeente Cota, wordt gekenmerkt door een hoog aantal kleinschalige tuinders die de markt van het nabij gelegen Bogota bevoorraadt. De vermarkting vond hoofdzakelijk plaats via een centrale inkoopplaats waarvan de inkopers zelden een behoorlijke, laat staan constante prijs boden voor de aangeboden productie. Samen met de hoge productiekosten, die er voor geïmporteerd zaaigoed en chemicaliën betaald moeten worden, kunnen boeren hun uitgaven vaak niet gedekt krijgen, noch de noodzakelijke middelen vinden om te investeren in het volgende gewas of te voorzien in de behoeften van het gezin. Vanuit sociaal oogpunt bekeken beschreven boeren zichzelf als individualistisch en voor hun bedrijfsmanagement afhankelijk zijnde van externe adviezen die zich meestal beperkten tot die van handelaren. De combinatie van al die factoren stimuleerde misbruik van *inputs*, voor het overgrote deel synthetische agrochemicaliën, wat op zijn beurt weer leidde tot behoorlijke schade van het milieu en ten lange leste tot armzaliger gewassen. De bedoeling nu was om gebruik te maken van de toegenomen belangstelling voor biologische producten, of ten minste van gezondere producten, onder consumenten en milieubeschermers om daarmee producenten meer te bewegen tot aanpassing van productiemethoden in de richting van duurzaamheid.

Na de theoretische en contextuele achtergrond van het onderzoek beschreven te hebben, gaat het boek verder met de beschrijving van de vier fasen waaruit de leerweg van de boeren bleek te bestaan.

Fase I omvat drie hoofdstukken en beschrijft de situatie aan het begin van het op duurzaamheid gerichte omschakelingsproces. Hoofdstuk 4 beschrijft het proces dat gebruikt werd voor de participatieve diagnose. Een tekening die de informatiebronnen van boeren zichtbaar maakt, liet zien dat de kennis waarvan boeren afhankelijk zijn, eenzijdig en in hoge mate van afkomstig is van handelaren. Beperkingen, die tijdens de productie en bij vermarkting ondervonden, werden door de boeren in volgorde van belangrijkheid geïnventariseerd. De boeren dachten gezamenlijk ook na over de mogelijke oplossingen voor de gevonden beperkingen. Het omschakelingsproces richting duurzame landbouw werd in volgorde van belangrijkheid vormgegeven in de vorm van een serie stappen die achtereenvolgens genomen moesten worden. De methode die gebruikt werd om het omschakelingsproces en de toepassing ervan in de praktijk mogelijk te maken, is in hoofdstuk 5 beschreven. De methode die gebruikt werd bij de prototypering voor geïntegreerde en biologische landbouwbedrijven, werden in onderhavig onderzoek aangepast. Nieuwe methodes werden toegevoegd. Die betroffen: deelname door boeren en de organisatie daarvan, beheer van de bodem, water, gewasproductie, marketing strategieën, ecologische infrastructuur en duurzaamheid van gehele bedrijven. De resultaten worden in hoofdstuk 6 gegeven. Terwijl men voorheen gewend was om elk jaar minerale kunstmest en verse kippenmest te geven, dienden de deelnemers aan het project nu organische stoffen toe, die al naar gelang de resultaten van gewas en bodem analyses, op basis van gewasresten, dierlijke mest en specifieke natuurlijke meststoffen, door henzelf waren gemaakt. Zij mengden dergelijke toevoegingen aan een "soep" van micro-organismen, welke er aan bijdroeg dat de microbiële activiteit van de bodem werd verbeterd en daarmee de biologische beschikbaarheid voor planten en de bodemstructuur verbeterde. Wanneer de gewasbeschermingsituatie van een bedrijf, die met het oog op de behoeften van het op de lange termijn gerichte beheer van een bedrijf, in een situatie van omschakeling of van herontwerp verkeerde, maakten boeren gebruik van plantenaftreksels en biologische producten.

Fase II voert van een situatie waarin de boeren een begin hebben gemaakt met de toepassing van enige kennis van technische aard, naar een situatie waarin zij hun productie verbeteren door middel van samenwerking. Nieuwe aspecten kwamen daarbij naar boven en werden aangepakt. Hoofdstuk 7 beschrijft hoe nieuwe afzetkanalen werden ontwikkeld door consumenten dichter bij het productieproces te brengen met behulp van een agro-ecologische toeristische route. Ook zijn andere alternatieven zoals thuisbezorging, gespecialiseerde restaurants en nabij gelegen scholen bekeken.
Het proces dat moest leiden tot de ontwikkeling van een boerenorganisatie en team vorming wordt beschreven in hoofdstuk 8. Daarin komen de moeilijkheden behorend bij oplossing van conflicten onder de groepsleden naar voren.

Op basis van het gevoel voor de betekenis van kennis en gemeenschapszin die tijdens de eerste twee fasen waren opgebouwd, gaat fase III dieper in op de noodzaak om ook oplossingen te vinden voor vraagstukken die op hogere aggregatieniveaus (dan alleen de bedrijfsniveau) spelen. Op dat niveau wordt aandacht besteed aan de noodzaak van regionale ontwikkeling. Hoofdstuk 9 gaat daarom in op de betekenis van meer kennis over levende erfafscheidingen (hagen) en met name voor de arthropoden die daarin voorkomen. Hoofdstuk 10 laat zien hoe kennis over de noodzaak van meer biologische regulatie van ziekten en plagen in het gewas werd toegepast voor de opzet van een netwerk van levende erfafscheidingen binnen de gemeente.

Fase IV richt de blik op de toekomst door een begin te maken met de ontwikkeling van zelfstandigheid bij boeren. Met het oog daarop beschrijft hoofdstuk 11 hoe locale ondersteuners werden getraind om hun vaardigheden op gebied van zowel technische als didactische mogelijkheden te verhogen, waardoor boeren uiteindelijk autonomer konden worden.

Na de casus nog eens aan de hand van de vier fasen uit de leerweg die de boeren waren gegaan, bekeken te hebben, presenteert het laatste hoofdstuk een kritische kijk op de effectiviteit van hoe leerwegen worden ontworpen. Er wordt een analyse gegeven van de eindresultaten. Daarbij wordt aangegeven wat succesvol was en wat niet en waarom niet. Ook wordt aangegeven wat ondersteuners van boeren bij hun ontwikkeling van onderhavige resultaten kunnen leren. Tenslotte wordt de reeks van onderzoeksactiviteiten nog eens bekeken, maar nu uit oogpunt van de kracht van de methode en de gevolgen voor landbouwkundig onderzoek.

Resumen

La presente investigación se basa en un problema social de pequeños productores de hortalizas en la zona altoandina. Estos productores se caracterizan por su bajo nivel de ingresos, la gran dependencia en insumos externos y fuentes sesgadas de información, tierras seriamente degradadas debido a excesos en mecanización y aplicaciones de plaguicidas, y un mínimo poder de negociación en el mercado.

Para tratar de resolver este problema social, se identificaron dos problemas de investigación:

- Qué tipo de trayectoria se puede diseñar para el aprendizaje de manera a ayudar a pequeños productores de la Sabana de Bogotá a cambiar a prácticas más sostenibles de producción, que además se podría usar a gran escala y ser replicable? y
- Cómo puede la investigación en agricultura ayudar y cuáles actividades de investigación se requieren para facilitar el proceso de aprendizaje de los productores?

Para orientar la resolución de estos dos problemas, se propuso una metodología basada en el estudio de caso, y se introdujeron dos preguntas generales de investigación:

- Cuál es la naturaleza de los componentes y sus relaciones dentro de la secuencia respectivamente de las actividades de investigación, y el proceso de aprendizaje de los productores?
- Cuál es la naturaleza de la interfaz entre la secuencia de actividades de investigación y el proceso de aprendizaje de los productores?

En otros términos, este proyecto de investigación tiene relevancia por lo que estudia (1) el proceso de aprendizaje de los productores, (2) las actividades de investigación diseñadas para lograr este proceso de aprendizaje, y (3) su interfaz. Estos tres aspectos aparecen aquí como resultados empíricos de un proceso emergente, adaptativo e interactivo entre los investigadores y los productores. No fueron planeados ni presentados como hipótesis. Emergieron a medida que progresó el trabajo de campo.

Una serie de componentes del proceso de aprendizaje evolucionaron durante el proyecto y parecen ser esenciales para el diseño de un proceso de aprendizaje para pequeños productores. Se trata de:

- La exploración por un diagnóstico participativo (basado parcialmente en un análisis del contexto);

- La construcción de una plataforma para el aprendizaje que evoluciona desde las reuniones y sesiones de capacitación, por la toma de decisiones colectiva, hacia la asociación y organización.;
- Un proceso de reconversión de fincas diseñado con los productores que moviliza el conocimiento experto a nivel de la finca;
- La ampliación de la reconversión para incluir una zona más grande (nivel región o paisaje);
- La construcción de una organización para el mercadeo; y
- La creación de la capacidad de auto-facilitación para acceder a nuevos conocimientos y construir resiliencia (autonomía).

Mirando hacia atrás, pareció que los productores se movieron a los largo de tres dimensiones. La primera, tratando de aspectos ‘duros’ (‘beta’), llevó los productores de un situación de alta dependencia en insumos químicos externos sin garantía de recobrar su inversión, y mucho menos de lograr ganancias, a una en la cual eran capaces de escoger y combinar los métodos de producción más apropiados a sus condiciones y esperanzas de ingresos. La segunda abrió oportunidades para que los productores, hasta el momento egoístas, puedan unir esfuerzos con los compañeros para lograr el reconocimiento y mayor poder de negociación. La tercera llevó los productores de una situación de alta dependencia en otros para la información, para la adquisición de insumos y la venta de sus productos, a una en la cual eran más auto-dependientes, capaces de tomar decisiones acertadas, buscar información y preparar sus propios insumos si lo deseaban. En resumen, se volvieron más autónomos. Al súper imponer estas tres dimensiones, emergen cuatro fases en el proceso de reconversión a la producción sostenible. Estas fases no son secuenciales, sino que la reconversión técnica (‘beta’), y la construcción de la capacidad de aprender (‘gamma’) son procesos paralelos que se influencian y se refuerzan mutuamente.

El primer capítulo del libro provee una introducción a los problemas social y de investigación planteados. El contexto del estudio se describe brevemente, con una orientación sobre el contenido de los capítulos del libro.

El segundo capítulo revisa el marco teórico sobre el cual se basan la investigación y el proyecto e introduce las preguntas guías. Se presenta la teoría de la investigación sobre investigación en procesos de desarrollo. Los paradigmas, teorías y métodos de la agricultura ecológica y la participación de los agricultores son proporcionados. Luego se describe la metodología de la investigación, basada en un estudio de caso del proceso de aprendizaje de los productores.

El capítulo 3 describe el contexto inicial dentro del cual se implementó el proyecto como estudio de caso. El sitio, el municipio de Cota, se caracteriza por su gran número de pequeños productores que suministran hortalizas a la capital cercana, Bogotá. El mercadeo era limitado al terminal de alimentos donde los intermediarios rara vez ofrecían precios equitativos, y mucho menos estables, para los productos. Con los altos costos de producción para pagar la semilla y los insumos importados, los ingresos de los productores a menudo no cubrían los gastos, ni daban para invertir en el siguiente ciclo o para proveer las necesidades de la familia. A nivel social, los productores se auto-describieron como individualistas y dependiente de concejos externos, basados en los conocimientos de los vendedores de insumos. Todos estos factores se combinan para estimular el mal uso de insumos agrícolas, en su mayoría de síntesis química, lo cual a su vez conlleva a daños ambientales severos y a la larga productividades más bajas. La idea aquí era de aprovechar el interés creciente de los consumidores y defensores del medio ambiente en productos ecológicos, o por los menos más saludables, para motivar a los productores al cambio hacia la implementación de prácticas de producción más sostenibles.
Con base en este marco teórico y contextual del estudio, el libro ofrece luego una descripción de las cuatro fases del proceso de aprendizaje de los productores.

La Fase I cubre tres capítulos y describe la situación al inicio del proceso de reconversión a producción sostenible. En el capítulo 4, se describe el proceso utilizado para el diagnóstico participativo. Un mapa con las fuentes de información usadas por los productores revela la uni-direcccionalidad del flujo de conocimientos y la alta dependencia en los vendedores locales de insumos. Se elaboró y priorizó con los productores una lista de las restricciones a la producción y mercadeo de las hortalizas, agregando soluciones potenciales para cada ítem. La priorización llevó a la secuencia de pasos a seguir en el proceso de reconversión. La metodología usada para diseñar este proceso y su implementación se detallan en el capítulo 5. Los métodos usados en la metodología de prototipos para la agricultura integrada o ecológica en Europa fueron adaptados aquí, y algunos nuevos adicionados. Los métodos son: participación y organización de los productores, manejo del sistema suelo, manejo del agua, manejo de sistemas de cultivo, estrategias de mercadeo, manejo de la infraestructura ecológica, y sostenibilidad predial general. Los resultados de estos métodos se encuentran en el capítulo 6. En vez de aplicar fertilizantes minerales sintéticos y gallinaza fresca anualmente, los participantes preparan sus enmiendas orgánicas aprovechando los residuos de las cosechas, estiércoles de animales y fertilizantes naturales según los requerimientos basados en análisis de suelos y las necesidades del cultivo. Combinan estos fertilizantes con caldos microbianos para aumentar la actividad microbiológica del suelo, colaborando así en hacer disponibles los nutrientes a las plantas y mejorar la estructura del suelo. Aplican productos botánicos y biológicos para el manejo a corto plazo de plagas y agentes causales de enfermedades mientras reconstruyen o rediseñan sus fincas para el manejo a largo plazo.

La Fase II lleva los productores desde una situación donde han empezado a utilizar el conocimiento técnico para mejorar su producción y a darse cuenta de la importancia de trabajar juntos como comunidad. Aparecen nuevos temas de discussion que deben ser resueltos. El capítulo 7 describe los esfuerzo de diversificación de los canales de mercadeo, acercando los consumidores al proceso de producción mediante una ruta turística agroecológica. Entregas a domicilio, restaurantes especializados y colegios cercanos son otras alternatives exploradas. El proceso de organización de los productores y formación de equipo se relata en el capítulo 8, resaltando las dificultades de resolución de conflictos entre los miembros del grupo.

Con la acumulación de conocimientos y un sentido comunitario logrados en las dos primeras fases, la Fase III profundiza sobre la necesidad de buscar soluciones para una zona más amplia como herramienta para el desarrollo regional. El capítulo 9 estudia la utilidad de conocer más sobre las cercas vivas y los artrópodos albergados allí, mientras el capítulo 10 provee una aplicación práctica de tal información mediante la creación de una red de cercas vivas a nivel municipal basada en el realce del control natural de las plagas de los cultivos.
La Fase IV mira hacia el futuro con el comienzo de la construcción de la capacidad de los productores para cuidarse ellos mismos. Para ello, el capítulo 11 describe el entrenamiento de facilitadores locales, reforzando sus habilidades en métodos técnicos y didácticos, de manera a ayudar a los productores a tener mayor autonomía.

Después de mirar el estudio de caso a través de las cuatro fases del proceso de aprendizaje de los productores, el ultimo capítulo hace una revisión crítica de la eficacia del diseño del proceso de aprendizaje. Se ofrece un análisis de los resultados finales de todo el esfuerzo, estudiando el porqué de lo exitoso y lo menos exitoso y dar herramientas para otros facilitadores de procesos similares. Se revisan también los factores acondicionadores del éxito del proyecto y su continuidad en el tiempo. Finalmente, se analiza la secuencia de las actividades de investigación desde el punto de vista de su éxito y las implicaciones de los resultados en cuanto a la investigación sobre investigación agrícola.

Summary

The research is grounded in a societal problem of small vegetable farmers located in the high Andes. These farmers were characterised by their very low income, high dependence on external inputs and biased sources of information, land severely degraded due to excess mechanisation and pesticide applications, and poor negotiating power in the market.

To help solve the societal problem, two research problems were identified, specifically:

- What kind of learning trajectory can be designed to help small farmers in the high Andean Bogotá Plateau move toward more sustainable forms of production, that would also be useful on a larger scale and be replicable? and
- How can agricultural research help and what set of research activities are required to facilitate the farmer learning pathway?

To orient the solving of these two problems, a case study approach was proposed and two general research questions introduced:

- What is the nature of the elements and their relationships in the sequence of respectively the research activities, and the farmer learning pathway?
- What is the nature of the interface between the sequence of research activities and the farmer learning pathway?

In other words, the present research project is of interest because it looks at (1) the farmers' learning pathway, (2) the agricultural research activities designed to elicit this learning pathway, and (3) their interface. To the extent that they are described in this book, the three are empirical outcomes of an emergent, adaptive, interactive process between scientists and farmers. They were not planned or hypothesised. They emerged as fieldwork progressed.

The set of elements in the learning process that evolved during the project and that seem to be essential in designing a learning path for small farmers includes:

- participatory diagnostic exploration (partly based on an analysis of the context by the research);
- building a learning platform that evolves from meetings and training sessions, to collective decision-making, to association and organisation;
- a farm conversion process designed with farmers that mobilises expert knowledge at farm level;

- expanding the conversion to include a wider area (landscape);
- building a marketing organisation; and
- creating capacity for self-facilitation to access new knowledge and build resilience (autonomy).

Using hindsight, it seemed that the learning pathway of the farmers moved along three dimensions. The first, dealing with 'hard' ('beta') issues, took the farmers from the situation of high reliance on external chemical inputs with no guarantee of recovering their costs, much less of making a profit, to one where they are able to choose and combine production methods most appropriate to their conditions and expectations of economic return. The second opened opportunities for the hitherto atomistic self-centred farmers to join forces with fellow farmers so as to achieve recognition and bargaining power. The third moved the farmers from a situation where they were highly dependent on others for their information, for acquiring inputs and for selling their produce, to one where they were more self-reliant, able to make informed decisions, seek information and make their own inputs should they so desire. In sum, they became more autonomous. Superimposing these dimensions leads to the emergence of four different phases during the process of conversion to sustainable farming. Theses phases are not sequential but rather the technical conversion ('beta'), and the building of a learning capacity ('gamma') are really parallel processes that mutually influence and reinforce each other.

The first chapter of the book provides an introduction to the research and societal problems that are addressed. The context of the study is briefly described and an overview of the chapters given.

The second chapter reviews the theoretical framework on which the research study and the project are based and introduces the questions that both are guided by. Theory of research on research for development is briefly discussed. Paradigms, theories and methods relating to ecological agriculture and farmer participation are then covered. The research methodology, based on a case study approach to the learning pathway of the farmers, is described.

Chapter 3 describes the initial context in which the project case study was implemented. The location, the municipality of Cota, is characterised by the high number of small vegetable producers that provide the nearby capital, Bogotá. Marketing was limited principally to the food terminal whose middlemen rarely offered a good, let alone stable, price for the produce. Combined with high production costs to pay for imported seed and chemical supplies, income to the farmers often did not cover expenses, nor provide the necessary cash to invest in the next crop and to provide for family needs. On the social level, the farmers described themselves as individualistic and dependent on external advice, often limited to salespeople, regarding farm management. These various factors combined stimulated the misuse of agricultural inputs, for the most part of chemical synthesis, which in turn led to serious environmental damage and at length, poorer crops. The intent here was to make use of the increased interest in ecological products, or at least healthier ones, among consumers and defenders of the environment to motivate the producers to change their production methods to more sustainable practices.

Having provided the theoretical and contextual background for the study, the book then goes on to describe the four phases of the farmer learning pathway.

Phase I covers three chapters and describes the situation at the beginning of the conversion process to sustainable production. Chapter 4 describes the process used for the participatory diagnosis. A map showing the information sources used by the producers revealed the one-way directionality of knowledge flow and the high dependence on local sales people. Restrictions to production and marketing were listed and then prioritised by the farmers, who also brainstormed on potential solutions. The prioritisation led to the sequence of steps to be followed in the conversion process to sustainable farming. The methodology used to design the conversion process and its implementation is described in Chapter 5. Methods used in European prototyping integrated and ecological arable farming were adapted here, and new ones added. These methods are: farmer participation and organisation, soil systems management, water management, cropping systems management, marketing strategies, ecological infrastructure management, and farm overall sustainability. Results of these methods are provided in Chapter 6. Rather than adding synthetic mineral fertilisers and fresh chicken manure on a yearly basis, participants are now preparing organic amendments using crop residues, animal manures and specific natural fertilisers, according to soil analyses and crop requirements. They combine those amendments with microbial 'soups' that help to improve soil microbiological activity, thereby helping to make nutrients available to the plants and improving soil structure. They apply botanical and biological products in the short-term management of pests and diseases while beginning to rebuild or redesign their farms for long – term management.

Phase II moves from a situation where the farmers have begun to use some of the technical knowledge to improve their production and to realise the importance of working together as a community. New issues arise and are dealt with. Chapter 7 describes the efforts made to diversify marketing channels by bringing the consumers closer to the production process through an agroecological tourist route. Home deliveries, specialised restaurants, and nearby schools are other alternatives explored. The process leading to the organisation of the farmers and team building is covered under Chapter 8, underlining the difficulties of conflict resolution among the members of the group.

With the build up of knowledge and community feeling developed in the first two phases, Phase III delves deeper into the need to provide solutions to a wider area as a tool for regional development. Chapter 9 studies the usefulness of knowing more about live fences and the arthropods that inhabit them, while Chapter 10 provides a practical application of that information through the creation of a network of live fences at municipal level based on enhancement of natural control of crop pests.

Phase IV looks to the future by beginning to build the capacity of the farmers to stand on their own. To that end, Chapter 11 describes the training of local facilitators, reinforcing their abilities in both technical and didactical methods, in an effort to help the farmers toward more autonomy.

After looking at the case study through the four phases of the farmers' learning pathway, the last chapter provides a critical review of effectiveness in terms of learning pathway design. An analysis is provided of the end results of the entire effort, reviewing what was successful, what not and why, and what other facilitators can learn from these results. Conditioning factors for the success of the project and its continuity are also looked at. Finally, the research activity sequence is analysed from the point of view of its success as a methodology and the implications of the results for research on agricultural research.

Glossary

Agroecosystem: ecosystems that are used for agriculture, and comprise polycultures, monocultures, and mixed systems, including crop-livestock systems (rice-fish), agro-silvo-pastoral systems, aquaculture as well as rangelands, pastures and fallow lands (FAO, 1998).

Sustainable agriculture: refers to both integrated and ecological farm production, as opposed to the conventional production methods which are based on Green Revolution technology and know-how especially high rates of use of chemically synthesized inputs.

Integrated production: crops that are produced under integrated crop production principles such as clean water, use of synthetically-made pesticides only when absolutely required and then only products of toxicological levels III and IV, and a general tendency towards ecologically friendly practices that are considered safe and healthy.

Ecological production allows only natural sources for fertilisers and pest and disease management, according to Decree 544 for ecological production practices, which is based on the international recommendations set by the IFOAM for organic production. Under the Colombian legislation, the term 'ecological' includes all farming methods alternative to conventional methods, such as biodynamic, organic, biological, organic, etc.

About the author

Rebecca Lee was born on August 26, 1964, in Geneva, Switzerland, to Canadian parents. From living around the world due to her father's work postings, she developed an interest for international work at a very young age. She studied Plant Science at Macdonald College, McGill University, Canada, during which time she took a year off to hitch-hike across Africa. She graduated in 1986, having emphasised biological control methods of plant disease and tropical agriculture.

After a short stint in Ecuador working with the Ministry of Agriculture through the National Banana Office, she returned to Canada to work on her Masters at the Department of Rural Extension Studies of the University of Guelph. Her thesis, a naturalistic evaluation of a rural development project in Mali, emphasised the qualitative and more social effects of introducing technical innovations. She received her degree in 1989.

She then spent a year between Montreal and the Philippines on a food systems project with McGill International, before moving to Colombia with her husband in 1991. In Colombia, she first helped manage a 40 hectare vegetable farm just outside of the capital, Bogotá, while joining her husband in setting up the first vegetable plug production company in the country. She was then invited in 1995 to join the Horticulture Research Centre of the University of Bogotá Jorge Tadeo Lozano as coordinator for research on cleaner flower production. Seeing the need for training among professionals and technicians of the agriculture sector and in general for disseminating the results of the research centre and building up a closer contact with the users of the information, she later offered to set up an Extension Programme for the Centre. Through this programme, short courses are offered according to the requirements in the sector, crop manuals with fully Colombian content are published, the research results are shared with producers and public, and most importantly, the other researchers at the Centre have come to understand the need to involve the farmers at all levels for the research to be appropriate. The programme name has since been changed to Participatory Research Programme, reflecting better the philosophy of joint research with the farmers with which Rebecca has implemented development projects with small farmers.

She now combines her interests in ecological farming, managing a two-hectare vegetable plot certified ecological and helping small farmers, with consulting work on training facilitators and project evaluation for the Colombian Ministry of Agriculture and her hobby of native plant species which she shares with her husband.
She can be reached by e-mail at suamena@yahoo.ca or by regular mail at:
Carrera 1 Este, No. 74-64, Bogotá, Colombia.