Converting Small Holder Vegetable Farms to Sustainable[1] Production in Tropical High Andean Conditions

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Keywords: interactive conversion process, farmer learning, ecological methods, Colombia

Abstract

Small holder vegetable farms of the municipality of Cota in the Bogotá plateau in Colombia are typically one hectare or less in size. 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. An interactive methodology for conversion to ecological farming practices based on the European prototyping experience was developed with the farmers. Here, a more participatory approach was used in the diagnosis of restrictions to sustainability, as well as for the implementation of the conversion process. The latter is based on ecological sequence, farmers' needs and capacities, and market demand. Furthermore, upscaling the conversion process was studied by proposing an option for redesigning the landscape within the context of ecological production.

Because ecological farming is based on observation and inference to understand the relationship between 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 learning process in order to know how to implement ecologically sound agricultural practices. By combining their farming experience and knowledge of the area with scientific knowledge on soil microbiology, plant nutrition, pest and disease management including enhancement of biological control through the establishment of live fences, a viable methodology for converting farms has emerged. An interesting alternative is now available to the farmers to improve their income by supplying the growing niche for ecologically friendly produce in the local market.

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 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 levels.

Context

The municipality in which this study was undertaken, Cota, has an economy based largely on agricultural production, and of that vegetables contribute significantly. It is located in the high Andean Plateau that surrounds the capital, Bogotá, at an altitude of 2600m and 4°

1 'Sustainable' in this article refers to both integrated crop production methods (ie. where a variety of different methods are used for nutrient as well as pest and disease management) and ecological (which in Colombian terms is used for ecologically certified produce according to local legislation, law 072 of 2002, which in turn is heavily based on the International Federation of Organic Agriculture Movements guidelines). Sustainability was considered from economical, ecological and social points of view

Proc. XXVI IHC – Sustainability of Horticultural Systems
Eds. L. Bertschinger and J.D. Anderson
Acta Hort. 638, ISHS 2004
Publication supported by Can. Int. Dev. Agency (CIDA)

latitude. The climate allows for year-round production, although frosts can occur around New Year's.

The small farmers who participated are owners of plots varying in size from 1,000 to 10,000m2. When this research started in September 1999, 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. Interest in healthier products among consumers and the concern shown by the farmers regarding the indiscriminate use of pesticides led to the possibility of creating the conditions for introducing ecologically friendly products to fill this growing niche.

The Problem Addressed

Effective participatory research methods were little known in the Colombian 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.

Previous Work in the Area

Information on methodologies for the conversion of farms to sustainable production is still quite limited. In Europe, a methodology to ease farmers through the conversion process to integrated and/or ecological production was developed, called prototyping (Vereijken, 1999). The methodology consists in establishing a hierarchy of prioritized objectives with the farmers, transforming these objectives into measurable parameters (indicators of farm sustainability) and linking these parameters to production techniques, leading to the design of a preliminary prototype which is tried out and improved on until the objectives are accomplished. The prototype is essentially a collection of practices designed with the farmers to lead to more sustainable agriculture. 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, such as productivity, stability, system resilience, dependability and self-reliance (Conway, 1985, 1987). However, farmer participation in the European prototyping is limited. A more substantial and significant participation of the actors in the farming system, particularly the 'beneficiary' farmers, will help ensure that their objectives are met, leading in turn to a high level of ownership of the change process, required for success and long-term viability. Changes proposed here include more participation 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, 1999) among others.

MATERIAL AND METHODS

1. To design with the small holder vegetable producers of Cota, Colombia, a methodology for the conversion of their farms to more sustainable practices, based on an initial participatory diagnosis, in order to reduce the negative impact of agriculture on the environment, while valuing local knowledge and improving farmer income.
2. To implement, monitor and adapt the methodology on pilot plots with the farmers measuring the effect on overall farm sustainability.
3. To determine what is required to scale up the process to regional level.

The project followed several phases in the design and implementation of a methodology with the producers for converting their farms to more sustainable practices.

These were: participatory diagnosis and prioritization of problems, interactive design of the methodology, selection of pilot plots, implementation of the conversion process on the pilot plots, evaluation of results with the farmers and consolidation of the process.

Participatory Diagnosis and Interactive Design

Meetings were set up in each of the rural neighbourhoods of the municipality to take into account geographical differences and ensure ease of access by the farmers. A knowledge linkage map was drawn with the farmers based on where they acquired information on new seeds, techniques, markets, and pest and disease control. This provided an idea of the actors within the local agricultural system. The situational diagnosis provided the farmers' opinions on restrictions to production and marketing and possible solutions. The farmers' prioritization of the restrictions was then used to design the conversion methodology. (For more on this process, see Lee, 2000, 2002).

Selection of Pilot Plots

A minimum of 10 plots was considered representative for the municipality and would also help the creation of a solid network for horizontal learning. Farmers who showed a pre-existing degree of interest in sustainable production were selected in order to be able to spend the relatively short time available (3 years) on the design and on-farm implementation rather than on trying to change potentially reticent farmers' visions.

Implementation of the Conversion Process

The solutions to the problems prioritized by the farmers included first of all a series of hands-on workshops to provide them with basic knowledge on sustainable practices on topics such as soil quality and microbiology, water quality and use, organic fertilizers, allelopathy and botanical products, and new seeds and varieties.

Based on the order of prioritization, the following methods were then implemented for farm conversion, varying somewhat the European prototyping:

1. Farmer Participation and Organization. Since farmer participation was deemed crucial to the success of the project, a method was incorporated to ensure that participation was considered actively. Farmer participation starts off weak, but it builds up throughout the conversion process to the point where they feel the need to associate.
2. Soil Systems Management. Integrated or ecological nutrient management, depending on how far the producer wanted to go, was emphasized here. Soil analyses were used as a basis for recommendations on inputs to be used. Organic amendments, microbial soups and botanical sources of nutrients were introduced. Minimal soil cultivation was also worked on to reduce damage to the soil structure by excess preparation by machine.
3. Water management. Training on the use of water according to crop needs and soil and climate conditions was provided. Appropriate irrigation equipment was evaluated and selected by the farmers with the project team support. Chemical and biological analyses of the water sources were supplied and mulching, addition of organic matter, enhancing live fences were also introduced as techniques that would help reduce water requirements.
4. Cropping Systems Management. The concept of multi-functional cropping systems was introduced as the combination of crops spatially or temporally to help the agroecosystem back to a higher level of resilience. Three basic techniques were used. Multiple cropping systems consists in having more than one crop in the same area at the same time. Cover cropping was used to reduce water evaporation and soil erosion and to protect soil microbiological fauna from the suns rays. Crop rotations for temporal variations were based on product type (leaf, fruit/flower, root/tuber and legume) as well as botanical family. This contributed to reduced pest pressure as well as increased biodiversity in the system. The concept of integrated crop protection was also introduced. First knowledge of the difference among the different pests and diseases was provided, then alternatives for their management were tried out and selected according to the farmers´ criteria.
5. Marketing Strategies. Diversification of marketing channels, aiming for direct contact with the consumers, training on product quality and value-adding and the strengthening of the

farmer group as a marketing association were worked on.

6. Ecological Infrastructure Management. This method was considered an essential element within an agroecosystem management approach. The farmers were encouraged to improve on the farm ecological infrastructure by choosing trees and herbs with multi-functional uses: economical return through harvesting, windbreaks, habitat for flora and fauna, including natural control agents (Lee et al., 2000) and source of botanical fertilizers and pesticides. A network of live fences was also designed at municipal level with a view to scaling up.
7. Farm Overall Sustainability. The idea here was to optimize the farm area and resources available. A software programme for farm sustainability (Pérez, 1999) was adapted to small holder vegetable production and data before and after intervention analyzed for five participant farms. Variables and indicators were included based on economical, social, ecological and productive considerations.

Evaluation with Farmers and Consolidation

The conversion process was continuously monitored with the farmers, with adaptations made according to the changing and progressing situation. A final oral evaluation was also made with them, to compare with the analysis provided through the farm sustainability programme.

RESULTS AND DISCUSSION

The main result is a methodology for farm conversion that evolved throughout the participatory process, as the technical results and evaluations provided the needs to be addressed in the next step. This is shown in figure 1. This design provides the guidelines for replication in other situations, allowing for the flexibility required to adapt to new circumstances.

Participatory Diagnosis and Interactive Design

The general situation is one of reduced income due to lower profitability. The main priority was therefore to acquire ways that would increase income. The farmers understood that without quality they would have difficulty marketing their produce. They therefore listed restrictions prioritizing them according to the order in which they would be confronted with a problem throughout the production process: soil, water, crops, market, technology, financial/administrative and finally the political context.

Selection of Pilot Farms

The project started with five farms. By May 2002, 28 farmers on 21 farms were actively involved, representing 5% of the small producers of Cota.

Implementation of the Conversion Process

As much of the work in ecological farming remains empirical, an attempt was made here to choose those methods that had a demonstrated scientific basis, thereby providing the beginning of answers to skeptics. 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, for example based on local knowledge. In those cases, a small research project was established with the farmers to try out new options. The implementation of the seven methods described above resulted in the following observations.

1. Farmer Participation and Organization. Farmer participation from the beginning of the project was obtained through the diagnosis of their difficulties. Their continued participation ensured that the conversion design that emerged remained relevant to the changing situation. Relevance was monitored at individual level by the project team through conversations and observations during farm visits and by the farmer group by periodic group evaluations. Farmer autonomy was maintained by providing the information required to make an informed decision and leaving the final decision on resource management up to each participant. Near the end of the project, a group of

participants was also trained as local facilitators to maintain the flow of information and the parallel autonomy in decision-making, and thus build a local capacity to continue the process. The role of the project director varied between being a provider of information and a process facilitator.

2. Soil Systems Management. Organic amendments were used to help restore the microbiological soil populations and structure, helping to make available existing nutrients and balancing those in excess. Visible results include improved crop productivity and quality, and soil that changed from a powdery appearance to one with small aggregates. Most farmers have totally replaced the use of chemically synthesized fertilizers with organic sources.
3. Water Management. Where water used to be applied on a routine basis, the farmers now use this resource based on crop requirements and on climate conditions. Drip and micro-spray irrigation systems were tried and found to be more efficient in water usage.
4. Cropping Systems Management. The farmers have learned to manage crop rotations according to botanical family and product type, as well as to programme their crops to meet consumer demand. In crop protection, use of chemically synthesized pesticides was reduced and then replaced almost entirely by home-made or commercial sources of botanical remedies. They also learned how to use biological control agents such as Bacillus thuringiensis and Trichoderma harzianum. They have learned to observe nature in order to work with her.
5. Marketing Strategies. Commercialization channels were diversified by accessing the consumers directly. The main emphasis was made on an agroecological route which led Bogotá tourists through two or three participant farms to educate them on the production methods used, to a stand where they could purchase the vegetables. Home deliveries and restaurants were also introduced. The result was specifically a set of farmer-owned marketing strategies that signified better market control.
6. Ecological Infrastructure Management. Studies were made of insect populations inhabiting trees in existing live fences in order to establish which trees would be most appropriate to enhance the presence of natural control agents. Selection at farm level of tree species was also made on the basis of their usefulness economically (i.e. fruit trees).
7. Farm Overall Sustainability. Indicators for soil, water, and crops, as well as the technological component, economical aspects and a socio-cultural index (table 1), were used. The results of the evaluation are summarized in table 2. Generally, progress was obtained on all five farms analyzed, the water component being the weakest (Lee, 2002; Pérez and Lee, in prep.).

Evaluation with Farmers and Consolidation

The farmers gradually realised that working on their own multiplied the amount of effort required to keep updated on production techniques, market their produce and obtain fair prices. 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.

CONCLUSIONS

A methodology was developed to help project facilitators and producers convert farms to more sustainable production practices (figure 1). Based on the farmers' prioritization of restrictions to production, research activities were given 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. Interactive implementation allowed for the adaptation of activities as the situation progressed. Once they reached a certain technical ability that permitted them to feel more comfortable about the productivity of their individual farms, the farmers began to realise the importance of looking at conversion processes in a larger area, so that in the future, the region as a whole might become more sustainable.

For upscaling within the region, building local capacity to continue the conversion process was considered fundamental. Local facilitators were given additional training in technical aspects of converting farms to sustainable practices, as well on facilitating. By forming facilitator groups, platforms for sustainable social learning were created, which now allow the community to learn together in the absence of external support. To upscale to other areas, the conversion methodology can be applied, maintaining a sufficient level of flexibility to ensure adaptability to the particular situation.

In order to be able to address directly the problems that the producers face, particularly in the context of small holder production in South America, a broader approach to conversion must be taken than that by the European prototyping. Such an approach will allow for the flexibility required to adapt to new and changing situations, and to evolve the methodology parallel to the farmers' learning.

ACKNOWLEDGEMENTS

Thanks go to the University of Bogotá Jorge Tadeo Lozano for logistical support and to the Programa Nacional de Transferencia de Tecnología Agropecuaria of the Colombian Ministry of Agriculture for financial support. The mayor's office of the municipality of Cota provided some financial support for the work on live fences. The Dutch Foundation for Research on Organic Farming funded the work of the software programme and Miguel Angel Pérez built and ran it.

Literature Cited

Conway, G.R. 1985. Agroecosystem analysis. Agricultural Administration 20: 31-55.

Conway, G.R. 1987. The properties of agroecosystems. Agricultural Systems 24: 95-117.

Lee, R.A. 2000. Participatory prototype design for the conversion of vegetable farms to sustainable production in the Colombian high Andes. Phase one: Participatory Diagnosis International Farming Systems Association Symposium, Chile, 27-29 November.

Lee, R.A. 2002. Interactive Design of Farm Conversion. Linking Agricultural Research and Farmer Learning for Sustainable Small Scale Horticulture Production in Colombia. Published Doctoral Dissertation, Wageningen, University, NL.

Lee, R.A., Cure, J.R. and Pérez, M.M. 2000. Biodiversity and relative abundance of insects and spider mites in tree species used as live fences in the Bogotá Plateau. Revista Colombiana de Entomología 26 (1-2): 1-15.

Leeuwis, C. 1999. Integral technology design as a process of learning and negotiation.p.123-143. In: Leeuwis, C.(ed.), Integral Design: Innovation in Agriculture and Resource Management. Mansholt Studies 15. Mansholt Institute, Wageningen, NL.

Pérez, M.A. 1999. Evaluación de la sostenibilidad predial del sistema de producción bovino de leche de la Sabana de Bogotá, Colombia. Masters of Science thesis, Universidad Internacional de Andalucía, Spain.

Pérez, M.A. and Lee, R.A. (in prep.). Farm sustainability: Evaluating change in vegetable farms under conversion to ecological production.

Vereijken, P. 1999. Manual for Prototyping Integrated and Ecological Arable Farming Systems (I/EAFS) in interaction with pilot farms. AB-DLO, Wageningen, NL.

Tables

Table 1. Biophysical and economical indicators used to evaluate overall sustainability of vegetable farms in Cota, Colombia. Values within the desired range are given 1 point, those without the range, 0. (Taken from Lee, 2002).

Indicator	Variable	Desired values
Crop production	Tonnes.year^{-1}.ha^{-1}	> 12
Energy balance	Energy efficiency index	> 3
Productive efficiency of water	Dry matter based on crop yield (M^3 . T^{-1}. year^{-1}. ha^{-1})	> 500
Number of species used	Crop species produced per year	> 3
Number of species and individuals per species	Non-crop species found on the farm Number of individuals per species	> 3 > 1
Soil quality index	Soil structure	"flour", fine grains=0 granular to medium aggregates=1
	Maximum resistance to penetration at 30cm	< 200000 kg.m^{-2}
	Carbon / Nitrogen ratio	10-15
	Soil salinity	<0.74 mS.cm^{-1}
	Available phosphorous	30-60 ppm
	Calcium+Magnesium/Potasium 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
Pesticide use	Percent use of natural inputs	> 50
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
Soil biological activity	Worm count: individuals. m^{-2}	> 20
N balance: yield. ha^{-1} of N compared to N fertiliser input *	kg. farm^{-1}	> 0
Water received by crop compared to requirements	Rainfall.year^{-1} + irrigation volume x minutes x no of times) compared to evaporation rate	= 0
Self-supply of inputs	% of inputs produced on farm	> 20
Farm system resilience	% losses due to pests and diseases pre-harvest	< 30%
	Average cost . ha^{-1}. year^{-1}	
	Net annual income . ha^{-1}. year^{-1}	> $ 467,100 **
	Gross annual income . ha^{-1}. year^{-1}	> $4,720,000 **
	Annual net profit	> 20 %
Marketing activities index	Added value	Yes = 1 ; No = 0
	Market channel diversity	Yes = 1 ; No = 0
	Product differentiation	Yes = 1 ; No = 0

*Only inputs to the system and system outputs are accounted for. Recirculated materials are not included (for example, compost made on farm).
**The Colombian peso was valued at approximately $2300 per US dollar in June, 2000.

Table 2. Comparison among farms before and after intervention of the evaluation of biophysical and economical indicators by component. System sustainability values are given in percentage (Taken from Lee, 2002).

Farmer	1		2		3		4		5	
Soil component	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Soil quality index	0	0	0	0	0	0	0	0	0	0
Soil biological activity	0	1	0	1	0	1	0	1	0	1
Subtotal	0	1	0	1	0	1	0	1	0	1
Water component										
Productive efficiency of water	0	0	0	0	1	1	0	1	1	0
Water index	0	0	0	0	0	1	0	1	0	0
Subtotal	0	0	0	0	1	2	0	2	1	0
Plant component										
Number of non-crop species	1	1	1	1	1	1	0	1	1	1
Individuals of non-crop species	1	1	1	1	1	1	0	1	1	1
% losses in pre-harvest	1	1	1	1	1	0	1	1	1	1
Crop rotation	0	0	0	0	1	0	0	1	1	1
Subtotal	3	3	3	3	4	2	1	4	4	4
Technological component										
Nitrogen balance	0	0	0	1	1	0	0	0	0	0
Energy efficiency index	0	0	0	0	1	0	0	0	0	0
% inputs of natural source	0	1	0	1	0	1	0	1	0	1
Average yield $T.ha^{-1}.year^{-1}$	1	1	1	1	1	1	1	1	1	1
% input self-sufficiency	0	0	0	1	0	1	0	0	0	1
Subtotal	1	2	1	4	3	3	1	2	1	3
Economic component										
Net $income.ha^{-1}.year^{-1}$	1	1	1	1	1	1	1	1	1	1
Gross $income.ha^{-1}.year^{-1}$	1	1	1	1	1	1	1	1	1	1
Net annual profitability	1	1	0	1	1	1	1	1	1	1
Marketing activities index	0	0	0	1	0	1	0	0	0	1
Subtotal	3	3	2	4	3	4	3	3	3	4
TOTAL	**7**	**9**	**6**	**12**	**11**	**12**	**5**	**12**	**9**	**12**
% indicators fulfilled of 17	41	53	35	70	65	70	29	70	53	70

Figures

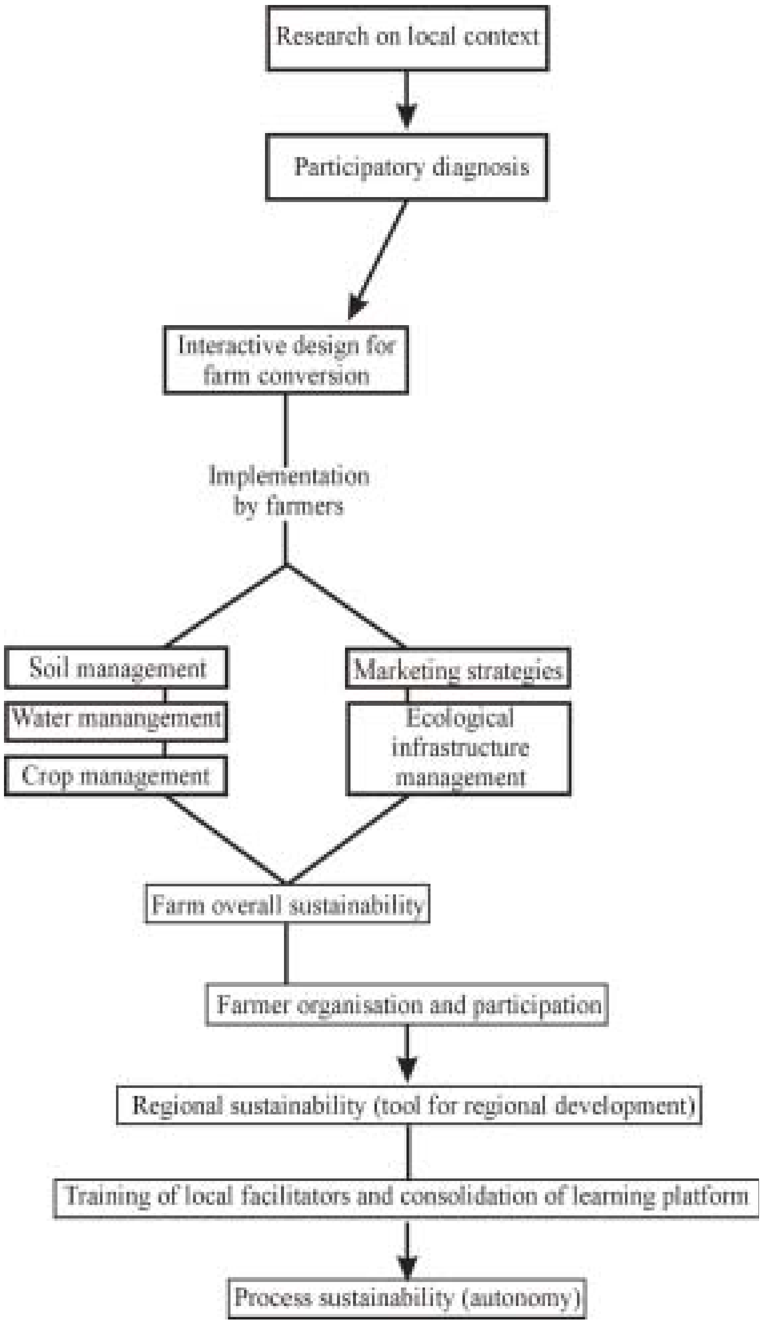

Fig. 1. Methodology for farm conversion followed by farmers in the municipality of Cota, Colombia.