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# ECOLOGICAL AGRICULTURE IN SOUTH-INDIA
## AN AGRO-ECONOMIC COMPARISON AND STUDY OF TRANSITION

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ABSTRACT

ECOLOGICAL AGRICULTURE IN SOUTH-INDIA; AN AGRO-ECONOMIC COMPARISON AND STUDY OF TRANSITION
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This report describes two research programmes carried out on ecological agriculture in India.

Experiences of twelve farmers, in transition towards ecological agriculture, are described and analyzed. A gradual approach is crucial for success. The duration of the transition period is directly related to the previous farming system, specifically the amounts of mineral fertilizers used. An average transition takes three to five years.

The comparative performance of seven farm pairs, consisting of one ecological and one conventional reference farm, is analyzed in relation to agronomic and economic performance. Ecological farms achieve similar economic results as conventional farms, for gross margin/ha (Rs 10,620.- and Rs 11,515.- respectively) as well as net farm income/labourday (Rs 32.-). Labour input per hectare also shows no significant difference. In ecological farms trees and livestock are far more numerous than in conventional farms (respectively 7:1 and 4:1).

Farming systems/Economy/Ecology/Sustainability/Ecological agriculture/Agriculture/Labour/Production/Transition/Comparison/Soil fertility/Crop protection/Income/Integrated farming/Agroforestry/India

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# CONTENTS

# PREFACE

This report is about the experiences of farmers. It describes the change process farmers went through to develop their conventional agricultural practices into a sustainable farming system. Furthermore, it gives data on the agro-economic performance of these sustainable farming systems compared with conventional systems. All data in this report describe the results of the activities of real farmers, for whom agriculture is their main income source. As such, this report is the first one giving detailed data on the comparative performance of ecological agriculture at farm level in the tropics. The report illustrates that, under the specific conditions of these farmers, their short-term needs for food and cash income can successfully be combined with the society's long-term need for sustainability.

These findings are published at a moment when the necessity for sustainable agricultural development is accepted by an increasing number of individuals, organizations and governments. The experiences of these farmers illustrate that ecological farming is economically viable, even without any support such as that available to conventional farmers (e.g. extension, subsidized inputs). However, it is this lack of support which seriously hampers the spreading and further development of sustainable farming. May these results be an inspiration for those who want to strengthen agricultural support systems towards stimulating sustainable farming practices. When numerous farmers have proven that it is possible, we should do our utmost to help others who want to move in the same direction.

L.C. Zachariasse
Director LEI-DLO

A.J.E. Ferf
Director ETC-Foundation

# ACKNOWLEDGEMENTS

This report is the result of the first year of field research into transition and agro-economic performance of ecological agriculture in South-India. This research programme is executed as part of the Agriculture, Man and Ecology (AME) programme, Pondicherry, India. ETC Foundation, Leusden, The Netherlands is implementing this programme since 1983. The Agricultural Economics Research Institute (LEI-DLO), The Hague, The Netherlands, participates in the research through consultancy support on the economic component of the research. In India, The Institute for Command Studies and Irrigation Management (ICSIM) is collaborating with the AME programme for the implementation of this research programme.

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- students of the Wageningen Agricultural University for their contribution to the transition research.
- the farm households who participated in this research and shared their experiences with us.

# SUMMARY

In South-India two research programmes were carried out. One studying the experiences of twelve farmers in transition towards ecological agriculture, and one analyzing the comparative performance of seven pairs of ecological and conventional farms in relation to agronomic and economic performance. Ecological agriculture is defined as a type of agriculture which seeks to optimize the use of local resources through creating complex and divers farming systems, aiming at a stable, growing and long lasting production level.

The main reasons for transition are to be found in environment/sustainability aspects as well as health and food quality. In transition a gradual approach is preferable. Only in cases where external-input application is very limited, transition can take place within one year. An average transition takes three to five years. In situations where the original applications of fertilizer and pesticides are high it might take seven years to complete a transition without major negative effects on farm income. The most important limiting factor is the lack of information on transition towards ecological agriculture. Availability of external resources can decrease the time needed for transition considerably. The main changes implemented are in soil fertility and pest and disease management. Practically, farmers focus on decreasing application of pesticides and fertilizer, increasing cultivation of perennial and leguminous crops and intensified application of organic manure.

On the basis of one year of monitoring field data only preliminary conclusions can be drawn on the agronomic and economic effectiveness of ecological agriculture. The greater diversity of techniques practised in soil fertility management as well as in plant management and greater diversity of crops cultivated in ecological versus conventional farming is striking. Ecological farms have seven times more trees per hectare than conventional farms. Conventional and ecological farms are for respectively 65% and 42% dependent on external nutrients. Yields realized in the different farming systems show no significant difference.

Ecological farm management has the potential to achieve similar economic results as conventional management. Total net-farm-income per labour day amounts to Rs 32.- for both systems. Labour input per hectare shows no significant difference, nor does the sexual division of tasks. The cash component of the total cost is 50% in ecological farms against 67% in conventional farms. In ecological farms the cost for manure are lower compared to the conventional farms and the costs for external labour are higher. Striking is the difference in the share of the livestock in the total income, 27% in ecological farms against only 6% in conventional farms. Although pests and diseases cause serious

problems during the transition phase, on the established ecological farms the absence of pesticides seems to create no problems.

# 1. INTRODUCTION

## 1.1 Background

'Sustainable' is the key pre-fix in any current article on development. What started as a small 'alternative' searching for new solutions got world-wide attention with the publication of the Brundtland report - 'Our common future'- in 1987. In the 1990 policy paper - 'A world of difference' - of The Netherlands Minister of Development Cooperation there is a strong focus on environmental issues. The continuous degradation of the natural environment is seen as a threat to the very survival of mankind. In degradation as well as preservation of nature, agriculture can and does play an important role. Farmers are the majority of the persons directly responsible for the management of natural resources at the local level. 'A world of difference' expects an important contribution from Low External Input and Sustainable Agriculture (LEISA), a name used to express the combination of the multitude of sustainable farming systems.

Solutions for the current problems can not be found within the limits of bio-physical aspects and purely technical alternatives only. Solutions will have to be set within a framework taking into account the possibilities and limitations of the natural environment, the socio-economic and political context. It is only within this realistic complexity that workable solutions can be found.

The underlying research describes the experiences of practising farmers who, on the basis of their own resources, searched for sustainable farming methods within the actual limitations of the existing socio-economic situation.

## 1.2 Research within the Agriculture, Man and Ecology programme

The Agriculture, Man and Ecology (AME) programme, Pondicherry, India, aims at the promotion of socially just, economically viable and ecologically sound land use systems within the Indian subcontinent. The AME programme is implemented by ETC Foundation, Consultants for Development Programmes, Leusden, The Netherlands, with financial support from The Netherlands Government. In 1988, the advisory committee to the project suggested The Netherlands Government to have research undertaken into the economic possibilities of ecological farming methods. Although research in this field has been undertaken in Europe and Northern America, hardly any research on the economics of sustainable agriculture has taken place in the tropics. Research undertaken mainly focuses on the effects of certain techniques. It is expected that the results of this research, focusing on the

farming systems level, will be useful to investigate the economic and agricultural productivity as well as sustainability of Low External Input and Sustainable Agriculture practices. Furthermore, it is expected that a simple methodology can be developed for comparative study of ecological and conventional/traditional farming for agronomic and economic aspects in a tropical setting. In the third place it is expected that well documented case studies on the development of sustainable agriculture can strengthen project and programmes in this field.

ETC Foundation requested the Agricultural Economics Research Institute (LEI), The Hague, The Netherlands, for consultancy support to the research. The Institute for Command Studies and Irrigation Management (ICSIM), Bangalore, India, was contracted for research implementation in collaboration with the AME programme. March 1989 the research proposal was formulated (Werf & Narayan, 1989), field work started in June 1989.

## 1.3 Description of farming systems

Studying ecological agriculture in South-India requires a description of the different farming systems present. Traditional, conventional and ecological agriculture can be seen as the three extreme corners of a classification triangle (figure 1).

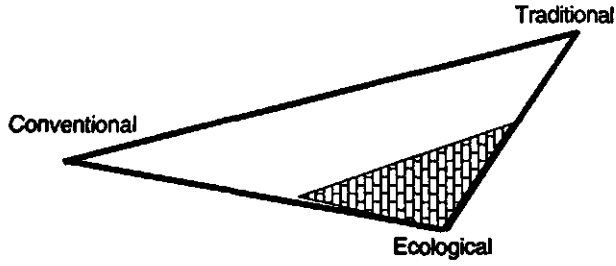



*Figure 1.1 The traditional, conventional and ecological farming systems; corners of the classification triangle. Marked area represents Low External Input and Sustainable Agriculture*

Most of the farming practised in South India can be placed on the continuum from traditional to conventional agriculture. Practices developed by generations of subsistence farmers are combined with results of scientific research as brought to farmers by the extension service.

Traditional agriculture is a subsistence oriented farming system, using low levels of locally available inputs. Conventional agriculture makes intensive use of external inputs, ranging from fertilizer to information, for market oriented production. Ecological or sustainable agriculture seeks to optimize the use of local resources through creating complex and diverse farms, aiming at a stable, growing and long lasting production level. Low External Input and Sustainable Agriculture could be seen as filling an important part of the bottom corner of the classification triangle.

In table 1 a schematic characterization of the three farming systems, as defined for this research, is given.

| System variables | Conventional | Ecological | Traditional |
|---|---|---|---|
| Productivity | high | high | low |
| Sustainability | low | high | moderate |
| Farm complexity | simple | complex | complex |
| Diversity environment | uniform | divers | divers |
| Production orientation | market | subsistence/ market | subsistence |
| External inputs seeds | high yielding varieties | improved local varieties | local varieties |
| Use chemical fertilizer | high | none | low |
| Use of biocides | high | none | low |

*Figure 1.2 Identifiable traits of three farming systems (Werf & Narayan, 1989)*

## 1.4 Objectives

The research is undertaken with the following three objectives:

A. To identify, qualitatively and quantitatively the socio-economic viability of ecological agriculture by itself and in comparison with conventional/traditional agriculture.
B. To identify, qualitatively and quantitatively the problems encountered by farmers in transition to ecological agriculture.
C. Examine the prospects of ecological agriculture on a long-term basis.

## 1.5 Set-up of this report

This report covers the first year of field work for the comparative agro-economic research as well as the completed transition study.

Chapter 1 introduces the research and the farming systems studied. Chapter 2 deals with the methodologies used, for transition and agro-economic research. In chapter 3 the results of both research programmes are given. In chapter 4 the methodology used is evaluated. Conclusions of the two research programmes, the methodology used and indications on the prospects of ecological agriculture on a long-term basis are given in chapter 5. The hurried reader it is advised to read the summary and chapter 5.

# 2. METHODOLOGY

## 2.1 Limitations and possibilities of case studies

A number of research methods are available for conducting farming systems research: rapid rural appraisal, surveys, single and multiple visits, collecting secondary data, case studies and experiments. They all vary in cost, coverage, accuracy, time and statistical validity (Maxwell, 1984). Since in this research only a limited number of well established ecological farms is available in the region, experiments and a case-study approach are the only options. Because an intensive study is required to gain insight in diversity and complexity of various ecological farming techniques, the case study approach appears to be the most appropriate methodology. Lampkin (1986) sees the use of case studies specially of importance in order to identify problem areas and to identify possible solutions, both extremely relevant in this situation, considering the early development stage of sustainable agriculture in India. Maxwell (1984) recommends the case study method specially for situations where not one crop but a whole range of enterprises is concerned, which is typically the case in ecological agriculture. A case study approach is also extremely useful when one not only wants to know what is happening on a farm, but also wants to elucidate the cause and effect relationships that are of influence. Another advantage of the case study approach in this situation, is the increased insight in the farming system through the personal contact between researchers and farmers. This greatly improves the possibility for correct interpretation of the data collected.

Two main disadvantages of case-studies are generally mentioned. In most case-studies little attention is paid to the representativeness of the selected cases for the sector studied. A clear selection procedure whereby the characteristics of case study farms are related to the characteristics of the group they represent can overcome this problem to some extend (Maxwell,1984). But in general the group of cases studied is not large enough to justify an extrapolation of the results to a sector, a region, or a country. Secondly, when studying a limited number of case-study farms it is very difficult to eliminate effects of factors which are not determined by the system. For instance locational, farm, economic, marketing and managerial factors.

## 2.2 Transition research

### 2.2.1 Introduction

Transition is the process of conversion of a farm from a conventional or traditional farming system to a stabilized ecological farming system (Werf, 1990A). For tropical situations no research has been done on the transition process at farm level. In the United States and Europe limited research findings are available on the process of transition. Most publications dealing with transition describe a single case (Andrew, 1987; Patriquin, 1986) or give guidelines for the process of transition (Aubert, 1982; Kirschenmann, 1988 and Zeelenberg, 1989). Only some very recent studies (Macrae, 1990 and Andrews, 1990) give a broad based analysis of the process of transition.

Invariably all researches perceive the transition period as a crucial bottleneck for successful introduction of ecological agriculture. Specific problems include aspects such as rotation adjustment, biological transition and learning (Dabbert & Madden, 1986).

### 2.2.2 An explorative approach

Not having the possibility to use the experiences of others in designing the research an explorative, step-by-step, approach was chosen. As a first step the twelve selected farms were visited and the farmers were interviewed, making use of a questionnaire. Aim was to get a rough insight in the farm and farmer, farming techniques practised, reasons for transition, aim of transition, changes implemented, etcetera (see Annex 2). The results of this first set of visits were used to decide upon the next step. The cycle of collection, processing, analysis and checking of data was repeated three times.

The questionnaire designed for the first set of farm visits was actually used as a checklist for focusing of the discussions with the farmers. During the visits it appeared that the use of a questionnaire directed the farmers too much in their answers. Nevertheless this first stage gave a reasonable overview of the transition process for the different farms. This information was used to list specific questions for each case. In a second round of visits the case specific questions were discussed with the farmers, resulting in a better understanding of the transition process on each farm. Analyzing this information a rough description of the transition process and possible approaches could be made.

During a third round of interviews contradictory information from the first two interviews was checked. Simultaneously farmers were asked for their advice on a supposed transition of a neighbouring farm. This as a check for the general description and the different approaches of the transition process as arrived at by the researchers after the second round of interviews.

The results of the three rounds of interviews are laid down in an interim report containing the individual case descriptions and a generalized analysis of the process of transition. This report is translated into local language and distributed to the farmers. A two day farmers meeting followed, having the following objectives:

- Exchange of experiences amongst the farmers. Several farmers had earlier expressed a feeling of isolation in their search for an ecological farming system and the interest to meet and discuss with colleagues. This aspect of the meeting was greatly appreciated by all of them.
- Increasing the involvement of farm women in the research. Researchers felt that women had been involved too little during the interviews. During the meeting women participation in the general sessions was limited and diffident. In separate sessions their participation was active and confident. In the final (general) session it was concluded that 'we were able to recognize the role and capacity of our women' (Werf, 1990C).
- Checking of results of the transition research. The individual case descriptions were checked with the farmers and the researchers understanding of the transition process was discussed with them.

Furthermore this meeting was conducted in order to find out how the AME research programme could be made more participatory. Farmers expressed their interest to maintain records of their farm operations and the desire to be trained in basic research.

### 2.2.3 Classification and sampling

On the basis of a mailing undertaken by the AME project, eight ecological farms having completed the transition were identified. In addition to this, one farm currently in transition and three farms started as ecological farms were studied. Selection of farms was done according to the following criteria:

A. No or decreasing application of chemical fertilizers.
B. No or decreasing application of chemical biocides.
C. Conscious inclusion of ecological farming practices like stimulation of diversity and complexity, stimulation of soil life etc.

Selected farms were included in the research after a field visit and discussion with the farm manager. Farm locations are indicated in figure 2.1.

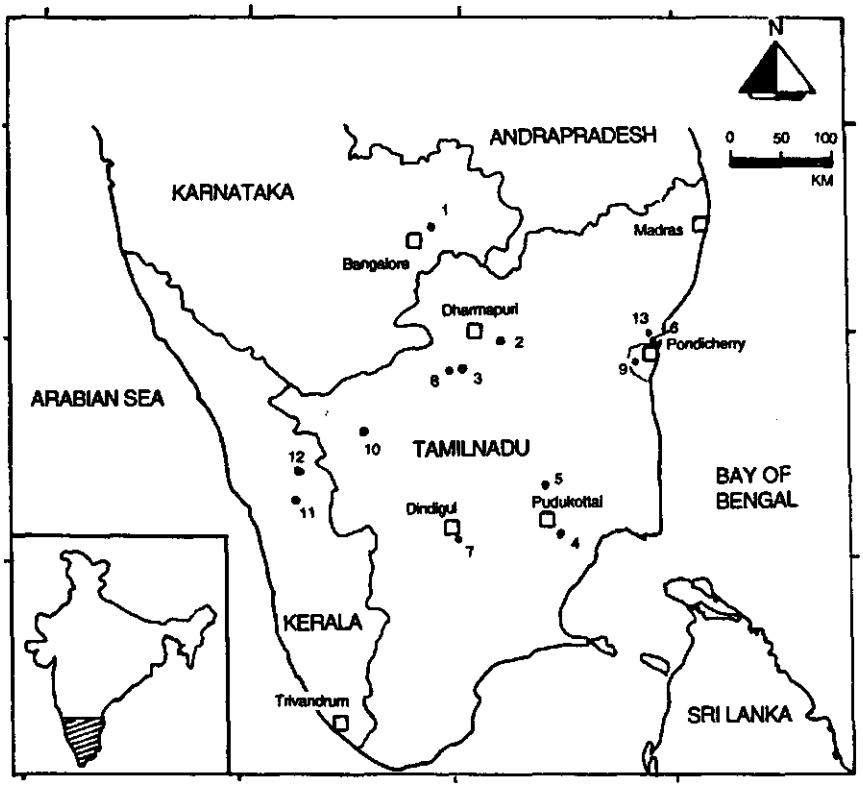



*Figure 2.1 Location of farms studied in South India. The numbers one to seven are the paired case studies of the comparative agro-economic research, consisting of one ecological and one reference farm. All the ecological farms included in the comparative study (excluding no 6) as well as the numbers 8 to 13 are the farms studied for the transition research*

## 2.3 Comparative agro-economic research

### 2.3.1 Introduction

Sofar no research findings have been published comparing ecological agriculture with conventional/traditional practices in a tropical setting. However, this type of research has been undertaken in Western countries (Lockeretz, 1984; Vereijken, 1985). Roughly speaking three different approaches have been utilized in the implementation of comparative research (Lampkin,

1984). Firstly and mainly, single farms have been compared with regional averages, a single partner farm or a hypothetical model. Here difficulties arise in eliminating the effects of non-system factors such as location, farm, economic, production and managerial elements. Secondly, samples of farms and partner farms can be compared. Here the problem lies in the limited availability of ecological farms, being too little for statistical elimination of non-system factors. Thirdly, in a few cases a controlled experimental approach was chosen, attempting to eliminate the influences of non-system elements. In this study every ecological case study farm is linked to a conventional reference farm with a similar cropping pattern in the near surrounding trying to eliminate as much as possible non-system factors (soil types, climate, topography etc.). It is obvious from other research that the farmer's management ability is a critical variable in evaluating the performance of ecologically managed farms (Lockeretz, 1989). This non-system aspect is very difficult to eliminate in a case-study approach.

Considering the huge yearly variations in yields and economic results on farms, monitoring the farms over a longer period is necessary for a proper evaluation of the farming system, including yield stability.

### 2.3.2 Approach and institutional setting

Focal point of the comparative study is the agro-economic viability of ecological agriculture and its perspectives at the farm level. Within the limits of the Agriculture, Man and Ecology programme it seemed most suitable to opt for a sample-of-farm-pairs approach, as it would simultaneously give the opportunity to analyze farmers experiences in ecological agriculture.

As AME lacks the skills and manpower needed for implementation of the economic component of the study, a well experienced economic research institute (ICSIM) was contracted as collaborative organization.

### 2.3.3 Classification and sampling

Selection of ecological farms is done according to the following criteria:

A. No application of chemical fertilizers.
B. No application of chemical biocides.
C. Conscious inclusion of ecological farming principles like stimulation of diversity and complexity, stimulation of soil life etc.
D. The farming system must have been practised for at least three years.

Selected ecological farms are included in the research after a field visit and discussion with the farmer. Each ecological farm is paired to a nearby reference farm, paying special attention to similarity in the following aspects; soil type, topogra-

phy, holding size, climate, cropping pattern, livestock, irrigated/rainfed and quality of farm management. Reference farms should differ from the ecological farms in use of fertilizer and pesticides. Farm locations are indicated in figure 2 (paragraph 2.2.3).

### 2.3.4 Data collection

The data to be collected can be classified in three groups:

- Initial descriptive information of the farms.
- Data collected monthly.
- Secondary data.

A starter tour by the research team is conducted for final selection of ecological farms, collection of initial data and selection of reference farms. The descriptive information of the farms include detailed physical end socio-economic information including soil type, rainfall, a detailed map of land use during the year, family size and composition, living conditions etc.

Also a farm inventory of the farm assets, including livestock is conducted in the beginning and at the end of the study period. Inventory of standing crops, cash and stocks of farm produce are omitted to limit the complexity of the data collection.

Regular data are collected monthly by researchers using a structured schedule covering all crop and livestock input-output flows in actual quantities and money value, total labour needs and total cash-flow (annex 4). Special attention is paid to internal input flows between livestock and crop activities. The farmers play an essential role in the process of data collection, therefore an active participation of the farmers is required during the data collection. In order to increase motivation a detailed agronomic and economic analysis of the farm in Tamil-language is presented to the participants after every year of data collection.

Secondary data are collected from the various departments of government organizations.

### 2.3.5 Data processing and analysis

The following steps for data analysis are undertaken: data validation, tabulation of results per pair, whole-farm analysis, analysis of specific activities, conclusions and verification. This is done separately for the agronomic and economic analysis, by AME and ICSIM respectively.

Data processing is mainly conducted using the FAO developed FARMAP computer programme. Results are tabulated per farm pair and presented in detailed agronomic and economic farm pair descriptions. These descriptions form the basis of two interim reports (Narayan, 1990 and Sivasubramanian & de Jonge, 1990).

In the whole farm agronomic analysis, the farms are studied for farming techniques practised (for soil fertility management

and creating plant diversity), nutrient balance (at farm gate and for main crop), external nutrient dependency and land use. In the economic whole farm analysis the labour input, variable costs, gross income, fixed costs, net farm income and cash income are analyzed. In annex 1 a list of definitions of the economic keyfigures used is presented. Per farm the before mentioned aspects are calculated separately for the main crop.

As it is a case study approach, conclusions are drawn on a pair-wise basis, taking the researchers comments on the figures as extremely important for understanding and interpretation. Conclusions regarding the perspectives of ecological agriculture are kept to a minimum as the analysis covers only one year of data collection. When data over a period of at least three year are available the focus can shift to these perspectives.

Verification takes place at various stages during analysis. A first verification is done during a field visit by consultants from LEI and ETC. A second verification is conducted during the analysis when the farm pair descriptions made by AME and ICSIM are compared. A final verification takes place during a meeting with the participating farmers in which the results of the first year are discussed.

## 2.4 Estimating sustainability

### 2.4.1 Levels of analysis

Sustainability has become a major issue in the design, execution and evaluation of projects in developing countries. In general terms sustainability refers to long-term availability of certain means to long-term achievements of certain goals (Van Pelt et. al,1990). In this study sustainability must be defined towards ecological sustainability. A development can be judged ecologically sustainable when long run (per capita) social welfare improvement is not impeded by environmental deterioration, either through environmental amenities or through environmental productivity, or through a combination of the two (Munn, 1989). When trying to analyze the sustainability of a farming system the scope is essential for the results obtained. Analysis can be conducted at farm level, at community or region level, but also nation-wide or world-wide implications can be studied. Only just recently attempts are made to incorporate sustainability in the traditional cost-benefit analysis (Pearce, 1989; Van Pelt, 1990). That indicates that at this moment it is very difficult to analyze certain costs and benefits in relation to sustainability. For instance how to measure the reduced soil erosion when farmers plant trees and shrubs around plots ? Another example is the partly replacement of fertilizers through manure. At farm level it may have positive effects on the soil fertility in the long-run, at regional level trade in manure could benefit other farmers and at national level the hard-currency saved can be used

in other projects. On the other hand negative effects may occur at the various levels. At present most of the necessary data are absent for conducting this type of analysis thoroughly.

In this research the farming systems are analyzed at farm-level since the agronomic and economic viability at that level is a first prerequisite for possible successful introduction. The positive and negative effects at other levels are not included. Based on these data analyses at other levels can be conducted. For instance the effect on nations food-security of a partly introduction of low-external-input agriculture.

### 2.4.2 Sustainability indicators

Currently, little is known on the measurement of ecological sustainability. There is not yet a widely accepted set of indicators defining this. All what can be done at the moment is monitoring of production and the use of natural resources and estimation of the effects on environmental quality. This can be done by monitoring the development of a farming system over a period of three to five years or more.

It is expected that during this research, easily measurable indicators of ecological sustainability can be selected on the basis of empirical findings. These indicators should have a clear relation with the accepted, only long-term measurable, definers of sustainability as 'maintaining or enhancing the quality of the environment' and 'conservation of natural resources'.

In this study soil fertility development and nutrient flow patterns are taken as leading threads for the analysis of ecological sustainability. Nutrient balances are studied at whole farm level as well as for the main crop, external dependency for nutrients and nutrient flow pattern are analyzed. The different techniques practised for soil fertility maintenance receive special attention. Further, attention is paid to the primary production cycle (vegetation - cropping system) and the secondary production cycle (animal husbandry - livestock management). In the cropping system specific attention is given to soil coverage, role of leguminous species, role of perennial, cropping diversity.

# 3. RESULTS

## 3.1 Transition research

'Transition is the process of conversion of a farm from a conventional or traditional farming system to a stabilized ecological farming system' (Werf, 1990A). After introduction of all agro-technical changes needed, it might still take some time before the transition is completed. This is specially the case when perennial play a major role in the new farming system.

In Europe and North-America the starting point normally is a conventional farming system which, in most cases, depends on external inputs and is market-oriented. In India however, transition may also start from a traditional farming system, which is subsistence-oriented and uses low levels of locally available inputs, possibly combined with limited amounts of fertilizer and pesticides. For this research conventional agriculture was defined as using farming practices and external input applications as advocated by government extension services. By far the most common agricultural system found nowadays in India is a mixture of both conventional and traditional practices.

Aim of the transition is to obtain a stabilized ecological farming system with a sustainable production.

Taking this diversified situation into account, transition can be depicted as in figure 3.1.

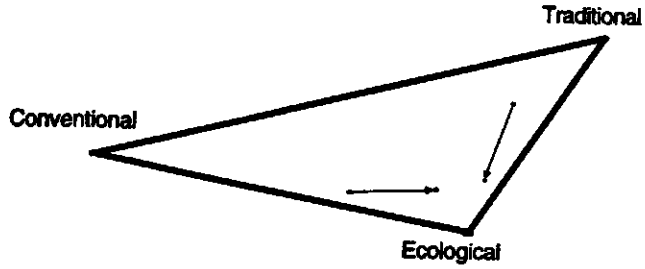



*Figure 3.1 The transition process depicted as a position change of the farm in the classification triangle towards the ecological corner*

### 3.1.1 Description of the surveyed farms

Twelve ecological farms ranging in size from 0.26 to 40 hectares were studied. All farms are in South India, nine in Tamil

Nadu, two in Kerala and one in Karnataka. South-India receives an average annual rainfall of 1 200 mm, the two monsoons (July-August, October - November) account for ninety percent of the total rainfall. Eighty percent of the holdings is smaller than two hectares. Less than twenty percent of the land can be irrigated.

With regard to aspects as holding size (average size 6.8 ha), access to water (52% of the land irrigated), education and off-farm income the farmers studied are mostly better off than average. These advantages enabled the farmers to take the risks of experimenting with an unknown farming system.

Reasons to opt for ecological agriculture vary greatly within the group. Production of healthy food, environmental aspects and sustainability of the farming system are mentioned by many. Philosophical motivations and the expectation of a better farm income are important in several cases. Table 3.1 indicates the different reasons for transition per farm, table 3.2 totalises the reasons mentioned and lists them in frequency.

*Table 3.1 Main and secondary reason for transition per farm*

| No | Holding size in ha. | Original farming system | Reason for transition | |
|---|---|---|---|---|
| | | | Main | Secondary |
| 2 | 3.0 | Traditional | Health | Environment |
| 3 | 3.2 | Traditional | Health | Environment |
| 8 | 2.8 | Traditional | Health | Environment |
| 5 | 4.3 | Conv. Ave. | Farm income | Independence |
| 4 | 14.0 | Conv. Ave. | Farm income | Environment |
| 9 | 40.0 | Conv. High | Health | Environment |
| 1 | 4.2 | Conv. High | Farm income | Environment |
| 13 | 2.4 | Conv. Inst. | Health | Environment |
| 7 | 2.0 | Conv. Inst. | Farm income | Health |
| 10 | 1.2 | Conventional | Environment | - |
| 11 | 0.4 | Conventional | Philosophy | Independence |
| 12 | 4.4 | Wasteland | Philosophy | Environment |

Conv. Ave. = Conventional with average use of external inputs
Conv. High = Conventional with high use of external inputs
Conv. Inst.= Conventional institutional farm

Lack of technical information on ecological farming is a serious problem for all. More than half work without any information and had to develop an ecological farming system on their own. Others could make some use of existing extension services and foreign literature. In India, there is only very little literature available on ecological agriculture.

*Table 3.2 Totalized reasons for transition and frequency as mentioned by the twelve farmers (Werf, 1990A)*

| Reason for transition | Frequency |
|---|---|
| Environment/sustainability | 9 |
| Health/food quality | 7 |
| Philosophy | 5 |
| Farm income | 4 |
| Independence | 1 |
| Water and labour scarcity | 1 |

Most farmers had seven to ten years of experience with ecological agriculture when surveyed. Two farmers had only two years of experience, two had respectively 13 and 15 years field knowledge, average is eight years experience with ecological agriculture.

Three farms are converted from virtually traditional farming practices and six farms are converted from a conventional farming system. In all these cases the farmers had agricultural experience. Three farms are started as ecological farms by the current owners, without any or only limited agricultural experience.

### 3.1.2 The transition process

Theoretically four different processes are possible. A farm may be converted all at once or parcel by parcel. In each of these approaches one can follow a gradual process or implement all necessary changes at once. The process of transition will be more distinct when the difference between starting situation and final situation is substantial. A transition has been considered as completed successfully once the farmers perceive the yields as having stabilized under the new fertility management practices. Table 3.3 shows the methods and time needed for transition.

The three virtually traditional farms, using only low levels of chemicals before transition, converted the whole farm at once. Use of pesticides was dropped, simultaneously fertilizers were fully replaced by organic manures, no major changes took place in yields. The transition was completed successfully in one year.

Two originally conventional farms, using average quantities of fertilizer, adopted a gradual transition process for the whole farm. Within three to four years these transitions were completed successfully.

Four of the originally conventional farms converted the whole farm at once. Two of these, previously using high levels of chemical fertilizers, incurred severe yield losses (up to 60%) and referred back to the use of fertilizers in the next year.

*Table 3.3 Method used and time needed for successful completion of transition in relation to the original farming system (Werf, 1990A)*

| No | Holding size in ha. | Original farming system | Transition method | |
|---|---|---|---|---|
| | | | At once | Gradual |
| 2 | 3.0 | Traditional | +(1 yr) | |
| 3 | 3.2 | Traditional | +(1 yr) | |
| 8 | 2.8 | Traditional | +(1 yr) | |
| 5 | 4.3 | Conv. Ave. | | +(3 yrs) |
| 4 | 14.0 | Conv. Ave. | | +(4 yrs) |
| 9 | 40.0 | Conv. High | - | +(4 yrs) |
| 1 | 4.2 | Conv. High | - | +(7 yrs) |
| 13 | 2.4 | Conv. Inst. | +(5 yrs) | |
| 7 | 2.0 | Conv. Inst. | Ongoing (2 yrs) | |

+ = completed successfully - = failed
Conv. Ave. = Conventional with average use of external inputs
Conv. High = Conventional with high use of external inputs
Conv. Inst.= Conventional institutional farm

After this, these two adopted a gradual transition approach; year by year fertilizer application was decreased and simultaneously organic manure use was increased. Farm 9, having the means to invest, completed transition in four years. Farm 1, having less resources, took seven years.

The remaining two, originally conventional farms, were run as institutional farms, one belonged to a non-governmental organization, the other one formed part of a leprosy hospital. In these cases yields decreased up to 30 percent but this was accepted within the institutional set-up. One of these farms started transition only two years ago, the other one completed transition in five years.

Three farms were started as ecological farms by the current owners, one of them had two years of agricultural experience, the others had no farming experience. In these cases the agricultural transition is intensely influenced by the change in profession of the 'farmer' involved. This influence made it impossible to conclude on completion of the transition, therefore these cases were not included in table 3.3.

Several farmers (both Conv. Ave. and Conv. High) expressed that yields increased during transition along with the development of soil fertility and even reached beyond conventional production levels. In rice, average grain yields of 6 250 kg/ha (Breugel and Brouwer, 1990) and 6 320 kg/ha (Subramanian, 1989) were realized under ecological cultivation. Several farmers expressed that ecological agriculture enabled them to reach self-

sufficiency in food items which earlier had to be partly purchased. Furthermore, a number of farmers mentioned distinct decreases on expenditures for inputs such as fertilizer, pesticides, concentrate and tractor tillage.

In certain cases transition could have been completed faster (e.g. through extra investments in organic manures) when farmers would have been better informed on transition and related problems. This aspect of lack of information combined with having to learn ecological agriculture while implementing the transition, had a great impact on the transition and the time needed for it. Both 'Conv. High' farmers expressed that with the experience they have now (11 and 15 years) they are able to do a transition of a farm similar to theirs in two to three years instead of the four and seven years they needed respectively.

### 3.1.3 Agricultural changes implemented

Farmers were asked to list what they perceive as the most important changes in agricultural practices made during transition (table 3.4).

*Table 3.4 Most important changes made during transition and frequency of mentioning by the twelve farmers (Werf, 1990A)*

| Changes | Frequency |
|---|---|
| Stop application of pesticides | 6 |
| Stop application of fertilizers | 5 |
| Increased number of trees and perennial species | 5 |
| Increased application of organic manure, green manures, compost | 4 |
| Increased cultivation of leguminous crops | 3 |
| Improved manure and urine handling | 2 |
| Initiation of multiple cropping | 1 |
| Increase of deep-rooted crops | 1 |
| Site-oriented species selection | 1 |

*Soil fertility*

Changes in soil fertility management were well prepared in most cases. All at once (Trad. and Conv. Inst.) or gradually (Conv. Ave. and High), chemical fertilizers were replaced by nitrogen-fixing crops, green (leaf) manures, animal manure, irrigation tank silt and agro-industrial by-products or waste.

Four different strategies for soil fertility improvement could be distinguished, all focusing on increasing the organic matter production on the farm.

* One farmer (no 12) practised 'natural regeneration', allowing a fallow period for natural soil improvement of a degraded area.
* 'Regulated natural regeneration' was practised in two cases (no 1 and 4), using green manure crops (Sesbania and Crotalaria) to reclaim alkaline lands for agricultural purposes.
* 'Enhanced self-improvement' using internally produced organic material was most common for soil fertility improvement, as it allowed for continued cropping. This was frequently combined with a gradual growth of the cattle population. Fodder production was increased in order to decrease the need for outside grazing and thereby loose less manure. In three cases cattle urine was collected. Composting and green (leaf) manuring are common practices.
* 'Enhanced improvement with externally obtained organic material' was practised by several farmers through collecting organic matter from outside the farm (green leaf manure) or purchases (e.g. manure, irrigation tank silt, coir dust, granite dust).

*Pests and diseases*

The need for changes in pest and disease management was in most cases not foreseen and caused serious problems in several farms. This seems to be due to lack of knowledge and information. Capability of coping with these problems differed greatly between the individual farmers. Adaptations made included changes in the varieties grown (in some cases high yielding varieties were replaced by local varieties) and deletion of susceptible crops (e.g. cotton).

Certain farmers claimed to have less problems after several years. They attribute this to the use of organic manures, creation of an overall healthier field ecosystem and increased presence of natural predators. Pest control techniques were mainly derived from traditional agriculture. Companion planting, decoctions of insecticidal plants (e.g. Azadirachta indica), spraying of diluted cow urine and the use of oil lamps to catch night-flying insects were frequently practised.

*Crop management*

Striking changes in crop management include increased growing of leguminous and fodder crops, a higher cropping intensity through multiple cropping and a shift towards local varieties. Increasing the number of trees on the farm is mentioned by five farmers as a major change and implemented by several others too. Therefore, the complete effects of a transition can actually be

fully estimated only after the trees are full-grown. In a few cases crop rotations were widened. Weed control remained unchanged, mainly hand weeding, sometimes intercultivation was practised.

*Livestock management*

In six out of twelve cases the quantity of livestock in the farming system increased during the transition. Along with increased on-farm production of fodder,thereby decreasing external grazing, and improved manure and urine management more nutrients could be recycled within the farm.

*Erosion control*

Erosion control activities were increased mainly due to the growth in awareness of environmental and sustainability aspects. Techniques practised show a higher priority for increasing vegetative soil cover (through e.g. use of cover crops, intercropping and increasing the percentage of perennial and trees) than in conventional agriculture. Mechanical measures, like decreasing tillage, contour bunding and mulching, were also practised.

The transition research was concluded by a farmers meeting. During a discussion the following points were concluded by the farmers as essential aspects of ecological agriculture (Werf, 1990C):

- The organic matter content of the soil has to be increased in order to reduce dependency on chemical fertilizer. This can be achieved by cultivation of (N-fixing) fodder crops and green leaf manures and increasing the livestock population for manure production.
- Soil tillage should be minimized and where possible replaced by mulching, cover crops, intercropping, and inclusion of trees in the field.
- Weeds can be used as (living) mulch to prevent soil moisture evaporation and can be used in compost preparation.
- A variety of selected trees should be planted for provision of cattle fodder, improvement of the soil, supply of green leaf manure and as a wind break.
- Drought resistant species should be preferred for annual crops as well as trees.
- Erosion control by contour bunding and soil cover is essential.

### 3.1.4 Farmer characteristics

Farmer characteristics of importance in relation to the transition process were those influencing the self-learning capacity of the farmer, such as innovativeness, financial freedom, family tradition and place of residence. Due to the almost

complete absence of information each farmer had to find his/her own way out. Experience in agriculture and willingness to experiment were farmer characteristics making the transition easier. The financial freedom of a farmer directly influenced the length of the transition. Limited investment possibilities (e.g. for soil fertility improvement) directly prolonged the transition period, as could be seen when comparing the length of the transition period of both 'Conv. High' farms. A family tradition in agriculture had a direct positive influence on the transition, as traditional agriculture proved an important source of information for the farmers. In South-India, farmers normally live in villages and not on the land itself. However, living on the farm proved to be of major importance for an effective and efficient transition. One farmer expressed the need for continuous attention in ecological agriculture as follows:
'Transition (...) is a matter of watching and observing'.

## 3.2 Comparative agro-economic research

### 3.2.1 Introduction

In the comparative agro-economic research many different types of data have been collected at farm level. In this chapter a summary of the most essential data collected in the 7 case studies are presented. For more detailed information the reader is referred to AME and ICSIM reports (AME,1990 and Narayan,1990).

Since in a number of cases only a part of the farm activities have been studied, keyfigures normally used in a whole-farm analysis are in this study converted into figures per ha.

After the description of results of the case studies, it is tried to extract some general aspects of ecological and conventional farming from the case studies. Hereafter a limited analysis at crop level is presented.

### 3.2.2 Results of case studies

#### 3.2.2.1 Case study 1

The ecological farm is a very well developed farm and the farm household is practising ecological farming since twelve years. Livestock plays an essential role in the farming system for income generation (milk) as well as for manure production. The cropping system is rather complex. Also on the reference farm the cropping pattern is rather complex with many different crops, but almost no mixed cropping. On the reference farm 57% of the gross cropped area are vegetables and 42% grains. Whereas on the ecological farm these figures are respectively 25% and 20%. Pulses make 22% and other crops 30%. The only similar crop activity is sole paddy. Livestock plays a less important role on the reference farm compared to the ecological farm. Both farms have

1.2 ha eucalyptus trees, which have not been incorporated in the study. In table 3.5 the main characteristics are summarized.

*Table 3.5 Characteristics of farms in case study 1*

| Characteristics | Ecological | Reference |
|---|---|---|
| State | Karnataka | Karnataka |
| Total holdings size (ha) | 4.2 | 2.3 |
| Area studied (ha) | 3.0 | 1.1 |
| Total number of different crops | 16 | 10 |
| % of studied area irrigated | 71 | 48 |
| Main crops (area wise) | Fruit orchard<br>Mulberry<br>Paddy | Tomato<br>Paddy<br>Millet |
| Main livestock (no. wise) | Cows<br>Chicken | Buffalo |
| Residence | On-farm | Off-farm |

From table 3.6 can be seen that the gross income per ha is considerably higher on the ecological farm. More than 60% of the gross income on the ecological farm is derived from silk-worm-cocoon production, with a high gross margin per ha (Rp 54 000/ha). On the reference farm tomato accounts for 40% of the gross income, with paddy on the second place (15%). The gross margins of both activities are considerably lower (Rp 36 000 resp. Rp 17 000 per ha) compared to cocoon production. It can be concluded that the differences in cropping pattern have a great influence on the economical results and a comparison of the results of the farming systems is therefore very difficult.

Crop production forms on both farms the main part of the gross income, but income from livestock is more important on the ecological farm. On both farms around 70% of the production (measured in gross income per ha) is sold. The variable costs are much higher on the ecological farm due to the high input costs of the cocoon production. This results in a higher gross margin per ha and a higher net farm income per labourday for the reference farm in the 1989/90 season. On the ecological farm much hired labour is used and little female labour is involved. On the ecological farm the percentage of child labour is relatively high. Despite the high amount of hired labour the percentage of cash in the total costs is lower on the ecological farm, mainly due to fertilizer expenses on the reference farm. The external nutrient dependency is therefore much higher on the reference farm. Both farms have a positive nutrient-balance at farmgate for NPK.

The household of the reference farm has no others sources of income, while on the ecological farm a considerable off-farm income is realized (38% of total income).

*Table 3.6 Main production characteristics in 1989/1990 season of farms in case study 1*

| | Ecological | Reference |
|---|---|---|
| Gross income/ha | 56 183 | 45 685 |
| % crop activities | 82 | 90 |
| % sold | 69 | 74 |
| Variable costs/ha (Rp) | 28 676 | 10 611 |
| Gross margin/ha (Rp) | 27 507 | 35 074 |
| Labourdays/ha | 710 | 529 |
| % female | 15 | 53 |
| % hired | 70 | 21 |
| Net farm income/labourday (Rp) | 43 | 66 |
| Off-farm income (Rp) | 41 400 | 0 |
| % cash of total costs | 42 | 58 |
| Total assets/ha (excl trees,Rp) | 129 990 | 92 254 |
| Trees/ha | 260 | 41 |
| External nutrients/ha (kg NPK) | 142 | 375 |
| External nutrient dependency | 39 | 67 |
| Nutrient-balance at farmgate | | |
| Nitrogen (kg N/ha) | +56 | +51 |
| Phosphate (kg P/ha) | + 8 | +18 |
| Potash (kg K/ha) | + 3 | +14 |

3.2.2.2 Case study 2

The farms in case study 2 have to some extend a similar cropping pattern. Paddy, millet, tomato, groundnut and horsegram are present as sole crop in both farms. On the reference farm the percentage of vegetables and oil crops (groundnuts) is high (respectively 32% and 40% of the gross cropped area). On the ecological farm 'other crops' take 39% of the gross cropped area (sugar cane, coconut etc.). In both farms mixed cropping is practised and also the total number of different crops cultivated is similar.

Apart from animal traction on the ecological farm there are no livestock activities on both farms. Other characteristics are given in table 3.7.

The gross income per ha is much higher on the ecological farm than on the reference farm (table 9). Tapioca (46%) and paddy (16%) contribute most to this gross income on the ecological farm. The large areas of finger millet and tomato give a relatively low gross income. On the reference farm paddy (24%) has the greatest contribution to the farm income. The yields in kg/ha are higher on the ecological farms for paddy and ragi, while the yields of tomato, groundnut and horsegram are higher on the reference farm.

*Table 3.7 Characteristics of farms in case study 2*

| Characteristics | Ecological | Reference |
|---|---|---|
| State | Tamil Nadu | Tamil Nadu |
| Total holdings size (ha) | 3.2 | 2.6 |
| Area studied (ha) | 3.2 | 2.6 |
| Total number of different crops | 13 | 11 |
| % of studied area irrigated | 100 | 43 |
| Main crops (area wise) | Sugar cane<br>Groundnut<br>Tapioca | Groundnut<br>Tomato |
| Main livestock (no. wise) | Bullocks | - |
| Residence | On-farm | Off-farm |

The variable costs per ha are higher on the ecological farm due to higher costs of seeds, wages and hired mechanical labour and feeding costs for the bullocks. This results in a higher gross margin per ha. The labour-input per ha however is considerably higher on the ecological farm resulting in a similar net-farm-income per labourday.

*Table 3.8 Main production characteristics in 1989/1990 season of farms in case study 2*

| | Ecological | Reference |
|---|---|---|
| Gross income/ha (Rp) | 10 986 | 6 118 |
| % crop activities | 98 | 100 |
| % sold | 55 | 54 |
| Variable costs/ha (Rp) | 4 631 | 2 223 |
| Gross margin/ha (Rp) | 6 355 | 3 895 |
| Labourdays/ha | 369 | 216 |
| % female | 45 | 61 |
| % hired | 61 | 62 |
| Net-farm-income (Rp) | 7 168 | 3 796 |
| Net farm income/labourday (Rp) | 22 | 20 |
| Off-farm income (Rp) | 700 | 0 |
| % cash of total costs | 52 | 65 |
| Total assets/ha (excl trees,Rp) | 99 208 | 111 735 |
| Trees/ha | 86 | 18 |
| External nutrients/ha (kg NPK) | 30 | 96 |
| External nutrient dependency | 12 | 45 |
| Nutrient-balance at farmgate | | |
| Nitrogen (kg N/ha) | +16 | +52 |
| Phosphate (kg P/ha) | + 3 | + 9 |
| Potash (kg K/ha) | - 2 | + 9 |

The total net-farm-income on the ecological farm is almost twice that of the reference farm. The cash component of the total costs on the ecological farm is lower. Also the external nutrient dependency is much lower on the ecological farm. Only for potash a slight negative nutrient-balance occurs on the ecological farm. The reference farm has a larger portion of leguminous crops in the cropping pattern.

3.2.2.3 Case study 3

The farms in this pair differ considerably in size and in cropping pattern (table 3.9). Groundnuts and sugarcane are the only similar crops. The ecological farm has relatively much rainfed grains (sorghum and millet) while the reference farm has also paddy, cotton and some tomatoes. Both farms concentrate on sole cropping systems. Livestock plays an important role on the ecological farm and is absent on the reference farm.

*Table 3.9 Characteristics of farms in case study 3*

| Characteristics | Ecological | Reference |
|---|---|---|
| State | Tamil Nadu | Tamil Nadu |
| Total holdings size (ha) | 2.8 | 1.2 |
| Area studied (ha) | 2.8 | 1.2 |
| Total number of different crops | 7 | 7 |
| % of studied area irrigated | 57 | 100 |
| Main crops (area wise) | Sorghum | Groundnut |
| | Groundnut | Sugar cane |
| | Sesamum | Paddy |
| Main livestock (no. wise) | Bullocks | - |
| | Buffalo | |
| Residence | On-farm | Off-farm |

In table 3.10 the main production characteristics of this farm pair are presented. It appears that the gross income per ha of the reference farm is three times that of the ecological farm.

The results of the large sugarcane area (1.0 ha) on the reference farm determine the results (57% of the gross income) of this farm, with groundnuts (19%) on the second place. On the ecological farm the livestock activities contribute for 44% of the total gross income, the sesamum crop for 22% and the groundnuts for 14%. The groundnut yield in kg/ha on the reference farm is twice that of the ecological farm. Also the variable costs are higher on the reference farm, especially due to higher costs per ha of hired labour and hired mechanical labour. This results in a three times higher gross margin per ha on the reference farm.

*Table 3.10 Main production characteristics in 1989/1990 season of farms in case study 3*

| | Ecological | Reference |
|---|---|---|
| Gross income/ha (Rp) | 5 716 | 16 358 |
| % crop activities | 56 | 100 |
| % sold | 47 | 82 |
| Variable costs/ha (Rp) | 2 781 | 6 074 |
| Gross margin/ha (Rp) | 2 935 | 10 284 |
| Labourdays/ha | 72 | 262 |
| % female | 42 | 66 |
| % hired | 53 | 93 |
| Net-farm-income (Rp) | 6 051 | 11 066 |
| Net farm income/labourday (Rp) | 43 | 50 |
| Off-farm income (Rp) | 0 | 4 900 |
| % cash of total costs | 40 | 77 |
| Total assets/ha (excl trees,Rp) | 90 398 | 76 000 |
| Trees/ha | 27 | 7 |
| External nutrients/ha (kg NPK) | 38 | 78 |
| External nutrient dependency | 49 | 71 |
| Nutrient-balance at farmgate | | |
| Nitrogen (kg N/ha) | +15 | +10 |
| Phosphate (kg P/ha) | + 1 | - 3 |
| Potash (kg K/ha) | + 2 | - 7 |

The total labour-input however is 3.5 times higher on the reference farm. The net-farm-income per labourday is still higher on the reference farm, but compared to the gross margin per ha the difference is small. The total net-farm-income of the reference farm is 80% higher than on the ecological farm. The reference farm is much more oriented towards production for the market than the ecological farm. The fraction of female labour is much higher on the reference farm and most of the labour is hired. The fraction of cash costs in the total costs on the ecological farm are half of that on the reference farm. Also the external nutrient dependency is much lower on the ecological farm. As on most ecological farms the number of trees is higher than on conventional farms. However compared to other ecological farms the tree-density is low.

### 3.2.2.4 Case study 4

In this case study unfortunately only a limited area of the ecological farm has been studied, namely the 4.0 ha irrigated land on which mainly food crops are cultivated. One other plot of 4 ha are under rainfed cultivation and one plot of 4 ha near the house the farmer has developed a type of agro-forestry with a huge variety of trees. The figures presented for the ecological

farm therefore give an incomplete picture of this farm, but concentrate only on one plot. The ecological farmer has been earmarked by the government as a progressive farmer. He himself strongly advocates tree planting for two reasons:

- conservation of the environment through erosion control and nutrient recycling;
- a long term profitable investment for farmers

The reference farmer is also a very good performing farmer and well educated.

On the plot on the ecological farm grains and pulses are predominant, while on the reference farm grains, oil crops, vegetables and other crops are evenly distributed. Both farms concentrate on sole cropping activities. Paddy and sunhemp are the only two similar sole crops. Both farms have livestock for manure production, while the ecological farm also has quite some milk production.

*Table 3.11 Characteristics of farms in case study 4*

| Characteristics | Ecological | Reference |
|---|---|---|
| State | Tamil Nadu | Tamil Nadu |
| Total holdings size (ha) | 12.1 | 4.0 |
| Area studied (ha) | 4.0 | 4.0 |
| Total number of different crops | 9 | 9 |
| % of studied area irrigated | 100 | 80 |
| Main crops (area wise) | Paddy<br>Sorghum | Paddy<br>Sorghum |
| Main livestock (no. wise) | Cows<br>Bullocks<br>Goat<br>Sheep | Bullocks<br>Buffaloes |
| Residence | On-farm | On-farm |

The gross income per ha on the reference farm is slightly higher than on the ecological farm (table 13). On the ecological farm paddy (48%) and milk (24%) determine the gross income, while on the reference farm banana/soybean (39%), paddy (19%) and groundnut (13%) are the most important activities contributing to the gross income. The average kg yield per ha of paddy on the ecological and reference farm does not differ very much: respectively 4 300 kg and 4 000 kg. The reference farm is much more market-oriented than the ecological farm. Variable costs per ha are lower on the ecological farm. In comparison with the reference farm the extra costs on hired labour are compensated by the savings on costs of fertilizer and pesticides. Higher variable costs on the traction animals results therefore in higher total variable costs per ha on the reference farm. The labour-intensity on

both farms is comparable, only on the reference farm almost all labour is hired.

The cash component of the costs is higher on the ecological farm, mainly due to hired labour involved. The use of external nutrients is considerably higher on the ecological farm than on the reference farm, while the external nutrient dependency is lower. The total level of nutrients use is therefore much higher on the ecological farm, resulting in a higher positive nutrient-balance for N, P and K.

*Table 3.12 Main production characteristics in 1989/1990 season of farms in case study 4*

| | Ecological | Reference |
|---|---|---|
| Gross income/ha (Rp) | 11 869 | 14 323 |
| % crop activities | 61 | 91 |
| % sold | 31 | 70 |
| Variable costs/ha (Rp) | 5 074 | 6 125 |
| Gross margin/ha (Rp) | 6 795 | 8 198 |
| Labourdays/ha | 287 | 268 |
| % female | 66 | 52 |
| % hired | 99 | 41 |
| Net farm income/labourday (Rp) | 25 | 31 |
| Off-farm income (Rp) | 28 100 | 8 450 |
| % cash of total costs | 63 | 43 |
| Total assets/ha (excl trees,Rp) | 105 851 | 97 125 |
| Trees/ha | 218 | 62 |
| External nutrients/ha (kg NPK) | 222 | 127 |
| External nutrient dependency | 48 | 63 |
| Nutrient-balance at farmgate | | |
| Nitrogen (kg N/ha) | +127 | +72 |
| Phosphate (kg P/ha) | + 24 | +13 |
| Potash (kg K/ha) | + 43 | +22 |

3.2.2.5 Case study 5

In table 3.13 the main characteristics of case study 5 are presented. The total holding size of the 'ecological' farm is 4.0 ha of which 1.0 ha is studied. Since only this plot is studied, and also on the reference farm one plot of 1.0 ha is taken into account, the whole farm analysis in this case study is of limited value. In both plots grains (paddy and sorghum) are predominant in the cropping pattern. Apart from paddy and sorghum mixed cropping is used in the ecological farm while only sole cropping occurs on the reference farm. This results in twice as much different crops cultivated on the ecological farm. Livestock is

present on both farms, only on the ecological farm cows are present for milk production.

*Table 3.14 Characteristics of farms in case study 5*

| Characteristics | Ecological | Reference |
|---|---|---|
| State | Tamil Nadu | Tamil Nadu |
| Total holdings size (ha) | 3.6 | 1.6 |
| Area studied (ha) | 1.0 | 1.0 |
| Total number of different crops | 12 | 6 |
| % of studied area irrigated | 100 | 100 |
| Main crops (area wise) | Paddy<br>Sorghum | Paddy<br>Sorghum |
| Main livestock (no. wise) | Buffaloes<br>Cows | Bullocks<br>Buffaloes |
| Residence | On-farm | Off-farm |

In table 3.14 the main results of the 1989/90 season of the farms are presented. The gross income per ha on the ecological farm is twice that of the reference farm. The 0.7 ha paddy accounts for most of this gross margin (62%) with output from livestock (milk, manure and new animals;14%) and the mixed crop of cowpea/cotton/okra (9%) as second and third. On the reference farm rice is even more predominant: 80% of the gross income comes from paddy.

The yield level of the paddy on the ecological farm is much higher than on the reference farm: 4 000 kg/ha versus 1 700 kg/ha. The sorghum yields, the other comparable crop, show little difference 617 kg/ha versus 560 kg/ha. On the reference farm paddy and sorghum are the main sources of income and almost all of it is consumed. The ecological farm is much more market-oriented. The variable costs on the ecological are higher due to a much higher level of use of manure. The reference farm has an average cost per ha on manure and fertilizer of Rp 1 800, against Rp 3 300 on manure only on the ecological farm. On the ecological farm 90 more labourdays per ha are used compared to the reference farm. Almost all of this labour comes from within the family, with much more women involved in the ecological farm.
Off-farm income is higher on the ecological farm and the cash component of the total costs is considerably lower on the ecological farm compared to the reference farm. On the reference farm the use of external inputs is much higher than on the ecological farm. Both farms have a positive nutrient-balance for N, P and K. The surpluses on the reference farm are higher, especially for nitrogen.

*Table 3.14 Main production characteristics in 1989/1990 season of farms in case study 5*

| | Ecological | Reference |
|---|---|---|
| Gross income/ha (Rp) | 15 081 | 7 944 |
| % crop activities | 86 | 95 |
| % sold | 48 | 3 |
| Variable costs/ha (Rp) | 5 865 | 3 533 |
| Gross margin/ha (Rp) | 9 216 | 4 411 |
| Labourdays/ha | 402 | 312 |
| % female | 72 | 52 |
| % hired | 8 | 1 |
| Net farm income/labourday (Rp) | 21 | 9 |
| Off-farm income (Rp) | 3 300 | 1 400 |
| % cash of total costs | 10 | 66 |
| Total assets/ha (excl trees,Rp) | 24 737 | 45 862 |
| Trees/ha | 527 | 33 |
| External nutrients/ha (kg NPK) | 153 | 238 |
| External nutrient dependency | 12 | 45 |
| Nutrient-balance at farmgate | | |
| Nitrogen (kg N/ha) | + 21 | +161 |
| Phosphate (kg P/ha) | + 2 | + 29 |
| Potash (kg K/ha) | + 20 | + 34 |

### 3.2.2.6 Case study 6

Farm pair 6 is located in the state of Pondicherry. The ecological farm belongs to the Auroville trust. The owner is entitled to use the land as long as he participates in the Auroville living-community. The farmer on the ecological farm works part-time in a bakery, while also through hiring out the bullock cart off-farm income is generated. Both farms have a relatively simple cropping pattern with millet and groundnuts as main crops (table 3.15). On the ecological farm no irrigation takes place. The reference farm has a tank irrigated area of 0.6 ha on which paddy is grown, but this plot is not included in the study. In both farms livestock is present for milk and manure production.

Since not the whole farm area is studied the economic key-figures concerning the whole farm are of limited value and must be interpreted as figures for the studied area only.

In table 3.16 the main results of the 1989/90 season of both farms are presented. The gross income per ha of the reference farm remains far behind that of the ecological farm. The gross income on the ecological farm is mainly determined by the milk production (64%) with crop production of minor importance. With comparable numbers of milk producing livestock, it must be concluded that on the ecological farm milkproduction is given much

*Table 3.15 Characteristics of farms in case study 6*

| Characteristics | Ecological | Reference |
|---|---|---|
| State | Pondicherry | Pondicherry |
| Total holdings size (ha) | 1.8 | 2.6 |
| Area studied (ha) | 1.6 | 1.2 |
| Total different number of crops | 6 | 3 |
| % of studied area irrigated | 0 | 37 |
| Main crops (area wise) | Pearl millet<br>Groundnuts | Pearl millet<br>Groundnuts |
| Main livestock (no. wise) | Bullocks<br>Cows | Cows |
| Residence | On-farm | Off-farm |

higher priority than on the reference farm. The gross income per ha of the crop activities is also higher on the ecological farm mainly due to a higher cropping intensity. The two similar crops (groundnut and millet) show both a higher yield on the reference farm: groundnut 750 kg/ha versus 1 000 kg/ha; millet 100 kg/ha versus 250 kg/ha. The reference farm operates mainly at subsistence level, while more than 60% of the gross income at the

*Table 3.16 Main production characteristics in 1989/1990 season of farms in case study 6*

| | Ecological | Reference |
|---|---|---|
| Gross income/ha (Rp) | 9 643 | 2 117 |
| % crop activities | 30 | 79 |
| % sold | 63 | 5 |
| Variable costs/ha (Rp) | 8 744 | 2 545 |
| Gross margin/ha (Rp) | 899 | -428 |
| Labourdays/ha | 149 | 176 |
| % female | 64 | 72 |
| % hired | 92 | 70 |
| Net farm income/labourday (Rp) | 5 | 2 |
| Off-farm income (Rp) | 12 120 | 370 |
| % cash of total costs | 42 | 55 |
| Total assets/ha (excl trees,Rp) | 29 813 | 37 019 |
| Trees/ha | 349 | 19 |
| External nutrients/ha (kg NPK) | 151 | 134 |
| External nutrient dependency | 34 | 66 |
| Nutrient-balance at farmgate | | |
| Nitrogen (kg N/ha) | + 80 | + 60 |
| Phosphate (kg P/ha) | + 1 | + 11 |
| Potash (kg K/ha) | + 31 | + 25 |

ecological farm is sold. The variable costs per ha are also much higher on the ecological farm , mainly due to concentrates and fodder for the livestock (71% of the variable costs). The variable costs for the crop activities are comparable, whereby the savings on fertilizer and pesticides are compensated by higher labour costs. The gross margin per ha is very low on both farms and even negative on the reference farm. The labour-input per ha shows little difference, whereby especially on the ecological farm most of the labour is hired. This is logical due to the off-farm activity of the ecological farmer (reflected in the difference in off-farm income). The percentage of female labour is slightly higher on the reference farm. The asset position of the reference farm is slightly better than the ecological farm. A large difference between the number of trees per ha is notified. External nutrient dependency and the cash-part in the total costs is higher on the reference farm. Both farms have a positive nutrient balance for N, P and K.

3.2.2.7 Case study 7

The farmers of the farms in this case study both have their main activity outside the farm. Both have engaged a permanent labourer for the farm operations. The farms have a similar cropping pattern with banana, paddy, sorghum and coconuts in sole cropping systems. Both have possibilities for irrigating all the area (table 3.17). The ecological farm has no livestock while on the reference farm two bullocks are present.

*Table 3.17 Characteristics of farms in case study 7*

| Characteristics | Ecological | Reference |
|---|---|---|
| State | Tamil Nadu | Tamil Nadu |
| Total holdings size (ha) | 2.0 | 2.6 |
| Area studied (ha) | 2.0 | 2.6 |
| Total number of different crops | 3 | 3 |
| % of studied area irrigated | 100 | 100 |
| Main crops (area wise) | Paddy<br>Banana | Paddy<br>Banana |
| Main livestock (no. wise) | - | Bullocks |
| Residence | Off-farm | Off-farm |

The gross income per ha of both farms is comparable (table 3.18). Banana accounts for the largest part of the income (67% of the gross income on both farms), with paddy as the second important crop. The average paddy yield is also comparable with 3 650 kg/ha on the ecological and 3 880 kg/ha on the reference farm. The variable costs per ha are slightly higher on the reference

farm, mainly due to higher costs for manure and fertilizer. On both farms much labour per ha is used, with the highest labour input on the reference farm (130 labourdays/ha more than on the reference farm). The net-farm-income per labourday is therefore higher on the ecological farm: Rp 63 versus Rp 45. The total net-farm-income however is 20% higher on the reference farm. Almost all costs are actual cash-costs on both farms. The number of trees per ha is only slightly higher on the ecological farm.

*Table 3.18 Main production characteristics in 1989/1990 season of farms in case study 7*

| | Ecological | Reference |
|---|---|---|
| Gross income/ha (Rp) | 33 529 | 35 875 |
| % crop activities | 100 | 100 |
| % sold | 86 | 75 |
| Variable costs/ha (Rp) | 12 912 | 16 711 |
| Gross margin/ha (Rp) | 20 617 | 19 164 |
| Labourdays/ha | 435 | 565 |
| % female | 49 | 59 |
| % hired | 100 | 100 |
| Net-farm-income (Rp) | 39 018 | 46 665 |
| Net farm income/labourday (Rp) | 63 | 45 |
| Off-farm income (Rp) | 24 000 | 33 500 |
| % cash of total costs | 93 | 100 |
| Total assets/ha (excl trees,Rp) | 118 360 | 100 000 |
| Trees/ha | 54 | 46 |
| External nutrients/ha (kg NPK) | 193 | 371 |
| External nutrient dependency | 100 | 100 |
| Nutrient-balance at farmgate | | |
| Nitrogen (kg N/ha) | + 34 | +129 |
| Phosphate (kg P/ha) | + 6 | + 33 |
| Potash (kg K/ha) | + 52 | + 74 |

All nutrients for the crop activities come from outside the farm. The total use of nutrients is much higher on the reference farm compared to the ecological farm. Both farms have a positive nutrient-balance for N, P and K. The reference farm however has a much higher surplus than the ecological farm.

### 3.2.3 General comparison of ecological and conventional agriculture

#### 3.2.3.1 Introduction

Although the emphasis in this study is placed on the individual case studies it is tried in this chapter to analyze a num-

ber of aspects and results of the two farming systems in general. The basis for this analysis is formed by the seven individual case studies. As much as possible the average figures from the case studies are compared to secondary data. However, the number of available and useful secondary data appeared to be limited. The analysis of the agronomic aspects is followed by an economic analysis of the two studied management systems. Hereafter relations between the studied factors are examined. Finally an agronomic analysis at crop level for two studied crops is presented.

### 3.2.3.2 Comparison of agronomic aspects of ecological and conventional farming

In table 3.19 the averages of most of the essential keyfigures determining the agronomic aspects of the studied farming systems are presented.

*Table 3.19 Averages and standard deviations of a number of agronomic keyfigures of ecological and their reference farms*

| | Ecological | | Reference | | t-test a) |
|---|---|---|---|---|---|
| | av. | st.dev. | av. | st.dev. | |
| Holding size (ha) c) | 3.1 | 0.8 | 2.2 | 0.6 | s |
| Irrigated (%) | 75 | 35 | 73 | 27 | ns |
| Different crops per farm | 9.4 | 4.2 | 7.0 | 3.0 | s |
| Part total gross income from crop activities (%) | 73 | 24 | 94 | 7 | s |
| Total Life Weight Units (LWU) b) | 6.0 | 3.9 | 2.8 | 2.4 | s |
| Number of trees/ha | 217 | 167 | 32 | 18 | s |
| Total external nutrients per ha (kg NPK) | 133 | 68 | 203 | 117 | ns |
| External nutrient dependency of crop activities (%) | 42 | 28 | 65 | 17 | s |
| Soil fertility improvement techniques per farm | 4.6 | 1.8 | 3.1 | 1.0 | s |
| Plant diversity techniques per farm | 4.1 | 1.8 | 1.7 | 1.2 | s |

a) t-test at 90% reliability level; b) 1 LWU = 250 kg; c) Excluding case study 4.

The average holding size of the ecological farms exceeds the holding size of the reference farms (in this calculation case

study 4 is dropped because of the extreme holding size of the ecological farm). Both are considerably higher than the state average holding size of 1.0 ha in Tamil Nadu and Pondicherry. No difference is found in the portion of irrigated area. On the ecological farms more different crops per farm are cultivated compared to the reference farms. In ecological farm management livestock activities play an essential role. Among others this is expressed in the percentage of the gross income which is derived from crop activities. On the ecological farms 73% comes from crop activities and 27% from livestock activities. On the conventional farms these percentages are respectively 94% from crops and only 6% from livestock activities. The average number of life weight units per farm is therefore higher on the ecological farms. On the conventional farms also a higher portion of the LWU's are coming from traction animals (88% versus 63%). Also the composition of the crops grown shows a difference. In table 3.20 the average land use per group of crops is presented for ecological and reference farms, including a comparison with state averages in Tamil Nadu. The main difference is found between pulses, vegetables and fodder crops. Pulses and fodder crops have a much more predominant position in the cropping system of ecological farms compared to the reference farms. On the other hand vegetables are very important in the cropping system of the reference farms. Also compared to the state average a higher percentage of pulses in the cropping system of ecological farms can be found.

*Table 3.20 Comparison of average land use per group of crops as percentage of gross cropped area on ecological farms, reference farms and Tamil Nadu state averages (1988-1989)*

| Crop group | Area (%) | | | |
|---|---|---|---|---|
| | Eco | Ref | Tamil Nadu | |
| Grains | 43 | 40 | 59 | |
| Tubers | 2 | 1 | - | |
| Pulses | 12 | 2 | 9 | |
| Oil crops | 18 | 19 | 14 | |
| Vegetables | 6 | 25 | 1 | |
| Other crops | 15 | 13 | 17 | *) |
| Fodder | 4 | - | - | |
| Total | 100 | 100 | 100 | |

*) Includes tubers, fodder and other crops.

One of the main differences in the two compared management techniques is the number of trees present on the farm. On the ecological farms on the average 217 trees per ha were counted against only 32 per ha on the conventional farms (table 3.19). On the ecological farms more tree-crops are part of the cropping pattern, but also around the farm much more trees are grown on bunds. Many of these trees produce green manure and are Nitrogen fixing.

All the incoming nutrients at farm gate are calculated from the incoming fertilizers, manure, fodder, concentrates etc. The result is a slightly higher (but not statistically significant) amount of total external nutrients imported on the conventional farms compared to the ecological farms. When also the output of nutrients is taken into consideration an estimate of the nutrient balance at farm gate can be given (table 3.21).

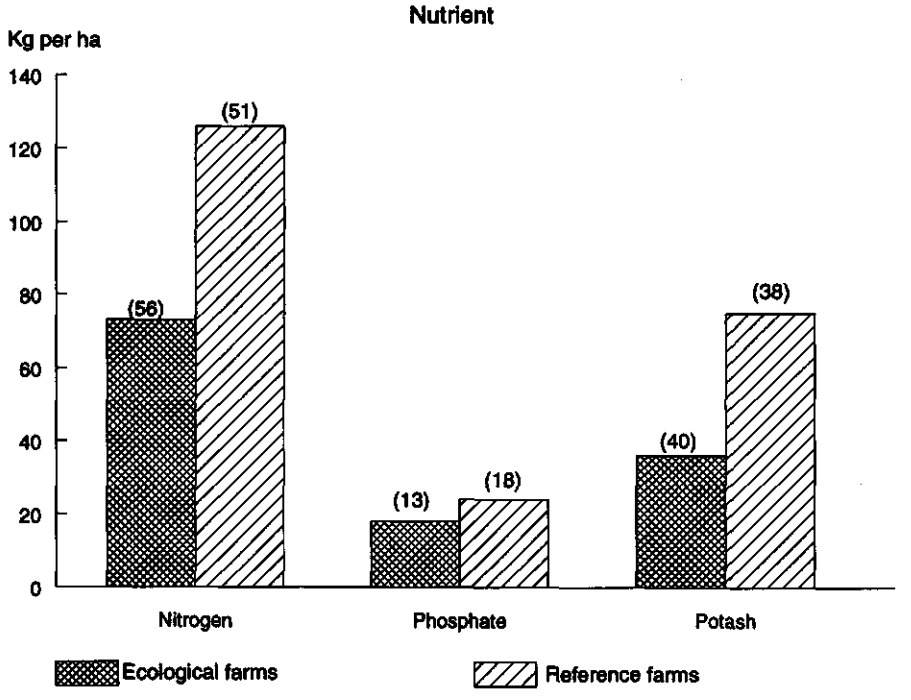
*Table 3.21 Average nutrient balance of 7 case studies at farm gate for N, P and K in kg per ha per year (total input minus total output)*

| Nutrients | Ecological farm | | Reference farm | |
|---|---|---|---|---|
| | kg. | st.dev. | kg. | st.dev. |
| Nitrogen | 50 | 38 | 76 | 48 |
| Phosphate | 6 | 8 | 16 | 11 |
| Potash | 21 | 20 | 24 | 23 |

Almost all farms maintain a positive nutrient balance for the three nutrients, but the standard deviation indicates a huge variation between the farms studied. Although statistically not significant, the average excess of all the three nutrients is higher on the reference farms. In these figures losses through leaching and volatilisation are not taken into account. Since the majority of the nutrient-inputs on conventional farms comes from fertilizers it is expected that losses on these farms will be higher.

That livestock plays a more important role on ecological farms is also expressed in the significant difference which is found in the portion of external inputs for crop activities. On the conventional farms 65% of the nutrients are from external sources, while on the ecological farms only 42% of the nutrients come from outside. The break down of these percentages for N, P and K on the ecological farm show little variation: 40%, 45% and 42% respectively. On the reference farm the percentages for N and P are considerably higher than for K (71%, 72% and 53% respectively). External nutrients on reference farms consist for

a little more than two-thirds out of chemical fertilizers (for N, P and K this is respectively 27%, 25% and 40%). Also the absolute average nutrient inputs for crop activities is higher on the reference farm compared to the ecological farms, especially for nitrogen and potash (figure 3.2).




* between brackets the standard deviation

*Figure 3.2 Average nutrient input in kg per ha of N, P and K for cropping activities on ecological and reference farms*

In ecological farms the nitrogen flow into the farm is more or less equally distributed among N-fixing crops, livestock and organic material from the market. In the reference farm most of the nitrogen comes in through fertilizers.

The number of different techniques used to improve the soil fertility is significantly higher on the ecological farms. In figure 3.2 the frequency on the studied farms of the distinguished techniques is presented.

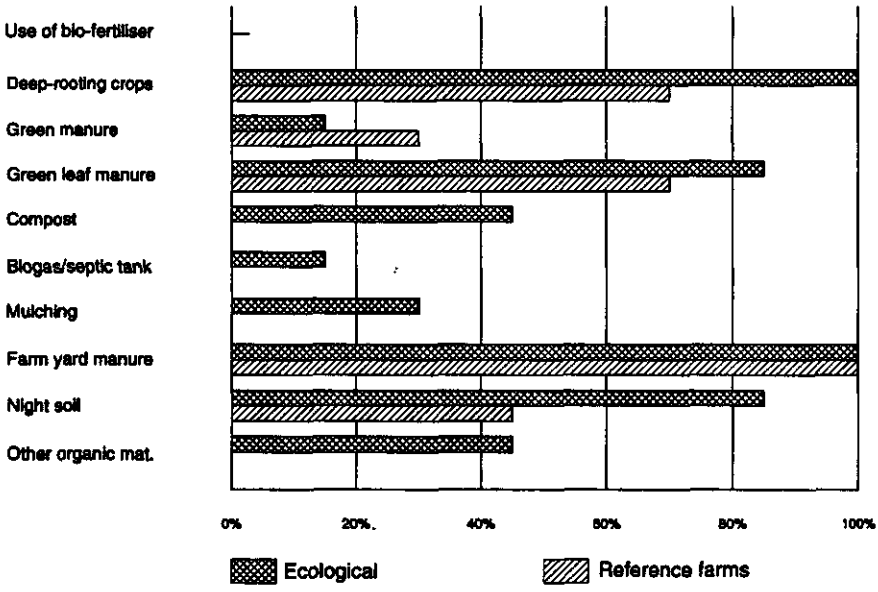



*Figure 3.3 Comparison of percentages of farms practising techniques for soil fertility maintenance for ecological and reference farms*

From figure 3.3 it appears that making use of deep-rooting crops, farm yard manure and green leaf manure is common on ecological as well as conventional farms. Compost, mulching and use of other organic materials is specifically practised on ecological farms.

The differences in techniques used to create plant diversity between the ecological and conventional farms are even greater, basically because a greater plant diversity is one of the main characteristics of ecological agriculture.

In figure 3.4 the frequency of the occurrence of the distinguished techniques is presented. Mixed/intercropping, agro-forestry and hedges/shelterbelts can be found in all farms, but is more frequently used in ecological farm management. Multi-storey cropping, selective weeding, use of cover crops and tree nurseries are only found on ecological farms.

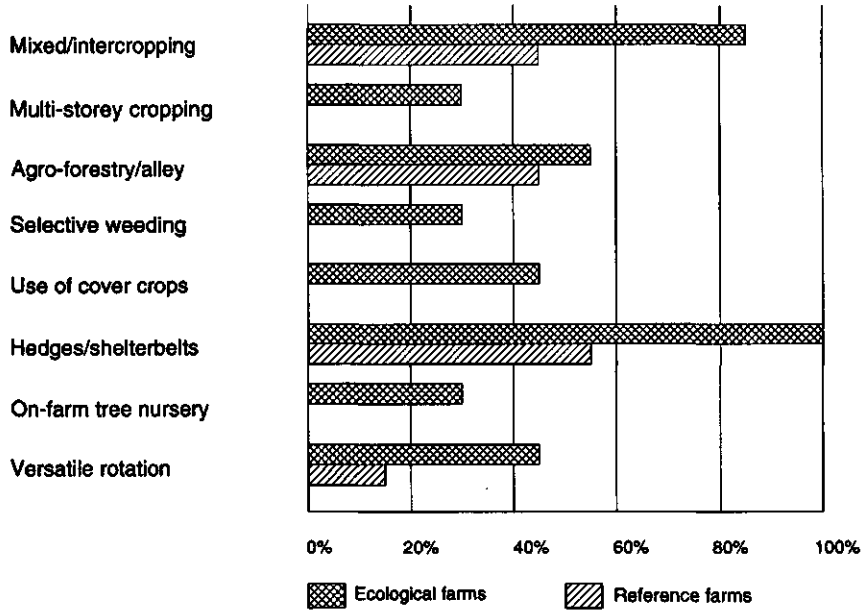



*Figure 3.4 Comparison of percentages of farms practising techniques for creating plant diversity for ecological and reference farms (%)*

### 3.2.3.3 Comparison of economic aspects of ecological and conventional agriculture

In table 3.22 a summary of the most important economic keyfigures are presented.

The overall economic results of the farms studied in the season 1989-1990 show a high variation and no significant difference between ecological and reference farms. Also the total number of labourdays per ha, the assets per ha and the off farm income show no significant difference. However the average off-farm income on the ecological farms is twice that of the reference farms. The percentage of total produce sold also gives no significant difference, indicating there is no general difference in market-orientedness of ecological and conventional farms. The only significant difference is found in the cash component of the total costs. On the reference farms 67% of the total costs consists of cash costs, while on ecological farms this is only 49%. This is caused by the decreased use of external inputs on ecological farms. A number of ecological farmers also expressed that the reduced need of cash was an important motivation to shift to

*Table 3.22 Averages and standard errors of a number of economic keyfigures of ecological and reference farms *)*

| | Ecological | | Reference | | t-test |
|---|---|---|---|---|---|
| | av. | st.dev. | av. | st.dev. | |
| Gross income per ha (Rp) | 20430 | 16700 | 18340 | 15100 | ns |
| Variable costs per ha (Rp) | 9810 | 8300 | 6830 | 4800 | ns |
| Gross margin per ha (Rp) | 10620 | 9050 | 11515 | 11900 | ns |
| Net farm income per labourday (Rp) | 32 | 18 | 32 | 21 | ns |
| Labourdays per ha | 346 | 193 | 333 | 142 | ns |
| Percentage of produce sold | 57 | 16 | 52 | 31 | ns |
| Cash part of total costs (%) | 49 | 23 | 67 | 18 | ns |
| Assets per ha (Rp) *) | 85480 | 38700 | 80000 | 26400 | ns |
| Net cash income per ha (Rp) | 7600 | 9350 | 6480 | 7850 | ns |
| Off-farm income per farm (Rp) | 15660 | 14700 | 6950 | 11200 | ns |

*) Assets calculated over total holding size.

ecological farming practices. The total net cash-income per ha, shows no significant difference. Since the average holding size of ecological farms exceeds the holding size of reference farms it can be concluded that the total net farm income on ecological farms will be higher than of the reference farm. The net farm income per labourday however shows no significant difference.

Since not all the farms have been studied completely a whole-farm-analysis is not possible. However in order to give an estimation of the situation at farm level, the studied area is assumed to be the total holding size in the following analysis of the net-farm-income and the cash income.

The average net-farm-income and cash-income is higher for the ecological farms, but due to the extremely high variation both differences are not statistically significant. Again a time series of results per farm over a number of years will give more information than an average over farms with so many different characteristics.

The economic results of the crop activities alone also show no significant difference. The average gross income per ha on ecological farms amounts to Rp 16 650, with an average gross margin of Rp 9 090. For the reference farms these figures are respectively Rp 17 380 and Rp 11 190. There is however a difference in the composition of the variable costs (table 3.24).

*Table 3.23 Estimated net-farm-income and cash income (Rp) per farm in the 7 case studies for ecological and reference farms (in 1990 Rs 16.50 = USD $ 1.-)*

| Case study | Net-farm-income | | Cash income | |
|---|---|---|---|---|
| | Eco | Ref | Eco | Ref |
| 1 | 68 142 | 30 727 | 81 420 | 25 989 |
| 2 | 7 168 | 3 796 | 4 896 | 659 |
| 3 | 6 051 | 11 066 | 5 560 | 9 493 |
| 4 | 12 040 | 20 084 | - 594 | 29 045 |
| 5 | 3 928 | -1 026 | 7 100 | 500 |
| 6 | -1 702 | -1 886 | 2 577 | -1 626 |
| 7 | 39 018 | 46 665 | 29 786 | 18 773 |
| Av | 19 235 | 15 632 | 18 678 | 11 833 |
| Std | 23 382 | 16 716 | 27 220 | 11 860 |

Seeds, manure and other costs show similar amounts per ha. The costs of wages and hired mechanical and animal labour are higher on the ecological farms. The use of manure is comparable, but adding the costs of fertilizer on the reference farm the total costs for fertilizing the soil are considerably higher on the reference farm. Here again it can be concluded that the nutrient input on reference farms is considerably higher than on ecological farms. The costs of pesticides on the reference farms make out 5% of the variable costs and approximately 3.5% of the total costs.

*Table 3.24 Breakdown of variable costs per ha (Rp) for crop activities on ecological and reference farms*

| | Ecological | | Reference | |
|---|---|---|---|---|
| | Rp. | % | Rp. | % |
| Seeds | 826 | 17 | 807 | 14 |
| Manure | 1 166 | 24 | 950 | 17 |
| Fertilizer | 0 | 0 | 1 004 | 18 |
| Pesticides | 0 | 0 | 260 | 5 |
| Wages paid, hired mechanical and animal labour | 2 721 | 55 | 2 383 | 43 |
| Others | 192 | 4 | 188 | 3 |
| Total | 4 905 | 100 | 5 592 | 100 |

*) Excluding case study 1 because of inaccurate breakdown of costs.

In chapter 3.2.2.2 is already mentioned that on ecological farms a higher portion of the gross income comes from livestock activities. More livestock is present, but also more animals are kept for production of milk, eggs and meat. The last aspect results in a higher gross income per Live Weight Unit (LWU) and also a higher gross margin per LWU on the ecological farms compared to the reference farms. There most of the animals are kept for traction purposes. On the ecological farms the gross income per LWU amounts to Rp 1 615 and the gross margin per LWU to 590. For the reference farms these figures amount to Rp 841 and Rp 335 respectively.

In table 3.25 a breakdown of the labour-input into categories is presented for the two groups of farms. Farmpair 1 has been excluded from this breakdown because of the extremely high labourinput per ha on this farmpair for silk-worm-cocoon production. The breakdown shows no great differences between the two farming systems. The higher labourinput for weeding and harvesting on the reference farms is remarkable. It is likely that these differences to a great extent occur due to the large variation in cropping patterns on the studied farms.

*Table 3.25 Average labourdays per ha per year according to type of activity of ecological and reference farms*

| Categories | Ecological | | Reference | |
|---|---|---|---|---|
| | Days | % | Days | % |
| Ploughing/levelling | 51 | 18 | 43 | 14 |
| Sowing | 18 | 6 | 14 | 5 |
| Manure/fertilizer applic. | 23 | 8 | 18 | 6 |
| Pest control | 0 | 0 | 2 | 1 |
| Irrigation | 38 | 13 | 38 | 13 |
| Transplantation | 23 | 8 | 20 | 7 |
| Weeding | 50 | 17 | 60 | 20 |
| Harvesting | 45 | 17 | 73 | 23 |
| Transport/bagging | 10 | 3 | 5 | 2 |
| Others | 28 | 10 | 27 | 9 |
| Total | 286 | 100 | 300 | 100 |

*) Excluding farm-pair 1.

It has been stated already that the average number of labourdays per ha show no significant difference between ecological and reference farms. However since the average holding size of ecological farms tends to be higher, the total labour requirements for ecological farms will also be considerably higher.

Using the average areas studied (2.5 ha on the ecological farm versus 2.0 ha on the reference farm) the total labour need on the ecological farm amounts to 715 labourdays per year against 600 labourdays for the reference farms. In this calculation the average holding size is not used as calculation basis as the areas not studied are mainly extensively cultivated.

In table 3.26 the source of labour according to sex and type is given for the two management systems.

*Table 3.26 Composition of total labour (%) according to sex and to type (family or hired) on ecological and reference farms*

| Categories | Ecological | Reference |
|---|---|---|
| Female | 47 | 57 |
| Male | 53 | 43 |
| Family | 25 | 38 |
| Hired | 75 | 62 |

On the reference farms the proportion of female labour is higher than on the ecological farms. On the ecological farms a higher portion of the labour is hired from outside. That is in agreement with earlier findings that ecological farmers have in general more other sources of income compared to reference farmers.

An interesting aspect is the sexual division of labour over the labour categories. It appears no differences exist between ecological and reference farms. Apparently the type of farming system has no influence on the division of tasks between male and female. In figure 3.5 the average sexual division of labour categories for all farms studied is given.

It appears that manure/fertilizer application, transplantation, weeding and harvesting are mainly female tasks. Land preparation, pest control, irrigation and transportation are mainly tasks for the male. In figure 3.6 the average labourfilms of the ecological and reference farm are presented. It appears that the labourfilm through the year takes a similar shape for ecological as well for reference farms. With peaks in July and August (weeding and harvesting at the same time) and a low period in May. The absolute labour need per farm is higher on the ecological farm, due to the larger area cultivated.

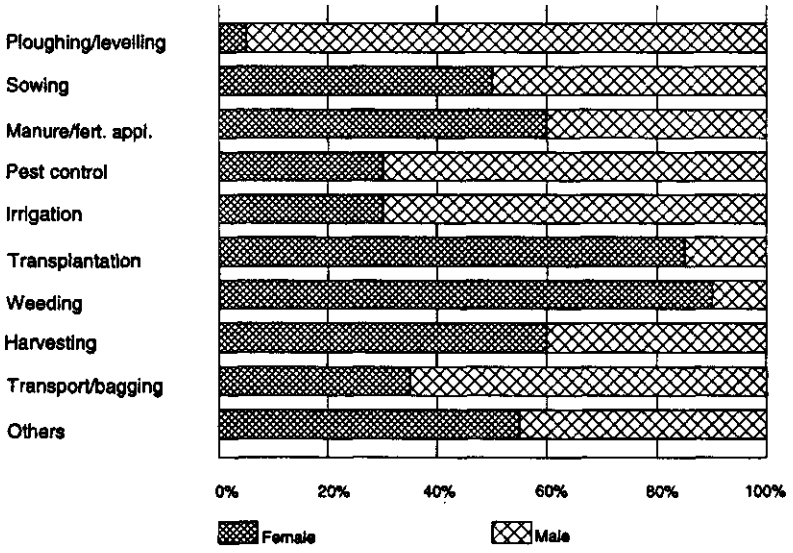



*Figure 3.5 Average percentage of female and male labour per labour categories for ecological and reference farms together.*

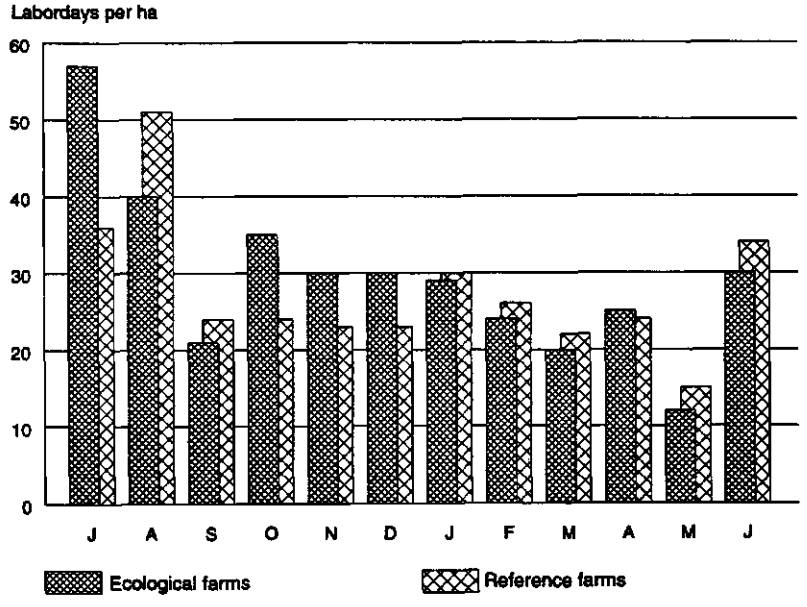



*Figure 3.6 Average labour film of ecological and reference farms in labourdays per ha*

### 3.2.3.4 Relations between factors studied

In order to discover possible relations between the most important keyfigures a correlation matrix is constructed with correlation coefficients. In annex 6 this correlation matrix is presented.

From this correlation matrix it appears that the net-farm-income per ha is positively correlated with the following factors:

- gross-income per ha (0.96)
- variable costs per ha (0.76)
- percentage of produce sold (0.66)
- assets per ha (0.56)
- labourdays per ha (0.82)
- external nutrients per ha (0.57)

A high gross income per ha, but also high variable costs per ha, high labour-input per ha (intensive production) correlate with a high net-farm-income per ha. A weak positive correlation is found between the assets per ha and the external nutrients used per ha.

None of the other keyfigures show a significant correlation with the net-farm-income.

Many of the other significant correlations between factors studied are logical consequences of the earlier discussed differences between ecological and reference farms. For instance the negative correlation found between the number of trees per ha and the percentage cash costs (-0.66) is a result of significant different characteristics of ecological and reference farms eg. a higher number of trees per ha and lower cash expenses on the ecological farms compared to the reference farms.

It was expected to find a negative correlation between the number of soil fertility techniques used and the number of plant diversity techniques applied on one side and the external nutrient dependency for crop activities on the other side. From the matrix it can be seen that indeed a negative relation exists, but that the correlation is rather low: -0.47 and -0.35 respectively.

### 3.2.3.5 Analysis at crop level

It was planned to make an thorough agronomic and economic analysis for a number of comparable crops or cropping systems in ecological and conventional farms. However, since not all data at crop level have been collected properly and the agronomic analysis of AME and the economic analysis of ICSIM are not completely compatible (chapter 4.2) only a very limited agronomic analysis at crop level can be executed, whereas the data for an economic analysis were not available at all.

In the agronomic analysis one main crop in every case-study has been studied on as well the ecological as the reference farm. In 5 cases sole paddy was studied and in 2 cases groundnuts.

*Table 3.27 Average yield (kg/ha), average input of N,P and K (kg/ha) and average nutrient balance at field border for N,P and K (kg/ha) for paddy on 5 ecological and reference farms.*

| | Ecological | | Reference | |
|---|---|---|---|---|
| | kg/ha | st. dev. | kg/ha | st.dev. |
| Yield | 4 822 | 2 124 | 3 953 | 2 152 |
| N-input *) | 59.6 | 34 | 93.2 | 44 |
| P-input | 9.4 | 3 | 22.0 | 10 |
| K-input | 43.3 | 27 | 45.0 | 28 |
| N-balance | -68.0 | 68 | -10.1 | 76 |
| P-balance | - 7.2 | 8 | + 8.3 | 15 |
| K-balance | -60.3 | 60 | -46.2 | 57 |

*) Including estimated N-fixation from leguminous crops.

Given the huge variation in yield figures, no significant difference between the paddy yield can be found. As has been stated before, also the method of yield measurement has been too inaccurate to arrive at reliable figures. The N- and P-input per ha is significantly higher on the reference farm compared to the ecological farms. The majority of the inputs on the reference farms is coming from fertilizers: 80% of the N-input, 82% of the P-input and 65% of the K-input. On the ecological farms all of the inputs are coming from organic manure and N-fixation. Apparently the higher nutrient-input for the reference farms is not translated into a higher output. However, more accurate studies are required to draw definite conclusions.

Except for P on the reference farm, negative nutrient-balances are found for N, P and K. On the ecological farms the balances at field border tend to be more negative than on the reference farm. However, losses through volatilization (of Nitrogen) and leaching, which are more when using fertilizer compared to organic manures, are not taken into account. Furthermore, effects of internal recycling are not included in this study. On top of this it has to be mentioned that the long-term positive effects of organic manure above chemical fertilizers (e.g soil structure, micro nutrients) can not be measured within one year of research. The combination of these three effects may be seen as expressed in the differences in yield levels between ecological and refer-

ence rice cultivation. However, this can only be evaluated after several years of research.

In table 3.28 for a number of sole crops the yield figures of the ecological and reference farms are compared with the district and state averages in that season.

*Table 3.28 Average yields (kg/ha) of a number of crops in 1989-1990 season in ecological farms, reference farms and in Karnataka state*

| Crop | Ecological | | Reference | | State |
|---|---|---|---|---|---|
| | kg/ha | farms | kg/ha | farms | |
| Paddy | 4 822 | 5 | 3 953 | 5 | 1 786 |
| Groundnut | 640 | 3 | 1 019 | 5 | 749 |
| Finger millet | 2 000 | 1 | 2 594 | 3 | 1 048 |
| Pearl millet | 730 | 3 | 250 | 1 | 565 |
| Sorghum | 845 | 3 | 560 | 1 | 677 |

This figures only give an indication of the yield levels compared to state and district levels. Interpretation of these figures is extremely difficult, because the status of the district and state figures is not clear and because the averages for the studied farms are based on very limited number of farms.

# 4. EVALUATION OF METHODOLOGY

## 4.1 Transition research

Twelve ecological farmers were interviewed on their experiences in conversion of their farm from conventional or traditional to a stabilized ecological farming system. These transition experiences were collected and analyzed. The method used gives the strengths as well as weaknesses of the study. It is an exploratory research, in which experiences were not analyzed statistically, but by the farmers themselves. However, to our knowledge this is one of the first times in a tropical setting that actual field level experiences on transition were collected, documented in detailed case descriptions and analyzed.

At the start of the transition research only the first stage was planned. Following stages were developed during implementation through a repeated cycle of collection, processing, analysis and checking of data. This approach proved to be an effective working methodology as it gave the opportunity to review the work done regularly and to check the researchers' findings, analyses and conclusions regularly with the farmers. Simultaneously the working method could be evaluated continuously and adapted as and when necessary.

Future research on transition should devote special attention to the translation of the results in sound policy advice for decision makers as well as direct advice for farmers. For the farmers involved, one of the most interesting parts of the research was the meeting in which they could exchange experiences, it would definitely be worthwhile to develop this further. Another possible research benefit for the farmers can be to receive a number of copies of their farm description (in English and local language), since many of them are confronted with an increasing number of visitors. Publication of an article describing interesting farming practices in a local newspaper can be an important stimulus and reward for the farmer involved.

## 4.2 Comparative agro-economic research

The case-study approach with a monthly round of data collection is giving a detailed and accurate insight in the existing farming system. The enthusiastic co-operation of the participating farmers has proven to be essential in this approach. The comparison however with conventional agriculture through selection of reference farms and through comparison with secondary data still needs improvement. Not always a satisfactory reference farm could be found, matching the ecological farm sufficiently. Also the cropping patterns of the farms show enormous differences (many different mixed cropping activities), resulting in limited

possibilities of comparisons at crop level. The already mentioned managerial influences also are a serious limitation in the methodology used. The survey should therefore be supported by simple experiments of a number of similar activities on the ecological and reference farm. This can improve the analysis at crop level, increase the accuracy of some of the data and may help to eliminate the managerial influence on the results to some extend. This will result in a combined approach of a regular survey of a limited size and an on-farm-research programme. At this point an evaluation of the methodology in relation to the determination of the economical and ecological sustainability of a farming system over a number of years is not yet possible.

Based on the experiences with this methodology in the first year a number of improvements are proposed:

- Many problems occurred with crops not having a full cropping cycle within the study period. It is therefore necessary to include stocks and standing crops in the balance at the begin and the end of the study period.
- Although farmer participation in the research is already high, a greater involvement of the total farm household in the research is required. Since the data collection is to be continued over a number of years a simple system should be designed in order to enable farm households to record data themselves. This is already implemented in the second year of research.
- The variation between the ecological farms in cropping pattern and social circumstances is enormous. This seriously limits the possibilities of a general analysis of ecological agriculture and extrapolation of the results. Whenever a more homogeneous group of ecological farms can be identified these should be considered for studying.
- Since yield is an essential factor in the agronomic and economic viability of a farming system the yield estimation of the farm households must be checked with actual yield measurements.
- In a number of case-studies not the complete farm but only one or two plots have been studied for various reasons. This has created serious problems in the analysis. In the second year of data collection only the complete holdings are studied.
- Further development of a methodology for measurement of ecological sustainability based on the use of a set of easily measurable indicators.
- Preferably one organization should execute the research. The experiences with two executing agencies prove that despite regular meetings the results of the two analyses (agronomic and economic) are not fully compatible.

# 5. CONCLUSIONS

## 5.1 Transition research

The main reasons for transition can be found in environment/sustainability aspects as well as health and food quality. It is striking to note that in this research all but one farmer mentioned at least one reason for transition which can be classified as ideological (environment/sustainability or philosophy). Wernick and Lockeretz (1977) and Blobaum (1984) doing similar research in the United States had only about one third of their respondents mentioning ideological concern as factor in the decision to convert to organic practices.

### 5.1.1 The transition process

None of the farms opted for a 'parcel by parcel' transition. Although this possibility seems to be most advisable (Macrae, 1990), specially for farmers working in uncertain situations (lack of information, no assured market), it is also hardly used in the West. A possible explanation for farmers not doing so, could be that once farmers are convinced they should change their farming system they prefer starting new practices, even only very gradual, above continuing the 'old' methods in any part of their farm. A gradual change over the total farm proved to be preferred.

In the cases where the original farming system was close to the traditional one (having only a limited use of external inputs) one can hardly speak of a process of conversion. The changes intended could be introduced within one year.

In the other cases farmers really went through a distinct period of accelerated change. An average transition took three to five years, comparable to the three to six years as mentioned by Macrae et al (1990) for temperate zones. In situations where the original applications of fertilizer and pesticides are high it might take seven years to complete a transition without major negative effects on farm income. When high fertilizer applications were dropped at once, this resulted in serious yield decreases at the start of the transition. In these cases farmers were economically forced to switch back to the use of fertilizer and opt for a gradual decrease only (cases 6 and 7). Madden (1984) and Liebhart and Culik (1986) mention American farmers having similar problems when opting for a 'cold turkey' transition, e.g. resulting in 40% yield reduction in maize. In tea cultivation in South-India, yield decreases of 21 to 33% were experienced in the first year of transition from conventional (240 to 300 kg fertilizer N/ha/year) to organic cultivation (Werf, 1990B).

### 5.1.2 Agricultural changes implemented

The main changes implemented were in soil fertility and pest and disease management. Practically, farmers focused on decreasing application of pesticides and fertilizer, increasing cultivation of perennial and leguminous crops and intensified application of organic manure. Specific problems lie in production of sufficient organic material on the farm and lack of knowledge on alternative pest control measures.

The importance given to increasing the number of perennial crops and trees is remarkably different from the European and North-American experiences. However, this is fully in line with the natural tendency in tropical ecosystems of accumulation and retention of nutrients in living tissues. In most of the European and North-American transition approaches rotation adjustment plays a major role (Dabbert 1986; Patriquin 1986; Kirschenmann 1988; Andrews, Peters and Janke 1990), in contrast to the results of this research. Only Zeelenberg (1989) and Andrew (1987) take soil and fertility as a starting point. Maybe this difference can be explained by the fact that the rotations as practised in South-India have not been changed as much as in the West through the introduction of chemical fertilizers and pesticides. Therefore, it is still possible to maintain soil fertility by natural means under current crop rotations, which can not be done anymore under the intensive conventional crop rotations in the West.

Other groups of changes implemented by the farmers included crop management (increasing leguminous, perennial and fodder crops), livestock management (increasing the number of livestock, improving urine and manure collection) and erosion control (increasing vegetative cover as well as mechanical measures).

Dabbert and Madden (1988) distinguish five effects influencing transition in the United States; rotation adjustment, biological transition, prices, learning and perennial development. The relative importance of these effects on transition in South-India is quite different from the experiences in Europe and North-America.

Rotation adjustment was practised in some cases but of minor importance only. Biological transition was the main agro-technical effect. Where high levels of fertilizer were applied, these had to be reduced very gradually to prevent considerable yield decreases. Development of balanced insect populations is another major aspect for which sufficient time is needed. The price effect was non-existent as products were used for home consumption or sold in conventional markets at regular prices. A specialized market for organic products does not yet exist in India. Learning was a main effect too, prolonging the transition much beyond what was agro-technically necessary. The perennial effect was mainly based on the increasing importance of perennial crops and trees. Concluding, it can be stated that learning and biological transition were the main factors determining the length

of the transition period, followed at some distance by the perennial effect. Rotation adjustment hardly played a role and the price effect was of no importance.

### 5.1.3 Farmer characteristics

Essential farmer characteristics for a successful transition were innovativeness, financial freedom, family tradition in agriculture and residence on the farm. Residence on the farm proved to be crucial for a successful transition. A high degree of innovativeness, financial freedom and family tradition in agriculture directly shortened the transition period.

### 5.1.4 Methodology

The case study approach proved to be effective in identifying problem areas as well as studying methods farmers developed to overcome these problems.

Structuring of the research as an explorative one was suitable in the given circumstances. The repeated cycle of data collection, processing, analysis and checking proved to be efficient as well as effective. However, for new research to be undertaken in this field it would be better to design it in a more participatory way right from the beginning. In such a set up considerable attention will then have to be given to the (changing) role of women in the transition process.

### 5.1.5 Barriers and methods for success

The most important barrier to transition as experienced by the farmers was the lack of information on transition and ecological agriculture. Also by American organic farmers this is perceived as a serious barrier to transition (Blobaum, 1984). Therefore each farmer has to do the transition alone. This explains the strong influence of the farmer characteristics on the length and smoothness of the transition.

Key element of a successful transition is a gradual approach. Gradual in two ways, first by testing proposed changes in a small area before introducing at large, secondly by sequencing the implementation of different changes and not introducing all changes foreseen at once. The pace of nature is a good guideline; i.e. increase your livestock by reproduction instead of purchase, develop your fodder crops before increasing the livestock, etc.

The time needed for transition is largely determined by biological aspects (the biological transition and perennial development effect of Dabbert and Madden (1988)).

## 5.2 Agro-economic research

### 5.2.1 Agronomic aspects

Although conclusions have to be drawn with considerable care, a few remarks can be made concentrating around soil fertility and crop management.

From the analysis of soil fertility management a number of preliminary conclusions can be drawn. In ecological farming a greater number of different techniques for soil fertility maintenance is practised compared to reference farms. The use of compost, nightsoil, mulching and deep-rooting crops is distinctly more common on ecological farms. Thereby ecological farms use a wider and more diverse base of nutrient resources than the reference farms. Nutrient balance at farm gate is positive for both farming systems. The export of nutrients through the farm gate is smaller than the import of external nutrients (including nitrogen fixation). For the reference farms it is more positive than for the ecological farms.

However, losses through volatilization (of Nitrogen) and leaching, which are more when using fertilizer compared to organic manures, are not taken into account. Furthermore, effects of internal recycling are not included in this study. On top of this it has to be mentioned that the long-term positive effects of organic manure above chemical fertilizers (e.g soil structure, micro nutrients) can not be measured within one year of research.

Ecological farms are less dependant on external nutrients than reference farms, and have a lower input of nutrients for crop activities. In spite of this, comparable yields are realized. The most obvious explanation for this is that the lower nutrient inputs are more effectively used. On one side, by lesser losses caused by volatilisation and leaching, because of not using easily dissolvable nutrients but also through better management, e.g. improved compost production and application methods and more use of N-fixing species. On the other side, by a more effective and efficient use of nutrients through internal recycling, a more diversified cropping pattern and the use of a multitude of soil fertility maintenance and plant diversity techniques. This is further strengthened by the additional beneficial effects related to the use of organic manure.

Looking at the level of a single crop, in rice cultivation both farming systems have a negative nutrient balance at field border. The ecological farms even more so than the reference farms, due to a lower level of nutrients input and higher withdrawal figures. The three above mentioned reasons (volatilization/leaching, internal recycling and use of organic manures) may explain the higher production levels of the ecological rice cultivation. It has to be studied whether these production levels are sustainable.

Considering crop management the land use practices show a striking difference for the higher number of different crops cul-

tivated on ecological farms as compared to reference farms. The higher importance of pulses in ecological farms as compared to reference farms, can be explained from the ecological need for diversification and nitrogen-fixation. Techniques for creating plant diversity are far more practised in ecological than reference farms. This is specially striking for activities such as; mixed/inter cropping, use of cover crops, hedges/shelterbelts, multi-storey cropping, selective weeding, on-farm tree nurseries and versatile rotations. Large differences in cropping pattern between the case-studies occurred. One common difference is that pulses have a greater share in the cropping pattern of ecological farms compared to the reference farms. An interesting feature is the importance of trees on the ecological farms. Almost seven times more trees are found on the ecological farms than on the reference farms. Another significant difference is the lesser dependence of the ecological farming system on crop activities only. Through a considerable livestock component, crop residues can be put to use and improved options for nutrient recycling from crops to soil are established.

It is not possible to judge the agricultural sustainability of a farming system on the basis of one year of research only. Data available so far do not give a sufficient basis for judgement yet. Field observations indicate a generally more conscious soil fertility management in relation to practices at field level in ecological farming than in the reference farms. In either situation, farmers have only little awareness of nutrient contents of products used and nutrient balance. Thus, nutrient management is more a matter of feeling and observation. Continuation of the study over a number of years has to prove whether soil fertility is sustainable in either farming system. Better soil protection through increased vegetation and vegetative diversity is obvious in the ecological farms.

### 5.2.2 Economic aspects

The individual case-studies reveal considerable differences in economic performance between ecological and reference farms in the studied season. Also between the case studies large differences occur. A proper separate analysis of each of the case studies can only be done when data of more seasons become available. At this point a combined analysis of the seven case studies shows no significant differences in the most important economic key figures between ecological and reference farms. As could be expected with such a heterogeneous group a large variation between the farms in one group exists. Apart from differences in individual performance and skills of farmers also the cropping pattern and livestock composition of the farms in one group show an enormous variation. Despite these differences, a first global conclusion from this first year of study is that in South-India ecological farm management has at least the potential to achieve economic results comparable with conventional farming methods.

The total net-farm-income per labour day amounts to Rp 32 in both groups, which is high compared to the average price of labour in the area (Rp 15 per day for unskilled male labour). Since also the average holding size of the studied farms is considerably higher than the State average it may be concluded that the studied farms can be classified as a well-above average group of farmers in terms of skills and resources. Observations from the enumerators also confirm this conclusion.

Due to the decreased use of external inputs on ecological farms, some significant general differences in the cost structure at farm level are found. Most striking is the difference in the cash component of the total costs, which is approx. 50% on the ecological farm, compared to 67% on the reference farm. For a number of farmers this feature has been a reason for the transition to ecological farming. Also the composition of the variable costs differs, whereby on the ecological farms the costs of manure per ha (including calculated value of internal deliveries) are lower and the costs of labour per ha (including hired mechanization) are slightly higher compared to the reference farms. The labour input in labour days per ha however shows no significant difference between the two farming systems. Since the cultivated area on ecological farms is higher, the total labour input per farm is higher on the ecological farms. The labour-composition also shows considerable differences whereby the share of male labour and hired labour in the total labour input is higher on the ecological farms. The sexual division of tasks in relation to type of farmwork is equal on the two farming systems. The share of livestock in the total gross income is much higher on the ecological farms (27%) compared to the reference farms (only 6%).

No difference is found in the market-orientedness of the farms, in both groups approx. 55% of the total produce is sold. However enormous differences between the case studies occurred, with two farms at subsistence level (only 3-5% of the produce sold) and heavy market-oriented farms (85% of the produce sold). Large differences in cropping pattern occurred between the case-studies, having considerable influences on the economic performance. The average level of off-farm-income per farm on ecological farms is twice that of the reference farms. This may indicate that at this moment ecological farming in India is in its preliminary stage and that in general farmers with sufficient other sources of income are willing and are able to bear the risks involved in the process of transition and experimentation.

## 5.3 Extrapolations

### 5.3.1 Transition

Extrapolating the results of the transition research will have to be done with the necessary care. The case study approach

and the limited number of cases make it impossible to come with conclusive remarks going beyond these cases. However, relating the findings presented here to the literature on transition from industrialized countries and to discussions on this topic amongst people working in the field of sustainable agriculture in developing countries, a number of generalized observations can be made.

In most cases described the decision for transition was based on broad environmental reasoning or general considerations of family health and food quality. However, these situations are to be considered as exceptional when thinking of changing agriculture in developing countries towards more sustainable practices.

Sustainable agriculture in developing countries is not likely to be achieved through a process of transition with a clearly defined target and time plan. It needs to involve large numbers of the agricultural population, not only farmers with a strong conceptual motivation as the current innovators studied in this research. As such it will not be realistic to speak of a clear transition process, the change will be much more gradual in all aspects. Instead of comparing it to the transition of an individual farm from conventional to ecological agriculture it can better be compared to the development currently taking place in conventional agriculture in industrialized countries. There a gradual change of the conventional farming system towards a more sustainable one can be seen. Think of the growing importance of Integrated Pest Management and Integrated Nutrient Management resulting in more effective applications of pesticides and fertilizer, thereby decreasing the quantities used. Then what is the relevance of this research and the information gathered? Exactly the same as the role of organic and ecological farming in industrialized countries; that of pioneer. First of all proving at field level that it is possible to farm ecologically and simultaneously economically. Furthermore, identifying bottlenecks and possible solutions in developing and introducing sustainable farming systems.

### 5.3.2 Agro-economics

The data presented are the first available on a comparative agro-economic basis for ecological and conventional agriculture in a developing country. On basis of the preliminary conclusions some remarks can be made towards the extrapolations of these results at national level.

First of all, it is seems that ecological farming methods can produce a similar output, using less external resources, and supplying the farmer with a similar income per labour day as conventional farming. When translated to a national level this would mean that sustainable agriculture does not put the short-term food security at risk, nor does it influence the farmers' income

negatively. The farming techniques practised under ecological management can even be expected to decrease the depletion of soil fertility and erosion. This would mean that the long-term food security could be better catered for by sustainable than conventional farm management. The lower use of external resources means a greater independence for the individual farmer as well as for the country at large. No or only limited use of mineral fertilizers at farm level will have a definite positive effect on a developing country's foreign exchange position.

Furthermore, it can be assumed that certain techniques practised on the ecological farms could enhance the efficiency of conventional farms. For instance, the soil fertility management techniques practised result in a higher nutrient efficiency. In conventional farms this would mean lower expenditure for fertilizer. At national level the effects will be in the same direction as described above.

The ecological farms studied had to develop their specific expertise on their own without any outside help. Taking this into account it can be expected that the potential of ecological farm management goes beyond the results of this study. If sustainable farming would receive similar attention from research and extension, the current results might even improve.

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# ANNEXES

## Annex 1 LIST OF TERMS

| | |
|---|---|
| Biofertilizer | Use of micro-organisms to fix/solubilize atmospheric and naturally occurring plant nutrients. |
| Bio-gas | Anaerobic decomposition of cowdung to generate methane gas as fuel and slurry as manure. |
| Cropping pattern | Sequence/System of cropping in a piece of land in one year. |
| Compost | Way of decomposing farm and animal wastes for increasing nutrient supplying ability of the materials. |
| Conventional agriculture | Agricultural aiming at production maximization through use of external inputs such as: fertilizers, pesticides, herbicides, mechanization etc. |
| Cover crop | Growing crops (usually creeper) as an undergrowth within the orchards or perennials. |
| Diversity | Diversity at farm level is created by using many different species of plants and animals to perform one function within the farming system (e.g. different tree and grass species to supply fodder for animal husbandry). |
| Ecological agriculture | Agriculture that seeks to optimize the use of local resources through creating complex and divers farms, aiming at a stable, growing and long lasting production level. |
| Farmyard manure | Partially decomposed farm wastes to enrich physiochemical properties of soil. |
| Green manuring | Leguminous plants grown on field and incroporated in situ to enrich soil fertility (specially nitrogen). |
| Gross income | Total valued output of farm activity or a number of farm activities. |
| Gross margin | Gross income minus variable costs. |
| Indigenous | Emphasizes that agricultural development should take into account the knowledge and technology existing in a given area. |
| Integrated | A term derived from Integrated Pest Management and transferred to overall agriculture; tries to develop balanced techniques and to establish thresholds for the economically viable and ecologically safe use of pesticides. |
| Low-external input | An economic approach stressing the need for many farmers to use of techniques that do not require expensive inputs from outside the farm. |
| Mulching | Covering the soil with organics to conserve moisture. |

| | |
|---|---|
| Multi-storey cropping | Arrangement of different crops in tiers for efficient utilization of sunlight and soil profile. |
| Multiple cropping index | Ratio of cropped area and total available land expressed in percentage. |
| Net-cash income | Total farm cash-income minus total sach costs. |
| Off-farm income | Total income from other sources than farm. |
| Selective weeding | Selective removal of voluntarily grown plants from the crop field. |
| Site-oriented | Developed on the insight that agricultural technology should be based on and the potentials of a given area. |
| Sustainable development | Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. |
| Traditional agriculture | A subsistence oriented farming system using low levels of locally available inputs. |
| Variable cost | All costs that vay with the size of a fam activity e.g. matials, fertilizers, etc. |
| Versatile rotations | Relative high diversity of crops grown on one plot within one year. |

## Annex 2 QUALITATIVE AGRO-TECHNICAL ANALYSIS OF TRANSITION - PHASE 1

CHECKLIST

1. When was the transition period started?
2. What is the ultimate aim of transition?
3. Was a plan for transition made (in writing or mentally) if so, then:

3.1 What was the time period originally scheduled and how is this followed?

3.2 How was the transition implemented?
- Gradual on the whole farm
- Full at once on the whole farm
- Gradual plot by plot
- Full at once, one plot after another
- Others, specify.

3.3 Which were the five most important changes that you would like to make/made during transition?

3.4 Which of the following were included in transition plan, actually changed and gave rise to problems?

| | Part of plan Yes/No | Practised Yes/No | Directions +/- | Problems Yes/No |
|---|---|---|---|---|
| A. FERTILITY MANAGEMENT | | | | |
| Fertilizer/use | | | | |
| Manure use | | | | |
| N-fixing crops | | | | |
| Cultivation | | | | |
| Perenual crops | | | | |
| Cultivation | | | | |
| Soil coverage | | | | |
| Land protected from erosion and run-off | | | | |
| Recycling organic matter | | | | |
| External inputs for soil fertility maintenance - | | | | |
| - organic | | | | |
| - inorganic | | | | |
| Compositing method | | | | |
| Tillage | | | | |
| Others | | | | |
| B. CROP MANAGEMENT | | | | |
| Number of plant species/varieties | | | | |
| Crop rotation | | | | |
| Cropping pattern | | | | |
| Wind breaks | | | | |
| Presence of weeds | | | | |
| Pest and diseases | | | | |
| Productivity | | | | |
| Others. | | | | |

| | Part of plan Yes/No | Practised Yes/No | Directions +/- | Problems Yes/No |
|---|---|---|---|---|
| **C. ANIMAL HUSBANDRY** | | | | |
| Number of animal species/breeds | | | | |
| Fodder production | | | | |
| Fodder imported | | | | |
| Concentrate production | | | | |
| Concentrate imported | | | | |
| Cattle shed | | | | |
| Manure collecti/on | | | | |
| Urine collection | | | | |
| Animal Health- diseases | | | | |
| veterinary costs | | | | |
| Livestock productivity | | | | |
| Livestock fertility | | | | |
| Number of animals per area unit | | | | |
| Others | | | | |
| **D. HOUSEHOLD** | | | | |
| External dependence for food | | | | |
| External dependence for fuelwood | | | | |
| Family health | | | | |
| Family income | | | | |
| Labour needs | | | | |
| Others | | | | |

4. Was any help received from outside the farm during:
   - transition planning?
   - transition implementation?

   If so by whom?
   - extension service
   - neighbours
   - ecological agricultural experts
   - others, specify

5. Where there any external influencing factors on transition implementation?

| | Negative | Neutral | Positive |
|---|---|---|---|
| Neighbours attitude | | | |
| Family attitude | | | |
| Neighbours farming method | | | |
| Loans of local bank | | | |
| Local extension service | | | |
| Others, specify | | | |

Annex 3 AGRO-ECONOMIC-STUDY-OF-ECOLOGICAL-FARMING-IN-INDIA

GENERAL-QUESTIONNAIRE

1. State
2. District
3. Taluk
4. Village
5. Altitude
6. Rainfall
7. Farm group: I Ecological
II Transitional
III Non-Ecological
8. Name of the head of household
9. Name of the Respondent and relation to HHH
10. Type of cultivation: Individual/Joint/Coperative
11. Mother tongue
12. Household information

| Sl. No. | Name | Relationship to HHH | Sex | Age | Place of birth | Education | Duration of | If migrated | Marital status | Occupation |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |

13. Housing condition and amenities available:
I) House type : Pucca/Semi Pucca/Katcha
II) Drinking water : Yes/No
III) If No, distance travelled
IV) Seperate bathroom: Yes/No
V) Seperate kitchen : Yes/No
VI) Electricity : Yes/No

14. Do you know of any other ecological or transition farm?
If so which agro-technical information and experiences do you exchange?

15. Land particulars (in acres):

| Status | Total | Cultivable Area | Irrigated area by source | | | | |
|---|---|---|---|---|---|---|---|
| | | | Canal | Well | Tank | Q/S | Value Total |
| Owned | | | | | | | |
| Leased in | | | | | | | |
| Leased out | | | | | | | |
| Total land | | | | | | | |

16. Crop pattern

| Parcel | Plot | Distance of place of residence | K/R/S | I/UI | O/LI/LO | Soil type | A | C |
|---|---|---|---|---|---|---|---|---|

17. Livestock

| Type | Breed | Sex Female/Bull/ Bullock | Production group Dry/Calf/ Heifer/Adult | Live-weight | Cattle-shed | Value |
|---|---|---|---|---|---|---|

18. Farm Asset Position:

| | | value | expected lifetime |
|---|---|---|---|
| Implements & Machinery: | I) Wooden plough | | |
| | II) Iron plough | | |
| | III) Sprayer | | |
| | IV) Diesel Pumpset | | |
| | V) Electric pumpset | | |
| | VI) Tractor/Trailer | | |
| | VII) Power Tiller | | |
| | VIII) Crusher | | |
| | IX) Farm well | | |
| | X) Others | | |
| | ) Perennials | | |

SOCIAL QUESTIONS

19. Who within the family mainly takes the decisions/does the task within the following fields?

| | Decisions | | Work | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| Cropping pattern | | | | |
| Ploughing | | | | |
| Compost application | | | | |
| Manure application | | | | |
| Fertiliser application | | | | |
| Seed selection | | | | |
| Sowing | | | | |
| Transplanting | | | | |
| Pesticide application | | | | |

| | Decisions | | Work | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| Biological plant protection | | | | |
| Weeding | | | | |
| Harvesting | | | | |
| Marketing | | | | |
| Preperation for home consumption | | | | |
| Livestock Dairy poultry | | | | |
| management goats | | | | |
| Education | | | | |

(Interview both Male and Female!)

20. Decision makers

| | Agri./Family Yes/No | Farm(yrs) Exchange | Family Agrl. Trg. Yes/No | Whether steps Eco | Agr. |
|---|---|---|---|---|---|
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |

21. Reason for changeover to (transition to) ecological agriculture

Farm income
Decrease risks
Increase independance
Avoid loans and indebtness
Love and respect for land
Specific agricultural problems
  e.g. animal health
  pesticide poisoning
Philosophical/ideological reasons
Human health

**Annex 4 REGULAR FARM SURVEY**
**INPUT/OUTPUT RECORDS**

**Farm No. :**
**Group No. :**
**Period**
**Name of the Respondent:**
**Relationship to HHH :**
**Enumerators Name :**

**A. CROP LABOUR INPUT**

| Parcel | Plot | Cropping System | Operation | LABOUR INPUT | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Family | | | Hired | | | Exchange | | | Wage rate | | | Kind | | |
| | | | | M | F | C | M | F | C | M | F | C | M | F | C | M | F C |

M = Male
F = Female
C = Child

| Animal Labour | | Mechanical Labour | |
|---|---|---|---|
| No. of days worked | Amount Paid | No. of days | Amount |

**B. CROP INPUT RECORD**

| Parcel | Plot | Input | Type | INPUT OF CROPS | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Unit of | Quantity | | Value | |
| | | | | Q | P | HP | P | HP |

Q = Quantity
P = Purchased
HP = Home Produce

**C. CROP OUTPUT RECORD**

| Parcel | Plot | Type of output | OUTPUT OF CROPS | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Total of production | | Sales | | Consumption/Int.delivery | |
| | | | Q | V | Q | V | Q | V |

Q = Quantity
V = Value

**D. CROP CHARACTERISTICS**

| Parcel | Plot | Crop/ Variety | Plant density in cm x cm | Planting date | Harvesting date | Soil Coverage % |
|---|---|---|---|---|---|---|

E. LIVESTOCK INPUT

| Type of livestock | Input | Type | Unit | INPUTS | | | | Hours/day outside farm |
|---|---|---|---|---|---|---|---|---|
| | | | | Quantity | | Value | | |
| | | | Q | P | HP | P | HP | |

| Operation | LABOUR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Family | | | Hired | | | Exchange | | | Wage Rate | | |
| | M | F | C | M | F | C | M | F | C | M | F | C |

F. LIVESTOCK OUTPUT

| Type of livestock | Type of output | OUTPUT | | | | | |
|---|---|---|---|---|---|---|---|
| | Unit of | Total Production | | Sales | | Consumed/Int.delivery | |
| | Q | Q | V | Q | V | Q | V |

G. LIVESTOCK PARTICULARS (mutations)

| Type of livestock | Total number (last inventory) | Additions | | | Substractions | | | Total number (at present |
|---|---|---|---|---|---|---|---|---|
| | | P | H | G | S | G | D | C | |

P = Purchased
H = Homebred
G = Gifts
S = Sold
D = Deaths
C = Consumed

H. FARM: FIXED COST

| Fixed Cost | Amount Paid |
|---|---|
| Land Revenue | |
| Cess | |
| Water tax | |
| Repairs | |
| Maintenance | |
| Others | |
| Total | |

I. INCOME FROM OTHER SOURCES (Rs)

| | |
|---|---|
| Agricultural labour | |
| Hiring out cart | |
| Artisan | |
| Business/Trade | |
| Service | |
| Non-Agricultural labour | |
| Leasing out land | |
| Rent | |
| Interest from Security/deposits | |
| Others | |

J. CONSUMPTION PATTERN

| | Value |
|---|---|
| Food | |
| Non-food | |
| Total | |

## ANNEX 5 CHECKLIST AGRICULTURAL SUSTAINABILITY

A number of indicators for agricultural sustainability are included in the general agro-economic questionnaire and the regular agro-economic farm survey or can be derived from there. Such as the nutrient balance calculations which are based on the monthly input/output figures for crops and livestock. Per heading the 'derived' aspects are shortly indicated.
The follow items were studied at farm level through field visits.

### 1. SOIL FERTILITY MANAGEMENT

1.1 Which of the following techniques for soil fertility maintenance are practised?
- Use of bio-fertilizers
- Deep-rooting crops
- Green manure
- Compost (farm/urban)
- Biogas/septic tank
- Mulching
- Farm yard manure
- Nightsoil
- Other organic materials

1.2 Soil testing was done for; pH, organic carbon (%), available N-P-K in (kg/ha).

1.3 Nutrient balance at farm gate.

1.4 Nutrient balance of main crop.

1.5 External nutrient dependency of the cropping system.

1.6 Nutrient flow diagram for nitrogen.

### 2. CROPPING SYSTEM

2.1 Which of the following farming methods, creating plant diversity, are practised?
- Mixed / Inter cropping
- Multi-storey cropping
- Agro-forestry/alley crop.
- Selective weeding
- Cover crops
- Hedges/shelterbelts
- On-farm tree nurseries
- Versatile rotations

2.2 Land use and cropping diversity.

## Annex 6. Correlation matrix

| | NFIHA | GIHA | HA | VCHA | CC | CA | SLD | IRR | ASSHA | TRHA | LBDHA | EXNHA | EXNDP | SFT | PDT | OFINC | LITR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NFIHA | 1.00 | | | | | | | | | | | | | | | | |
| GIHA | 0.96 | 1.00 | | | | | | | | | | | | | | | |
| HA | -0.04 | 0.02 | 1.00 | | | | | | | | | | | | | | |
| VCHA | 0.76 | 0.90 | 0.13 | 1.00 | | | | | | | | | | | | | |
| CC | 0.35 | 0.22 | 0.02 | 0.15 | 1.00 | | | | | | | | | | | | |
| CA | 0.36 | 0.27 | -0.08 | 0.08 | 0.44 | 1.00 | | | | | | | | | | | |
| SLD | 0.66 | 0.59 | 0.16 | 0.50 | 0.25 | 0.20 | 1.00 | | | | | | | | | | |
| IRR | 0.27 | 0.30 | 0.23 | 0.27 | 0.24 | 0.60 | 0.11 | 1.00 | | | | | | | | | |
| ASSHA | 0.56 | 0.52 | 0.67 | 0.46 | 0.43 | 0.35 | 0.50 | 0.37 | 1.00 | | | | | | | | |
| TRHA | -0.10 | 0.07 | -0.08 | 0.22 | 0.66 | -0.45 | 0.00 | 0.00 | -0.40 | 1.00 | | | | | | | |
| LBDHA | 0.81 | 0.91 | 0.03 | 0.84 | 0.20 | 0.46 | 0.41 | 0.52 | 0.44 | 0.17 | 1.00 | | | | | | |
| EXNHA | 0.57 | 0.53 | -0.22 | 0.35 | 0.42 | 0.15 | 0.09 | 0.08 | 0.04 | -0.03 | 0.54 | 1.00 | | | | | |
| EXNDP | 0.50 | 0.34 | -0.04 | 0.24 | 0.81 | 0.32 | 0.35 | 0.09 | 0.34 | -0.59 | 0.18 | 0.50 | 1.00 | | | | |
| SFT | 0.06 | 0.23 | 0.62 | 0.36 | -0.49 | -0.24 | 0.02 | 0.23 | 0.43 | 0.33 | 0.21 | -0.31 | -0.47 | 1.00 | | | |
| PDT | 0.15 | 0.38 | 0.54 | 0.65 | -0.37 | -0.41 | 0.23 | 0.12 | 0.28 | 0.54 | 0.37 | -0.17 | -0.35 | 0.74 | 1.00 | | |
| OFINC | 0.50 | 0.64 | 0.42 | 0.82 | 0.33 | -0.05 | 0.34 | 0.39 | 0.50 | 0.23 | 0.63 | 0.35 | 0.33 | 0.37 | 0.65 | 1.00 | |
| LITR | 0.37 | 0.34 | 0.39 | 0.30 | 0.01 | 0.18 | 0.14 | 0.35 | 0.38 | -0.23 | 0.32 | 0.02 | 0.23 | 0.23 | 0.26 | 0.24 | 1.00 |

NFIHA - Net-farm income/ha
GIHA - Gross income/ha
HA - Total area studied
VCHA - Variable costs/ha
CC - Percentage cash of total costs
CA - Net-cash income
SLD - Percentage of gross income sold
IRR - Percentage of total area irrigated

ASSHA - Total assets/ha
TRHA - Number of trees/ha
LBDHA - Labourdays/ha
EXNHA - Total external nutrients/ha
EXNOP - External nutrients dependecy (%)
SFT - Number of different soil fertility techniques applied
PDT - Number of different plant diversity techniques applied
OFINC - Total off-farm income
LITR - Percentage of household being literate