AB-e-1

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1. Designing Prototypes

Progress Reports of Research Network on Integrated and Ecological Arable Farming Systems for EU and associated countries (Concerted Action AIR 3 - CT920755)

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Summary

This first progress report of EU concerted action AIR-CT 920755 presents the state-of-the-art in European research on Integrated and Ecological Arable Farming Systems (I/EAFS). There are 16 projects ongoing, with some 40 scientist years devoted to 13 IAFS and 9 EAFS prototypes in 10 European countries.
Given that in 1985 there were only 2 projects ongoing, it is clear that enormous progress has been made in a few years. This is largely attributable to mutual stimulation within the framework of IOBC (International Organisation for Biological Control of Noxious Animals and Plants).
Thanks to major financial support from the EU, we now have the chance to improve and expand research by concerted action. The basic objective is to establish a common frame of reference by elaborating and standardising methodology, which will be laid down and disseminated by progress reports and finally by a manual.
In this progress report a first milestone is achieved by presenting the basic design of the 22 prototypes in a standardised way. These 22 identity cards comprise the hierarchy of objectives (Part 1), the set of parameters and methods quantifying and achieving the 10 major objectives (Part 2) and the layout (Part 3) of each prototype. The 22 identity cards clearly show the similarities and differences between the prototypes, to the benefit of all participating projects, whether ongoing or in preparation.
The report ends with critical but constructive conclusions and recommendations, calling for further progress on the methodical way to more sustainable farming systems in Europe.

Contents

1 Introduction to the concerted action

Integrated farming systems should be considered as a feasible first step to alleviate the consequences of the ongoing agricultural crisis in EU. However, these systems cannot change the fact that agrotechnology is clearly beyond its optimum, causing degradation of nature and landscape, pollution of the environment and overproduction of food. The latter is a major cause of the declining incomes and employment in rural areas. The pressure of growing EU surpluses on the world market is frustrating agriculture in other industrial countries and also in developing countries, in a way that is no longer tolerated by EU trade partners. Therefore, the only long term solution of the current crisis would be advanced ecological farming systems principally resting on a strong domestic market with quality labels and premium prices to ensure sufficient management achievements and economic margins (Vereijken, 1992).
Against this background, the current concerted action may be considered of strategic importance to the EU.
Its general objective is to come to a representative European network of research teams on Integrated and Ecological Arable Farming Systems (I/EAFS), essentially contributing to a sustainable development of European agriculture, based on a common methodology and an effective dissemination of the results.

1.1 State-of-the-art

Expertise in I/EAFS research has accumulated gradually since 1979, when the first 2 projects were started in Lautenbach (DE) and Nagele (NL). The first milestone was the start in 1988 of an initial working group within the framework of IOBC (International Organisation for Biological Control of Noxious Animals and Plants), with project leaders from DE, DK, F, I, NL, UK and CH. The second milestone was the joining of the 6 EU projects in a common shared-cost project within the framework of the CAMAR programme (1991-1993).
To achieve the general objective of the current concerted action we have to face some major challenges:

- *Transition from components to farming systems*
  As project leaders we all started as specialists in crop protection or another discipline. Since there is no tradition and no formal education in farming systems research, we are having to upgrade ourselves and the newcomers to become generalists at the farming systems level.
- *Transition from analysis to synthesis*
  Agricultural science has evolved from an applied to a fundamental science, with biology as the great example. Consequently, our recognition and support in the scientific community is based more on publication and citation than on practical use of our concrete solutions! Under these circumstances, it is very difficult to obtain administrative and financial support for research on farming systems, unless that research is analytical and is aimed at comparison of systems. As a result, much of European research at farm level generates knowledge of little or no practical use. Therefore, a stringent selection of projects that aim to synthesise is needed, to achieve the general objective of our concerted action.
- *Synthesis for short and long term*
  Most projects are put under strict supervision of senior scientists and often of practitioners and policy makers, too. Often these 'watch-dogs' do not allow the research team much freedom for long-term innovation. The project leader has to be particularly persevering and persuasive to obtain the space needed for non-conformist and creative research. In this respect it is vitally important to convince the supervising committee that Europe not only needs Integrated Systems that are feasible in the short term for the main group of farmers, but also Ecological Systems that are only feasible in the short term for pilot groups yet are indispensable as a pacemaker for sustainable development of the main group!
- *Broadening of the base*
  The only ongoing I/EAFS projects are in 7 EU and 3 other European countries (CH, S, FIN).
  To come to a representative EU research network, potential leaders have to be identified and supported in starting up new projects in the remaining EU countries, notably around the Mediterranean. It is also of EU interest to involve potential new members in Central Europe.

- *Standardisation of the methodology*
  In scientific terms, the major and most time-consuming challenge is to agree on a common methodology, first by identifying and quantifying objectives, parameters and methods as the basic design of prototypes. A start has already been made (Vereijken, 1992), but 4 years of concerted action will be required to provide a manual for common use. In the technical annex (annex I) the programme of workshops and reporting is described in detail.

1.2 Selection of European projects in I/EAFS prototyping

If concerted action is to succeed, the number of participants must be restricted to 30. Above this number, basic activities such as workshops will easily degenerate into symposia with insufficient exchange of visions and methodologies. Therefore, it has been decided to restrict workshop participation to 3 projects from large countries and 2 from small countries. Furthermore, the following set of criteria has been used to select participants:

(1) *Project duration ≥ 4 year*
It takes at least 4 years to develop prototype farming systems.

(2) *Size of prototype systems ≥ 4-6 hectares and field sizes ≥ 1 hectares*
An integrated or ecological system minimally requires a 4 or 6 years crop rotation and for representative layout and management a field should be at least 1 hectare.

(3) *Development = objective number 1*
Only projects primarily aimed at development are expected to deliver an appropriate contribution to the concerted action.

(4) *Scientist yr^{-1} ≥ 1 in systems development and ≥ 2 in total*
The development of prototype farming systems requires at least the above inputs from scientists.

(5) *Project full-timers ≥ 1*
The development of prototype farming systems requires the total commitment of at least 1 scientist.

(6) *Research leader ≥ 40 % involved*
The leadership of a farming systems project requires involvement of at least 2 days/week.

(7) *Priority of research leader = design*
The leadership of a farming system project primarily requires creative input.

From Table 1 it appears that 16 projects, including 13 IAFS and 9 EAFS prototypes, fulfil most criteria, except for criteria (4), (5) and (6) concerning research capacity. As far as the latter 3 criteria are concerned, it appears that research on farming systems in Europe is still in its infancy. In 1993, only DE 2a, DE 2b, NL 2 and UK 1 fulfil all criteria.
From Table 1 it can also be concluded that of the four southern European countries (Greece, Spain, Portugal and Italy) only Italy has an ongoing project. Therefore, the identification of potential participants in these countries is receiving special attention. Annex II indicates that a promising basis was laid by selecting 7 southern European colleagues for the first workshop on design of prototypes held in Wageningen in 1993. Some of these had the necessary wide-ranging expertise and some already had serious plans for I/EAFS prototyping.

Table 1. Selected list of European projects in I/EAFS prototyping ongoing in 1993

Criteria concerted action (explained in 1.2)		DE 1 Lauten-bach	DE 2a Reinshof	DE 2b Marien-stein	DK 1 Foulum	F 1 Boig-neville	F 2 Cour-seulles	IRL 1 Johns-town	I 1 Monte-paldi	NL 1 Nagele	NL 2 Flevo-land	UK 1 LIFE	UK 2 LINK	FIN 1 Suitia	S 1 Logården	S 2 Alnarp	CH 1 Burgrain
Duration	≥ **4**	79-?	89-97	89-97	87-?	90-99	90-96	93-96	91-97	79-?	91-96	90-?	92-97	94-99	91-99	92-04	90-02
Exp. or Pilot farm *		EF	EF	EF	EF	EF	EF	EF	EF	EF	PF	EF	EF	EF	EF	EF	EF
Number of farms		1	1	1	1	1	1	1	1	1	10	1	6	1	1	1	1
Integrated systems (IAFS)																	
Variants (crop rotations)		1	1	1	2	2	1		1	2		2	1	2	2	1	2
Ha/variant	≥ **4**	16.0	14.2	9.6	7.0	18.0	17.5		5.2	19.0		5.0	17.5	13.5	28.0	18.0	2.1
Ha/field	≥ **1**	6.0	3.6	2.4	1.5	3.0	2.0		1.3	2.0		2.4	3.5	2.5	4.0	3.0	0.7
Ecological systems (EAFS)																	
Variants (crop rotations)		1	1	1	1			1	1	1	10				1		2
Ha/variant	≥ **6**	5.7	6.8	6.4	9.0			56.0	5.2	22.0	32.0				22.0		2.1
Ha/field	≥ **1**	1.5	1.7	1.6	1.5			4.0	1.3	3.7	5.3				3.1		0.7
Objectives ranked																	
Development (synthesis)	= **1**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Comparison (analysis)		3	2	2	3	3	2	3	2	2	3	2	2	3	3	2	2
Demonstration		2	3	3	2	2	3	2	3	3	2	3	3	2	2	3	3
Scientist years**																	
Development	≥ **1**	1.5	1.5	1.3	1.0	1.5	0.5	0.8	1.0	0.6	1.5	3.0	3.5	1.0	2.0	0.6	1.0
Comparison		0.3	2.4	0.8	0	0	0.5	0	0.6	0.4	0	0.4	2.5	0.2	0.2	1.5	1.0
Demonstration		0.5	0.3	0.2	0.1	1.0	0.0	0.5	0.6	0.2	0.5	0.2	0.5	0.3	0.5	0.1	0.2
Total	≥ **2**	2.3	4.2	2.3	1.1	2.5	1.0	1.3	2.2	1.2	2.0	3.6	6.5	1.5	2.7	2.2	2.2
Project full-timers	≥ **1**	0	2	1	0	1	0	1	0	0	2	2	0	1	0	0	1
Research leader																	
% time involved	≥ **40**	50	40	45	50	20	25	20	30	50	80	75	35	80	40	30	20
Priorities of leader																	
Design components		1	3	2	2	4	3	4	4	2	2	2	2	2	2	2	4
Comparison components		3	4	4	3	3	4	3	3	4	4	4	4	4	3	3	3
Design systems	= **1**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Comparison systems		2	2	3	4	2	2	2	2	3	3	3	3	3	4	4	2

* Experimental farm is farm with more than one system being researched, therefore the systems and fields are mostly much smaller than in commercial farms. Pilot farm is a commercial farm with one prototype system being researched.

** A scientist year is a year of 1 full-timer or of 2 part-timers (50 %) or 4 part-timers (25 %) etc.

Table 2 General and specific social values and interests involved in agriculture*

Values and interests (not in order of importance) general	specific
1. Food supply	
	1.1 quantity
	1.2 quality
	1.3 stability
	1.4 sustainability
	1.5 accessibility
2. Employment	
	2.1 farm level
	2.2 regional level
	2.3 national level
3. Basic income/Profit	
	3.1 farm level
	3.2 regional level
	3.3 national level
4. Abiotic environment	
	4.1 soil
	4.2 water
	4.3 air
5. Nature/Landscape	
	5.1 flora
	5.2 fauna
	5.3 landscape
6. Health/Well-being	
	6.1 farm animals
	6.2 rural people
	6.3 urban people

* Simplified from (Vereijken, 1992)

2 A methodical way to design and identify prototypes of I/EAFS

At the first workshop on the design of prototypes of Integrated and Ecological Arable Farming Systems (I/EAFS) the participants practised 3 initial methodical steps:
(1) making a hierarchy of objectives;
(2) transforming major objectives into appropriate parameters to quantify them;
(3) establishing the methods needed to achieve the quantified objectives.
Step 1 results in Part 1 of an identity card of the prototype to be designed (Chapter 4). Steps 2 and 3 results in Part 2 of this identity card (Chapter 6). A standardised layout of the prototype completes the identity card as Part 3 (Chapter 8). By means of this identity card the basics of our prototyping can be explained in a fast and simple way, which is essential for collaborative research at European level.

2.1 Making a hierarchy of objectives

Table 2 presents 6 general values or interests involved in agriculture, subdivided into 3 or 5 specific values or interests. The first step you take as a designer of farming systems is to establish your hierarchy of objectives within this framework, taking into account the shortcomings of farming systems in your region and the targeted contribution your prototype should deliver to improve the situation in the short term (integrated prototype) or the long term (ecological prototype).
The procedure is simple: in the first round you rate your general objectives from 6 to 1 in descending order of importance. In the second round you rate your specific objectives within each general objective from 3 to 1 in descending order of importance (in food supply by 3, 2, 1, 0, 0 because there are 5 specific objectives, not 3).
Eventually, your top ten of specific objectives can be established by multiplying the ratings of specific objectives by the rating of their general objective (see Chapter 6).

2.2 Quantifying the objectives

Having put the objectives in a hierarchy you need to transform them into a suitable set of parameters to quantify them. Subsequently, the quantified objectives are used as the desired results at the evaluation of the prototypes. Prototypes are tested and improved until the results achieved match the desired results.
Given the overwhelming number of parameters available, there are two major reasons for not using a large set. Firstly, using a large set is time-consuming and expensive. Secondly, doing so does not assure that the objectives are integrated which is crucial because the objectives may conflict in many ways. Consequently, you must first identify a limited set of key parameters, to ensure that the objectives are integrated sufficiently. Additionally, you must establish a set of specific parameters for those objectives, that are not or only insufficiently covered by the integrating parameters.

2.3 Establishing methods and techniques

To develop IAFS prototypes in which potentially conflicting objectives are sufficiently integrated, you need a suitable set of farming methods and techniques. Current methods and techniques mostly serve one or two of your set of objectives and harm the others. Chemical crop protection is a clear example. Therefore, you first look for integrating methods and techniques which bridge the gaps between conflicting objectives and are not harmful to the others. Additionally, you may establish specific methods aimed at major specific objectives that are insufficiently covered by the set of integrating methods.

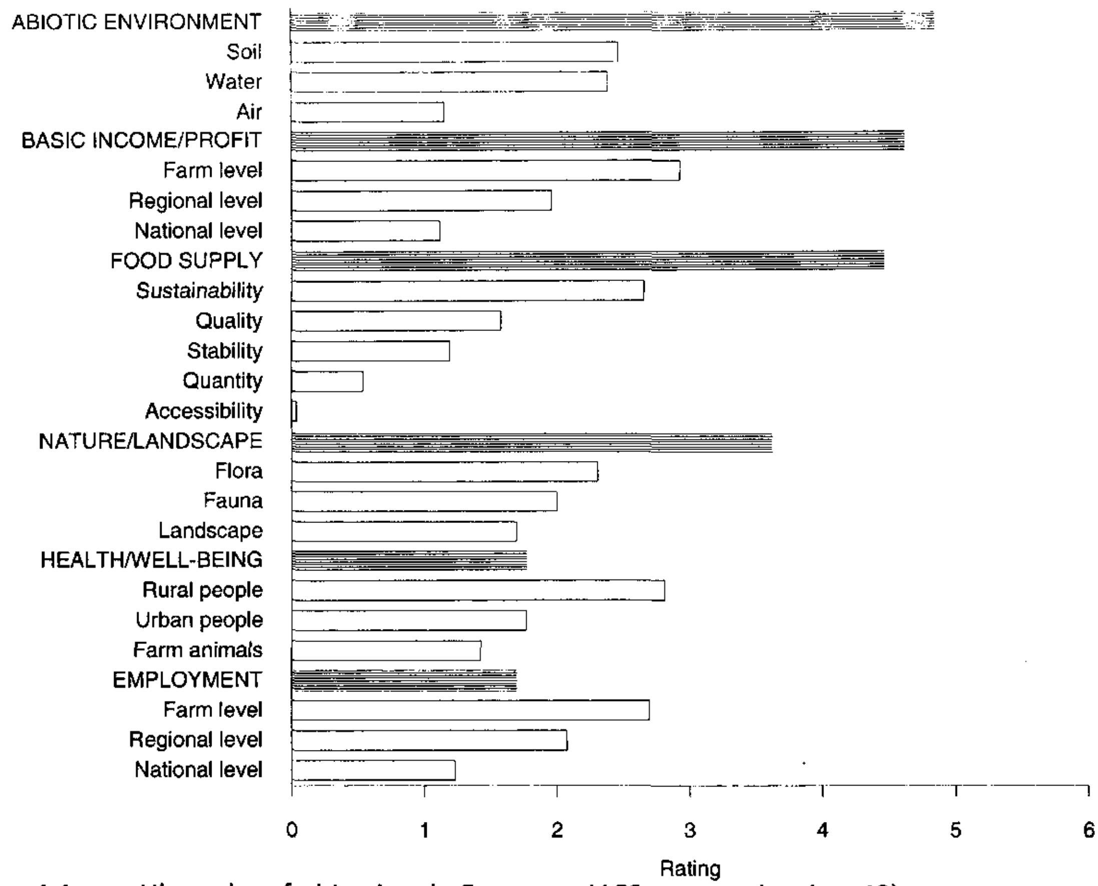

Figure 1.1 Hierarchy of objectives in European IAFS prototyping (n = 13)

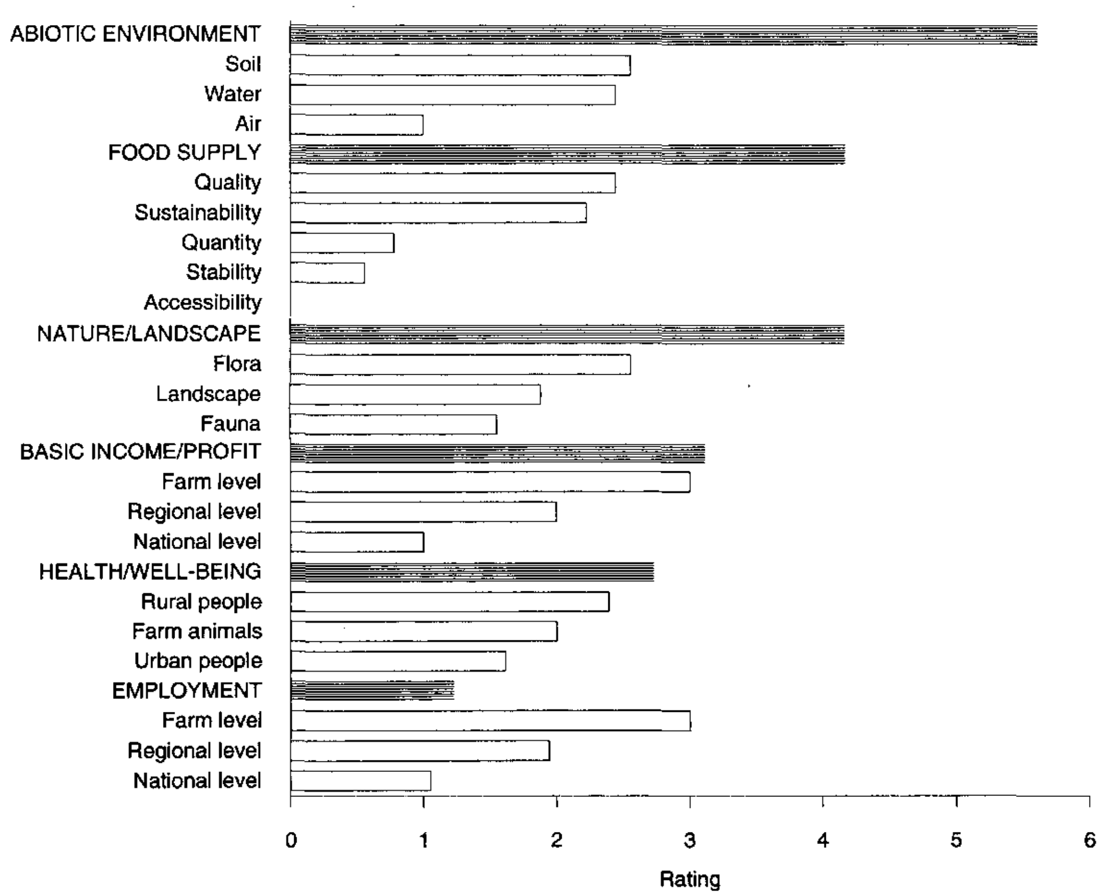

Figure 1.2 Hierarchy of objectives in European EAFS prototyping (n = 9)

3 European hierarchy of objectives

Based on the procedure described in 2.1, the creative leaders of the selected European I/EAFS projects each ranked their objectives in prototyping. The results of the single prototypes are presented in Chapter 4. In the current chapter results are presented as European mean hierarchies in IAFS and EAFS prototyping (Figs 1.1-1.2). Conclusions are drawn according to distribution-free multiple comparisons based on Friedman rank sums.

3.1 IAFS

General objectives (ratings 6-1)
The main objectives in European IAFS prototyping are - almost equally - abiotic environment, basic income/profit and food supply. Nature/landscape is emphasised less. Employment and health/well-being are hardly considered.

Specific objectives (ratings 3-1)
In abiotic environment, soil and water are given equal importance, whilst air is largely ignored.
In basic income/profit the farm level is clearly considered more important than the regional level, whilst the national level is largely ignored.
In food supply, sustainability is considered more important than quality and stability, whilst quantity and accessibility (price level) are largely ignored (rating 0-3, because there are 5 specific objectives, not 3).
In nature/landscape, flora, fauna and landscape are ranked almost equally.
As far as health/well-being and employment are considered, rural people and farm level receive most attention.

3.2 EAFS

General objectives (ratings 6-1)
The main objectives in European EAFS prototyping are abiotic environment, food supply and nature/landscape.
Basic income/profit is emphasised less and is significantly less important than the abiotic environment.
Health/well-being and employment are hardly considered.

Specific objectives (ratings 3-1)
In the abiotic environment, soil and water are given equal importance, whilst air is ignored (rating = 1 = minimum).
In food supply, quality and sustainability are considered equally important, whilst quantity, stability and accessibility are increasingly ignored (rating 0-3, because there are 5 specific objectives, not 3).
In nature/landscape there is little hierarchy between flora, fauna and landscape.
In basic income/profit the farm level is considered more important than the regional level, whilst the national level is fully ignored (rating = 1 = minimum).
As far as health/well-being and employment are considered, rural people and farm level receive most attention.

3.3 EAFS compared with IAFS

The major difference is that contrary to IAFS prototypes EAFS prototypes place basic income/profit subordinate to abiotic environment. This basic difference demonstrates the long-term EAFS strategy to rely on ecologically-aware consumers willing to pay premium prices for food products with high added value selling under a particular label. In contrast, IAFS prototypes follow a short-term strategy and try to be competitive on the world market, on the basis of high and efficient production that only permits a certain commitment to environment, nature/landscape and sustainability of food supply.

4 Hierarchy of objectives as Part 1 of the prototype's identity card

The hierarchy of objectives of each prototype is graphically presented against the background of the European average in alphabetical order of the country codes. In addition, the creative leaders and their team have provided a brief explanation of their top 3 objectives. Figs 1.1.1-1.1.13 present the IAFS prototypes and Figs 1.2.1-1.2.9 present the EAFS prototypes. In the figures the average ratings of the group are listed as squares. In this way the figures act as an identity card Part 1 of each prototype, showing where and to what extent it differs from the others in objectives. In Chapter 6, the Parts 2 of each prototype's identity card will be presented concerning parameters and methods.

4.1 IAFS

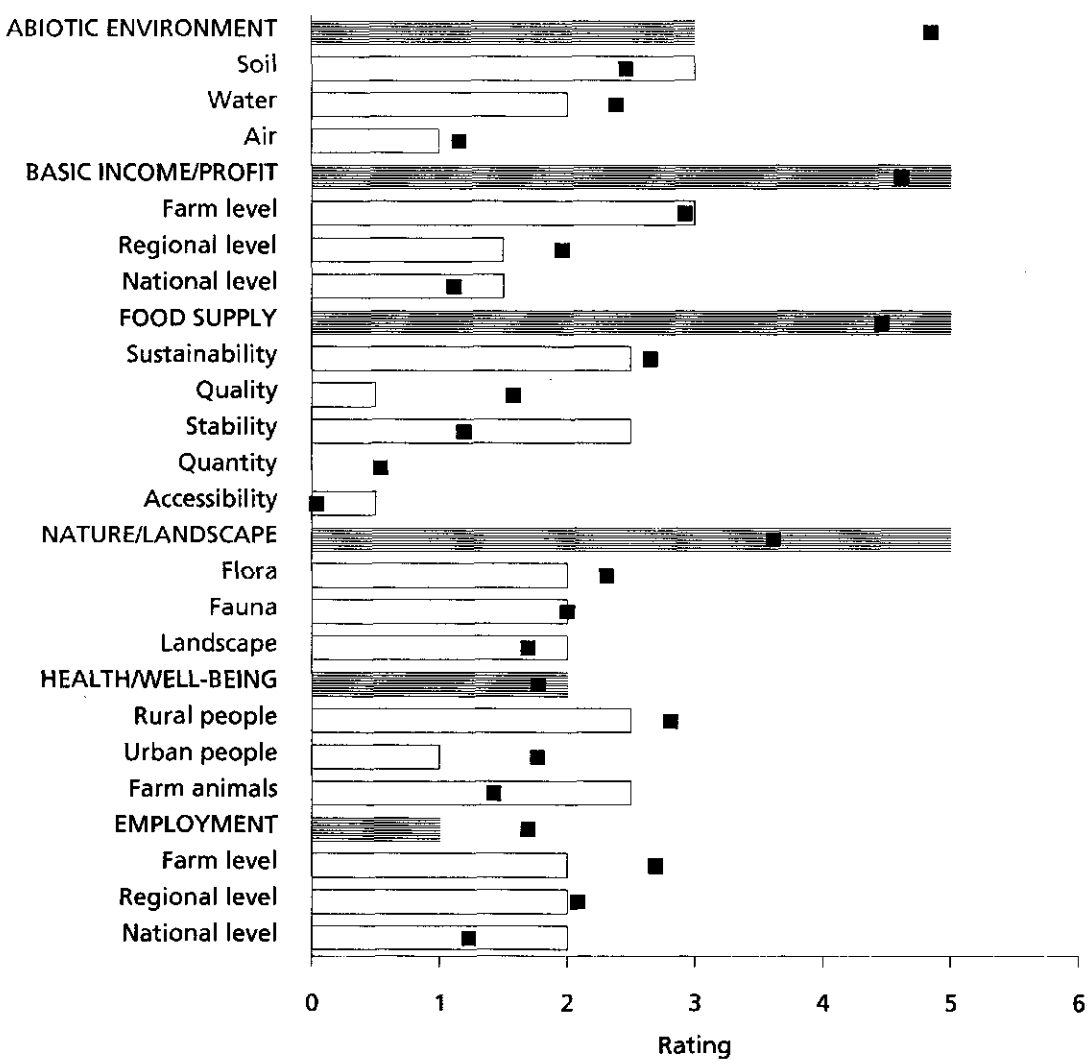

Figure 1.1.1 Hierarchy of objectives in IAFS prototyping in Lautenbach (DE 1) (squares - average of 13 European IAFS prototypes)

In Lautenbach (near Stuttgart) food supply, basic income/profit and nature/landscape are the joint equal main objectives. The basic principle is the integration of natural resources and regulatory components, to minimize the need for external inputs such as pesticides and fertilisers. It relies strongly on skilful management, especially of soil and soil life. Emphasis on basic income/profit is inherent to prototyping on a commercial farm. Besides, it will facilitate dissemination to other commercial farms.
Within these general objectives, there is scarcely any hierarchy between the specific objectives.

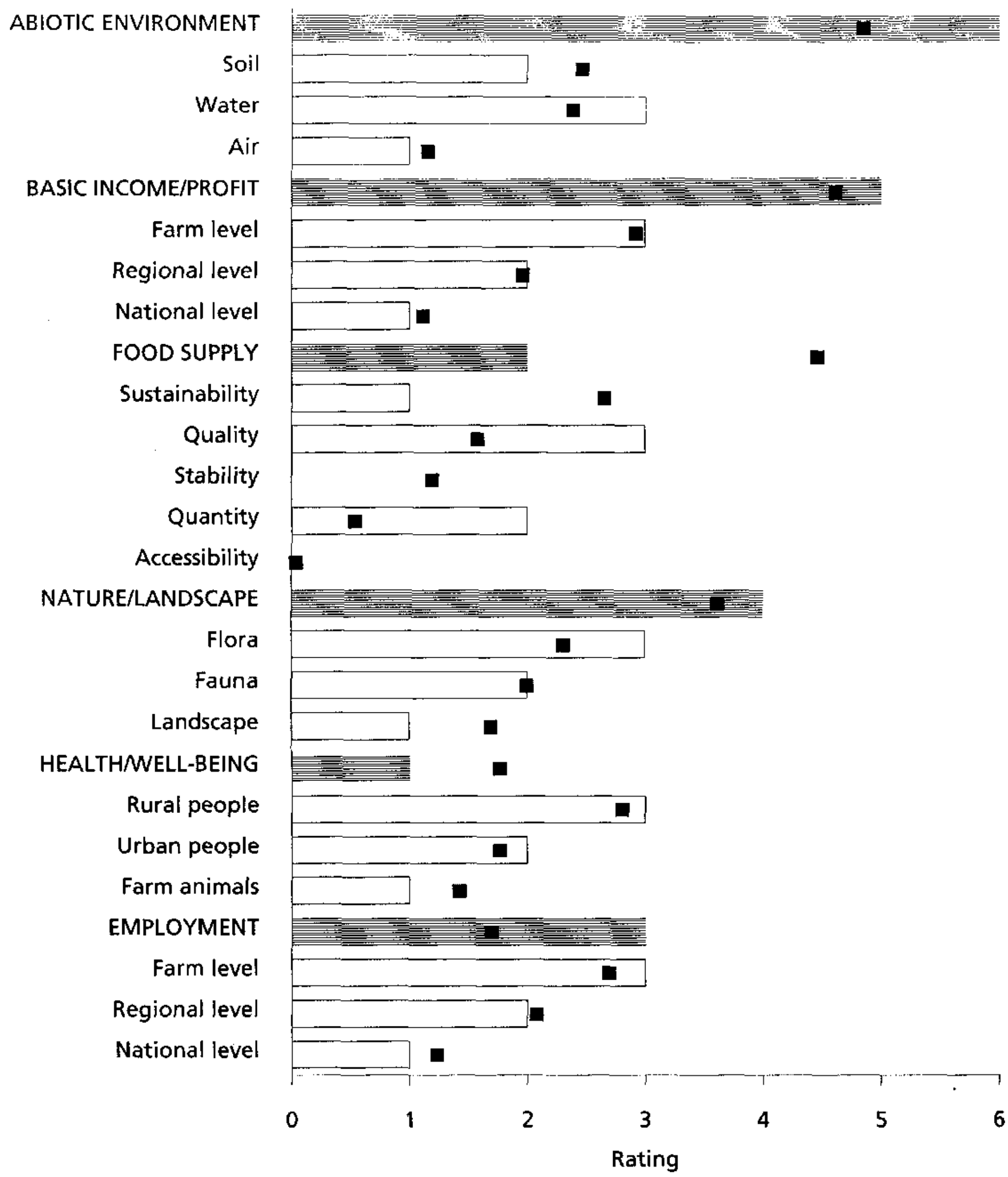

Figure 1.1.2 Hierarchy of objectives in IAFS prototyping in Göttingen for Reinshof (DE 2a) and Marienstein (DE 2b) (squares - average of 13 European IAFS prototypes)

In Göttingen the abiotic environment is the main objective, ahead of basic income/profit and nature/landscape.
In abiotic environment, prototyping is focused on groundwater protection, especially against nitrate leaching which may become a serious problem in this region because of high N inputs and heavy loads of N in the soil. Protection of the soil against erosion is a second priority. Therefore, tillage is reduced although higher inputs of herbicide may therefore be required.
These prototypes will follow the aims of new agricultural policy, to assure an enduring basic income/profit.
Nature conservation and landscape protection are the objectives increasingly demanded, especially by urban society. In most of the rural areas landscape is still dominated by conventional regional planning and cannot be changed within a few years. So for the moment the focus is on protection and development of flora and fauna, by creating an ecological infrastructure.

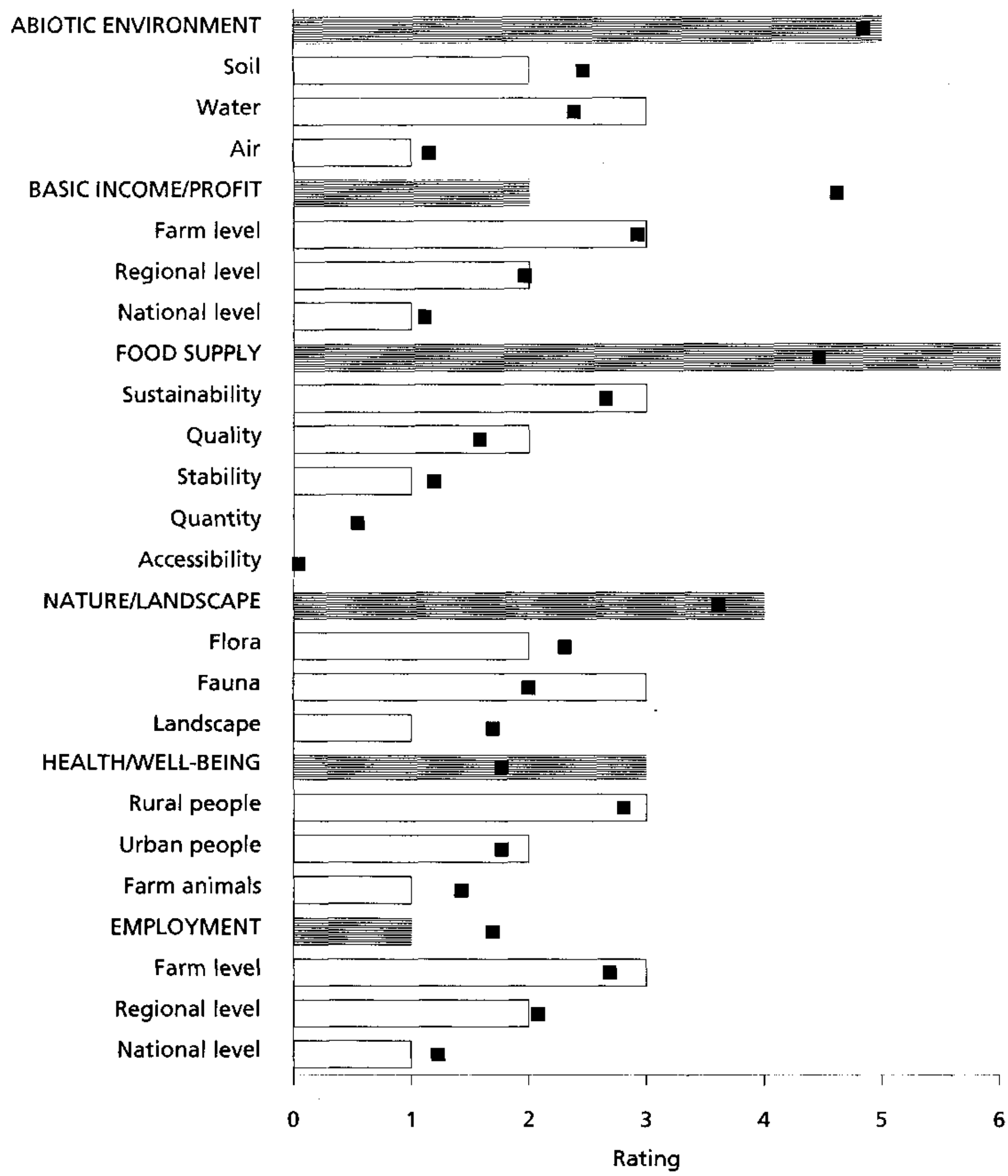

Figure 1.1.3 Hierarchy of objectives in IAFS prototyping in Foulum (DK 1) (squares - average of 13 European IAFS prototypes)

In Foulum (North - Jutland) food supply is the main objective, ahead of abiotic environment and nature/landscape.
In food supply, the focus is on sustainability, especially in looking after the long term soil fertility by management of soil organic matter and soil life in the sandy and therefore rather vulnerable soils in Denmark.
In abiotic environment, the focus is on water quality, i.e. protecting against pesticides and nutrients, notably nitrate. A major reason is that all drinking water in Denmark is derived from groundwater.
In nature/landscape, the fauna component of soil life is highlighted. The potential for natural control of pests is important, to diminish the need for pesticides.

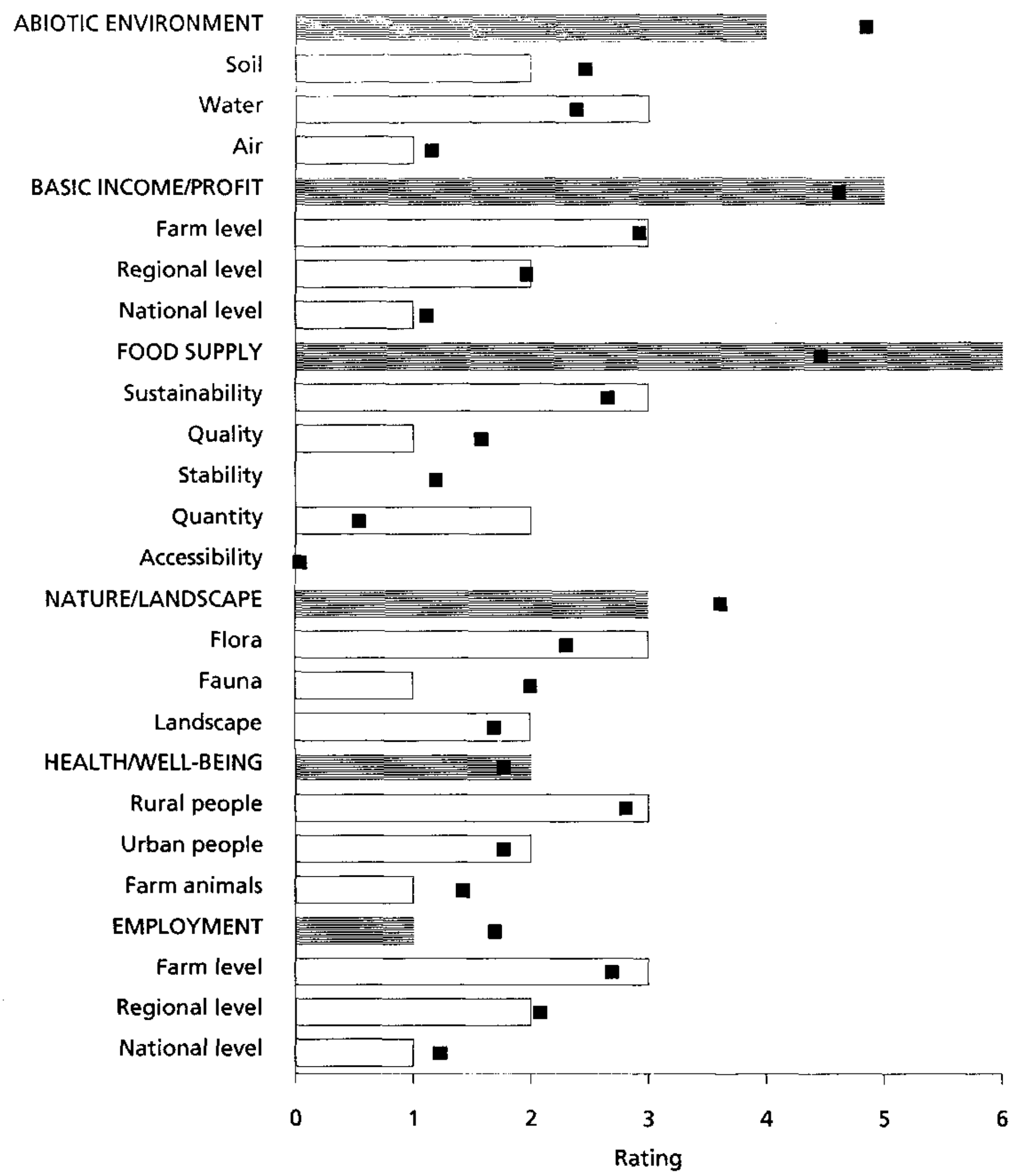

Figure 1.1.4 Hierarchy of objectives in IAFS prototyping in Boigneville (F 1)
(squares - average of 13 European IAFS prototypes)

In Boigneville (south of Paris) food supply is the main objective, ahead of basic/income and abiotic environment.
Food supply is considered the main objective in prototyping, because of the strategic importance of the region for the metropolis of Paris. The focus is on sustainability, especially with respect to maintaining the long term soil fertility of the shallow soils in this area.
To maintain the farmers in the Paris region, income and profit must remain attractive, to prevent the farmers from leaving the land for a job in the city.
The groundwater contamination, especially the nitrate contamination, is threatening the quality of drinking water for Paris. Therefore it will be given special attention in this project.

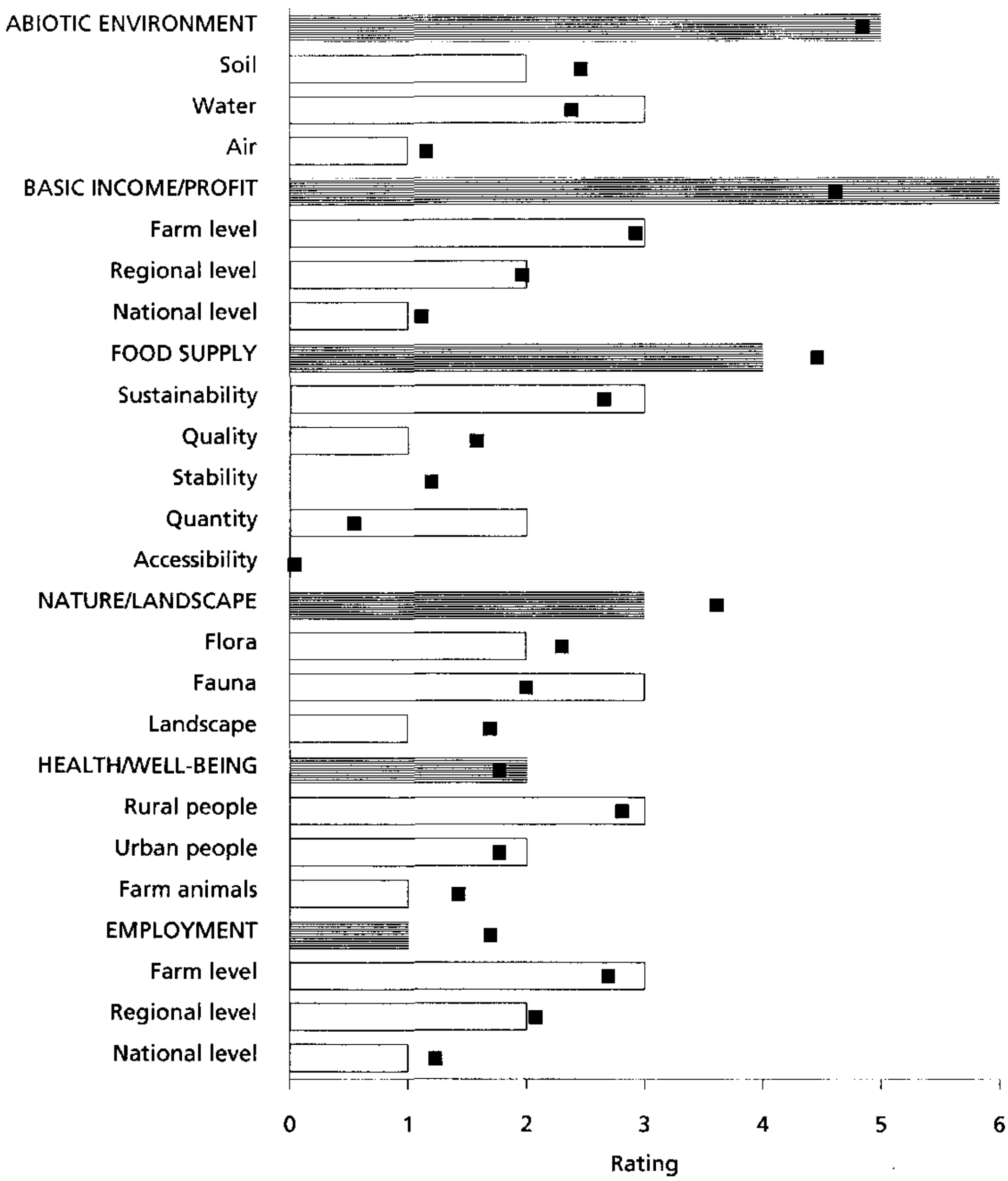

Figure 1.1.5 Hierarchy of objectives in IAFS prototyping in Courseulles (F 2) (squares - average of 13 European IAFS prototypes)

In Courseulles (Normandy), basic income/profit is the main objective, ahead of abiotic environment and food supply.
In abiotic environment the focus is on protecting groundwater against residues of fertilisers and pesticides. Leaching of N is a particular problem in the area.
In food supply the focus is on sustainability by conserving soil fertility.

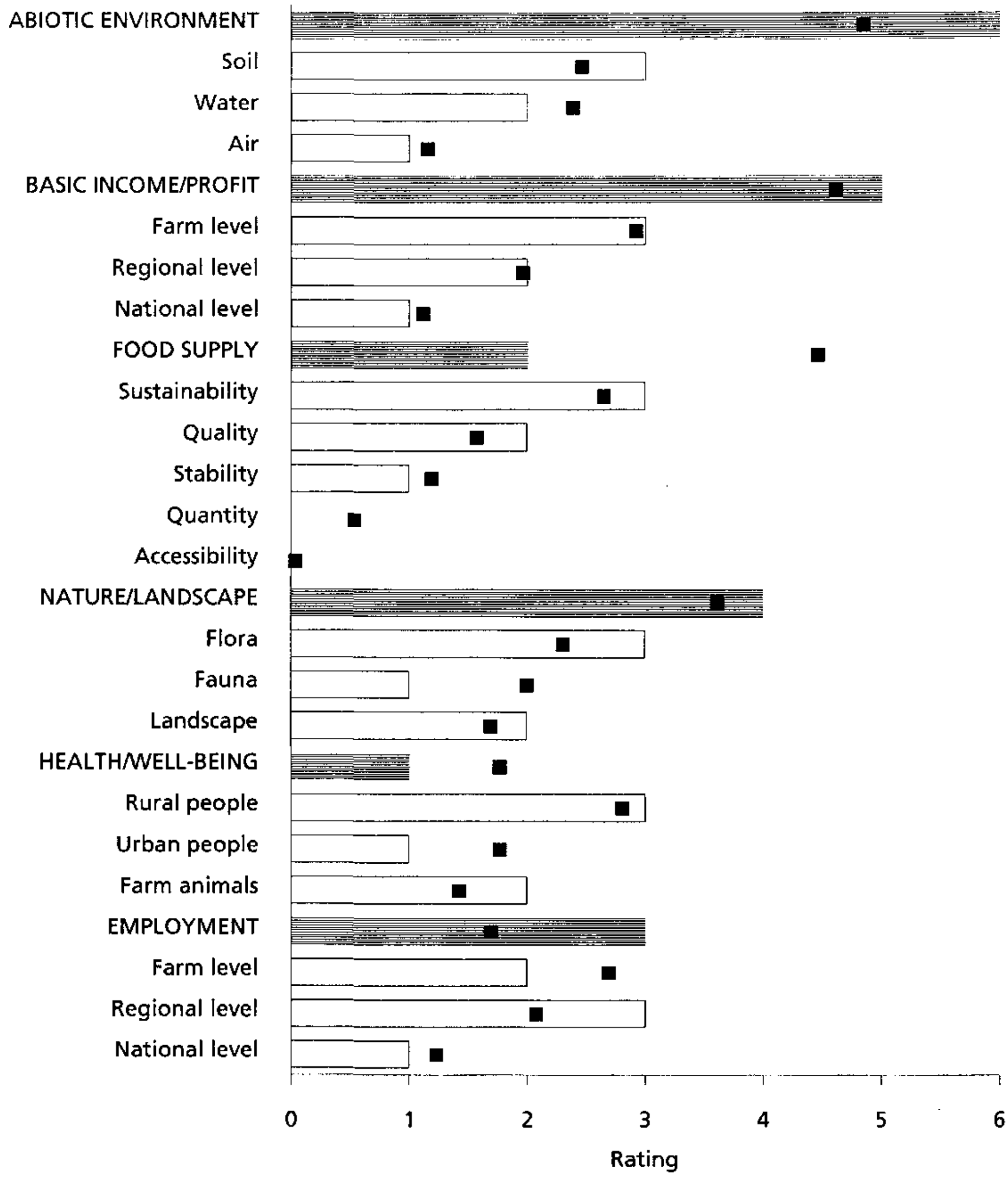

Figure 1.1.6 Hierarchy of objectives in IAFS prototyping in Montepaldi (I 1) (squares - average of 13 European IAFS prototypes)

In Montepaldi (Tuscany), abiotic environment is the main objective, ahead of basic income/profit and nature/landscape.
In abiotic environment the focus is on the soil compartment. Fertiliser inputs will be reduced and an efficient integrated nutrient management applied to achieve a balance between agronomically desired and ecologically acceptable nutrient reserves in the soil.
Basic income/profit will be based on efficient production, though some government protection will remain needed.
Nature/landscape is the third main objective because of its strategic importance for the regional economy which largely thrives on tourism.

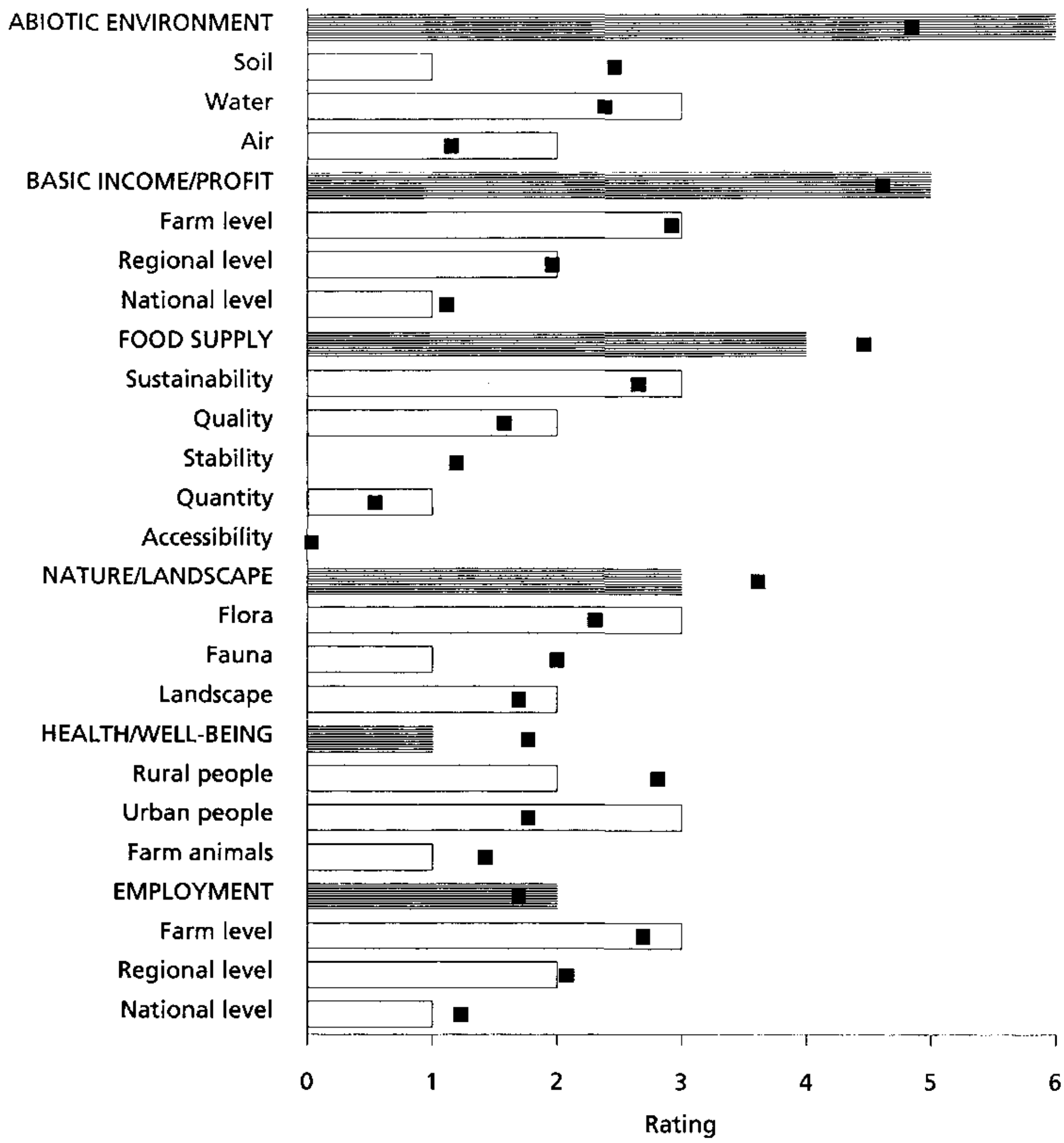

Figure 1.1.7 Hierarchy of objectives in IAFS prototyping in Nagele (NL 1) (squares - average of 13 European IAFS prototypes)

In Nagele (central clay region) abiotic environment is the main objective, ahead of basic income and food supply.
Top priority is given to the reduction of emissions of N and pesticides to the abiotic environment. The focus is on water, both groundwater (future water reserves) and surface water (eutrophication, contamination with pesticides). Air (most important emission- pathway for pesticides, NH_3 volatilisation) and soil (accumulation of nutrients and pesticides) are also considered. An integrated crop protection strategy including progressive exclusion of mobile, volatile and persistent pesticides will minimise environment's exposure to pesticides. Integrated nutrient management will reduce the leaching, volatilisation and accumulation of nutrients.
The second objective is basic income and profit, to be optimised within the world market by efficient production of high quality products.
Food supply is the third main objective in Nagele, with special emphasis on sustainability (nutrient reserves, organic matter content, soil structure/stability on one hand, and saving of energy/non-renewable sources on the other). Quality of produce is considered more important for achieving an appropriate farm income than quantity of produce, given the strong competition on the world market.

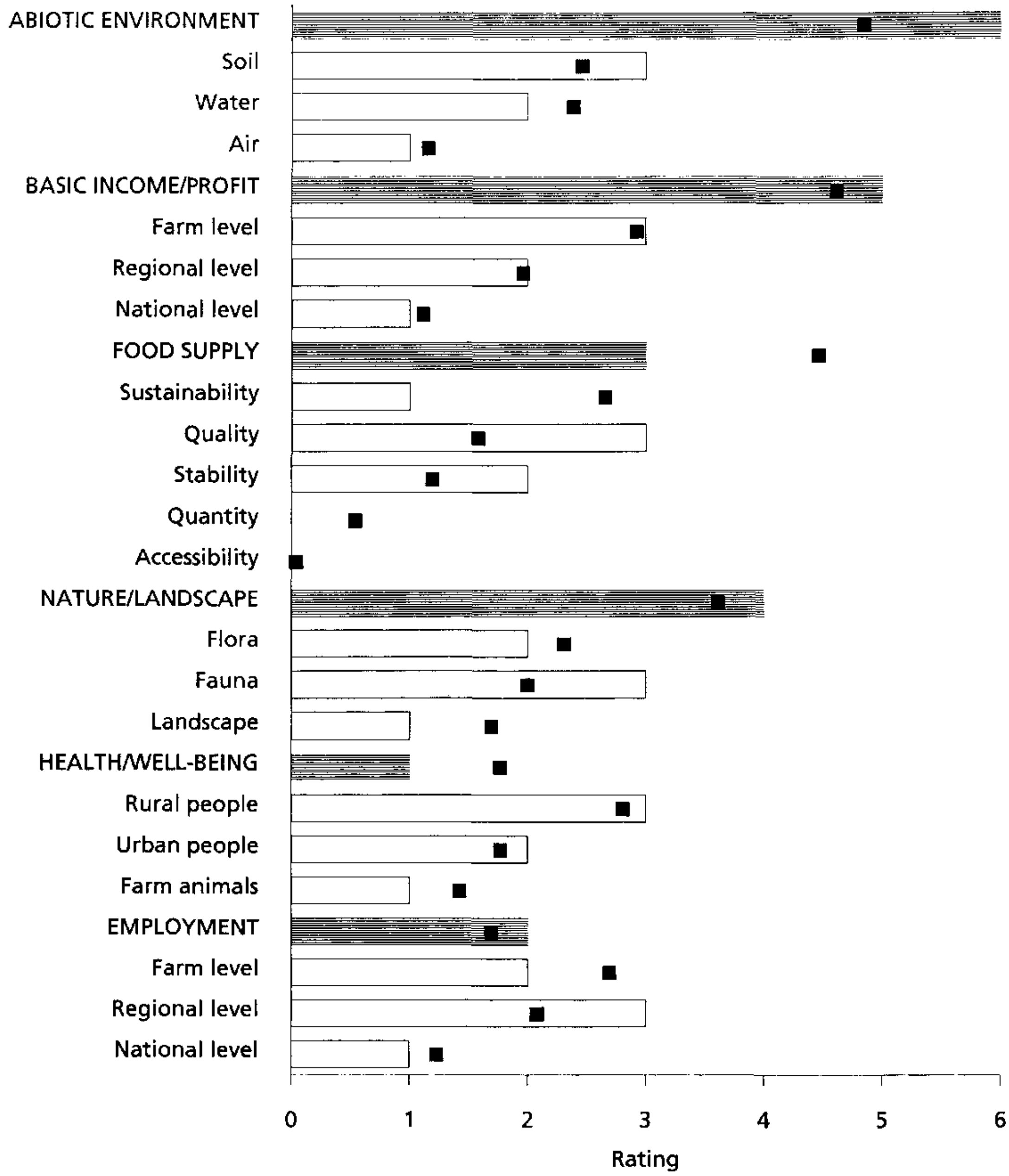

Figure 1.1.8 Hierarchy of objectives in IAFS prototyping in LIFE (UK 1) (squares - average of 13 European IAFS prototypes)

In Long Ashton (near Bristol) abiotic environment is the main objective, ahead of basic income/ profit and nature/landscape.
In abiotic environment soil protection is given the highest priority, especially against accumulation and leaching of nutrients and pesticides. It is based on encouragement of beneficial organisms and processes, especially in the soil, in order to conserve nutrients and reduce the need for external inputs.
Basic income/profit is mainly supported by reducing costs of fertilisers, pesticides and machinery. These are replaced by natural regulatory mechanisms for preventing severe outbreaks of pest, diseases and weeds. These mechanisms include crop rotation and soil life, to be enhanced by targeted soil management.
In nature/landscape as a third objective, the focus is on encouraging beneficial fauna by improving farm infrastructure by establishing ecological reservoirs.

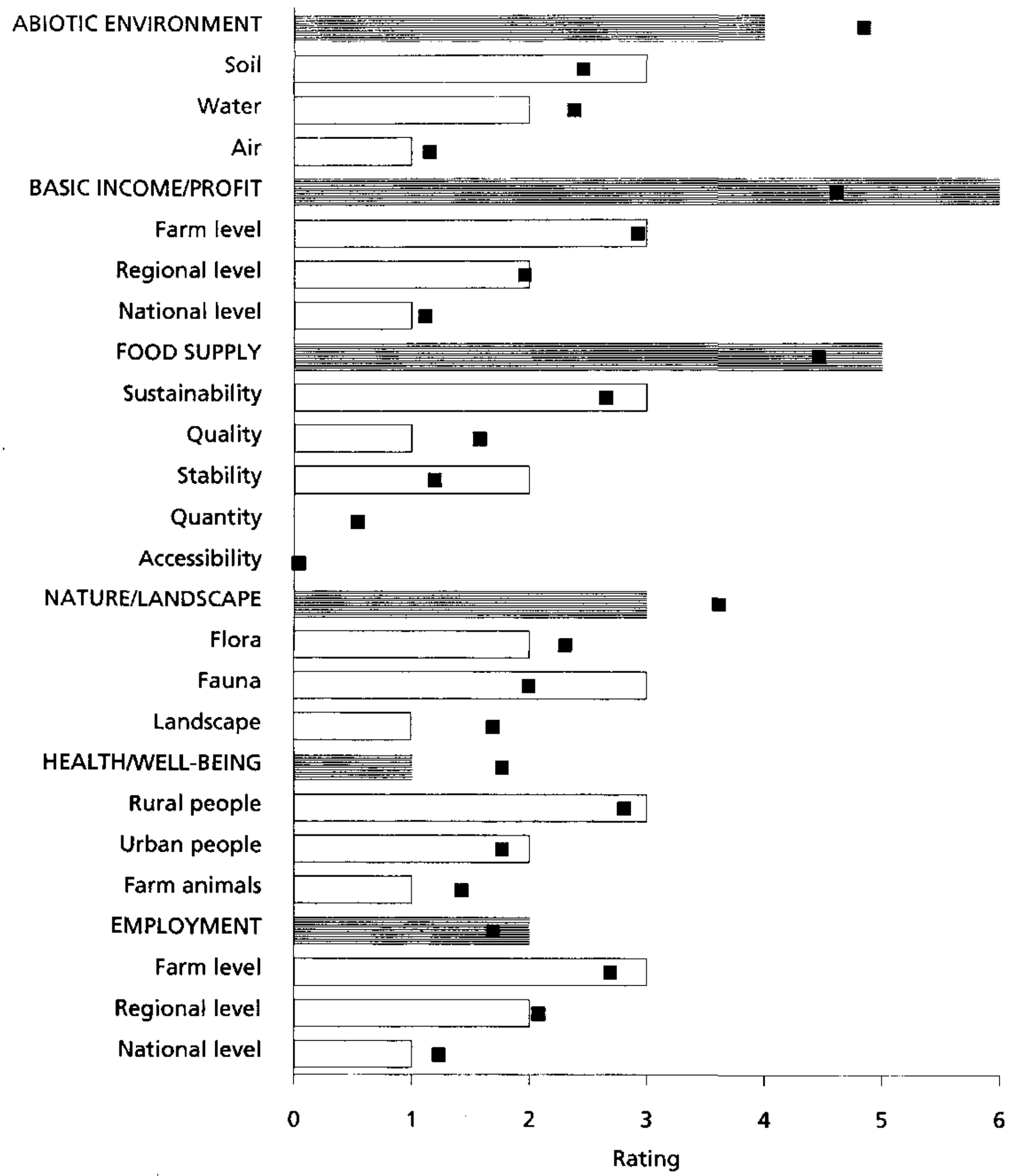

Figure 1.1.9 Hierarchy of objectives in IAFS prototyping in LINK (UK 2) (squares - average of 13 European IAFS prototypes)

In the six experimental sites supervised by ADAS, on commercial farms in England and Scotland, basic income and profit is the main objective, ahead of food supply and abiotic environment. Maintenance of income at the farm level is of prime importance but is based on efficient production and farming to Good Agricultural Practice standards, to protect the environment.
In food supply, sustainability and stability of production are given more emphasis than quality because of the strategic importance of arable farming for the national and international supply of food. Enhancement of the physical structure of the soil is important, to minimise soil erosion, optimise mechanical operations and preserve soil fauna.
In the abiotic environment, balancing of soil nutrient reserves and chemical inputs to match crop requirements and crop offtake is of great importance, to limit potential risks of leaching to water. Inputs of pesticides and fertilisers can only be reduced to a certain extent for environmental benefits, because an economic level of production must be maintained.

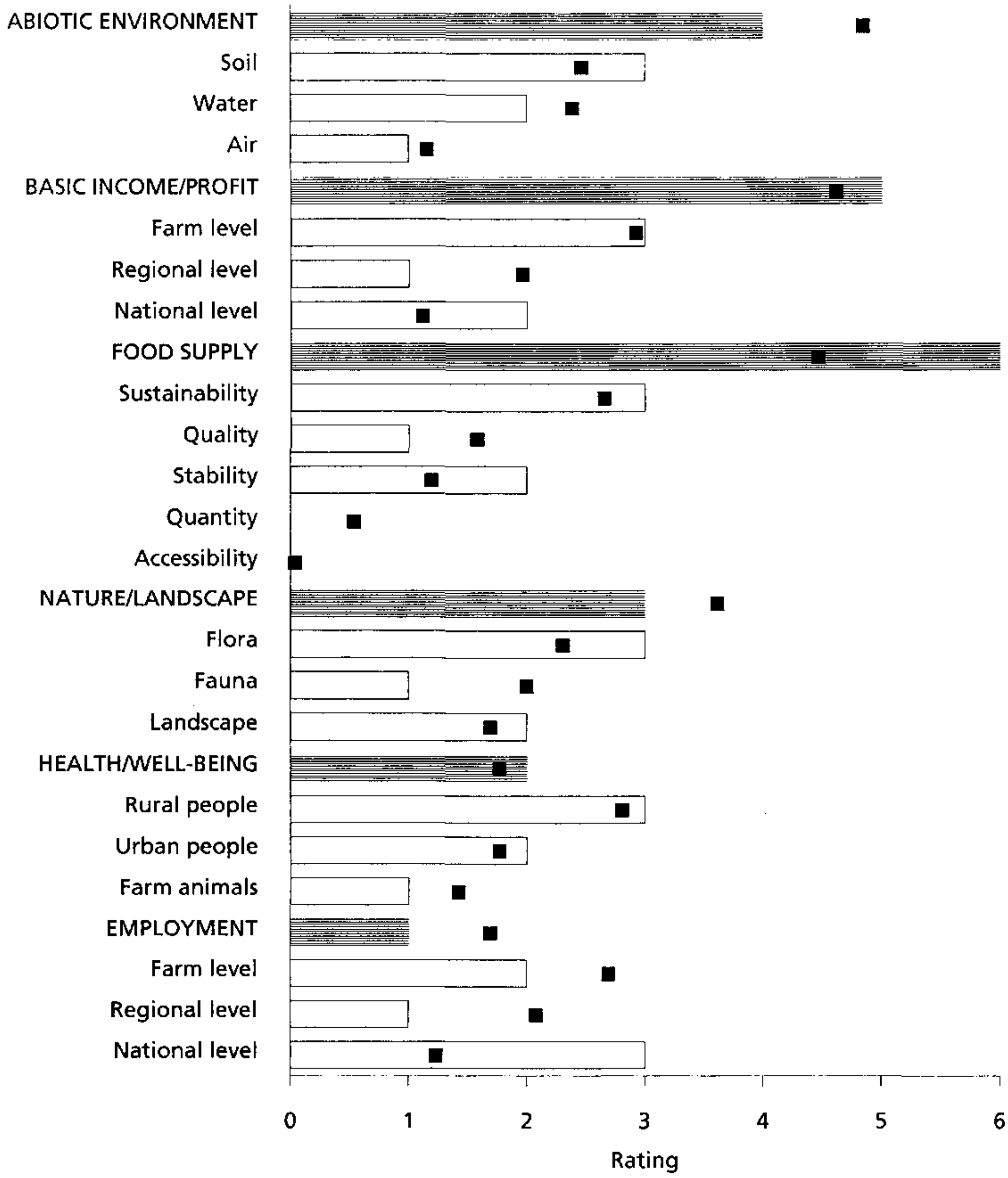

Figure 1.1.10 Hierarchy of objectives in IAFS prototyping in Suitia (FIN 1) (squares - average of 13 European IAFS prototypes)

In Suitia (near Helsinki) food supply is the main objective, ahead of basic income/profit and abiotic environment.

In food supply, the emphasis is on sustainability and stability of production which is difficult to achieve in Finland's unfavourable climatic conditions. Special attention is paid to ensuring biological and physical soil fertility and energy efficiency.

Second objective is basic income/profit, to be supported by low-cost systems, including progressive replacement of chemical inputs.

In abiotic environment, the emphasis is on prevention of water erosion and on maintenance of chemical soil fertility in an agronomically and environmentally optimum range.

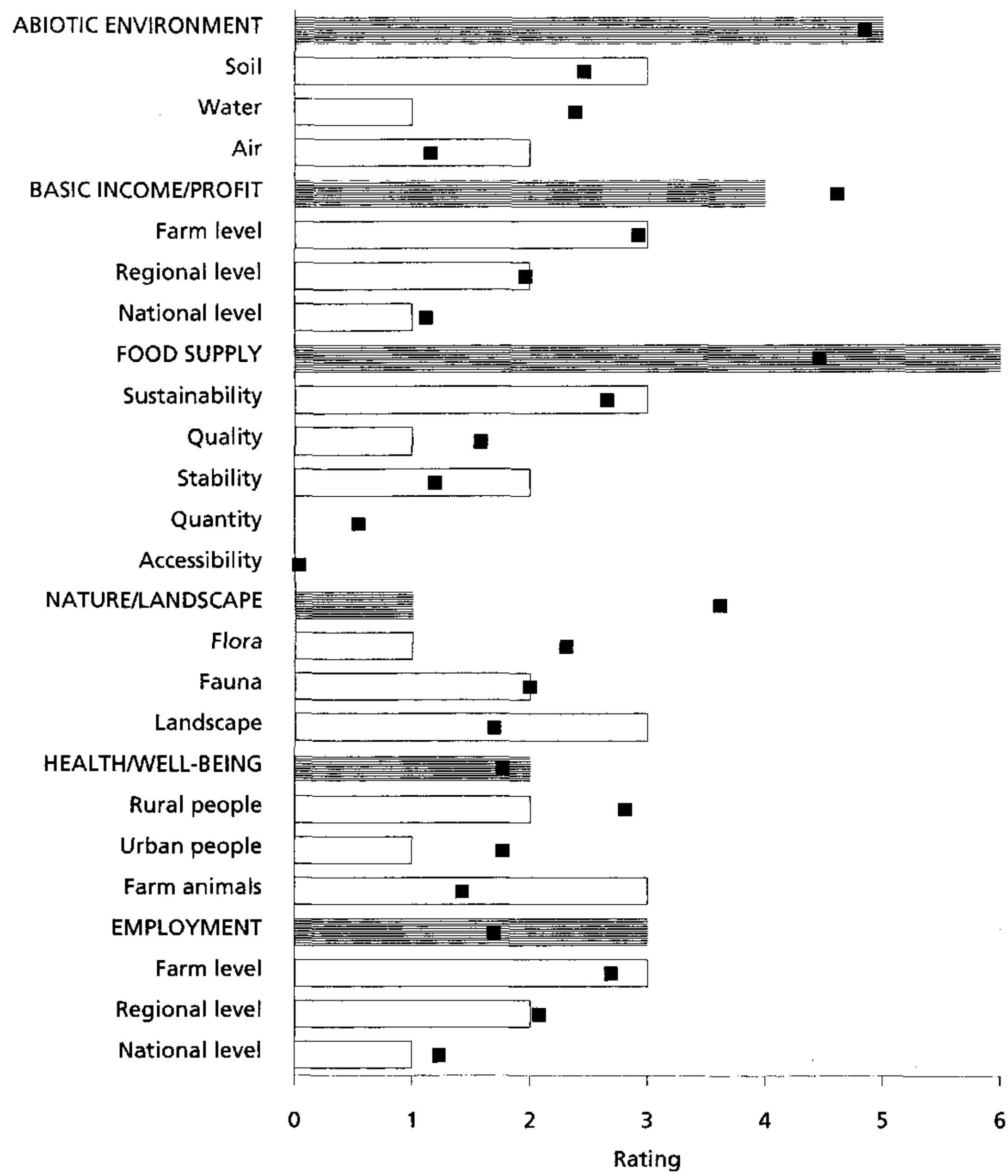

Figure 1.1.11 Hierarchy of objectives in IAFS prototyping in Logården (S 1) (squares - average of 13 European IAFS prototypes)

In Logården (Southwest Sweden) food supply is the main objective, ahead of abiotic environment and basic income/profit.
In food supply the focus is on sustainability, by optimum management of the heavy clay soil (40-50 % clay) aimed at optimum structure and biological activity in the topsoil. A further aim is minimum input of external energy by maximum use of farm-produced bio-energy (fuel from rapeseed) and self-sufficiency in feed-stuffs (mixed farm).
In abiotic environment the focus is on the soil compartment, by minimum input of fertilisers and pesticides.
In basic income/profit the focus is on the farm level, by all of the innovative measures mentioned above.

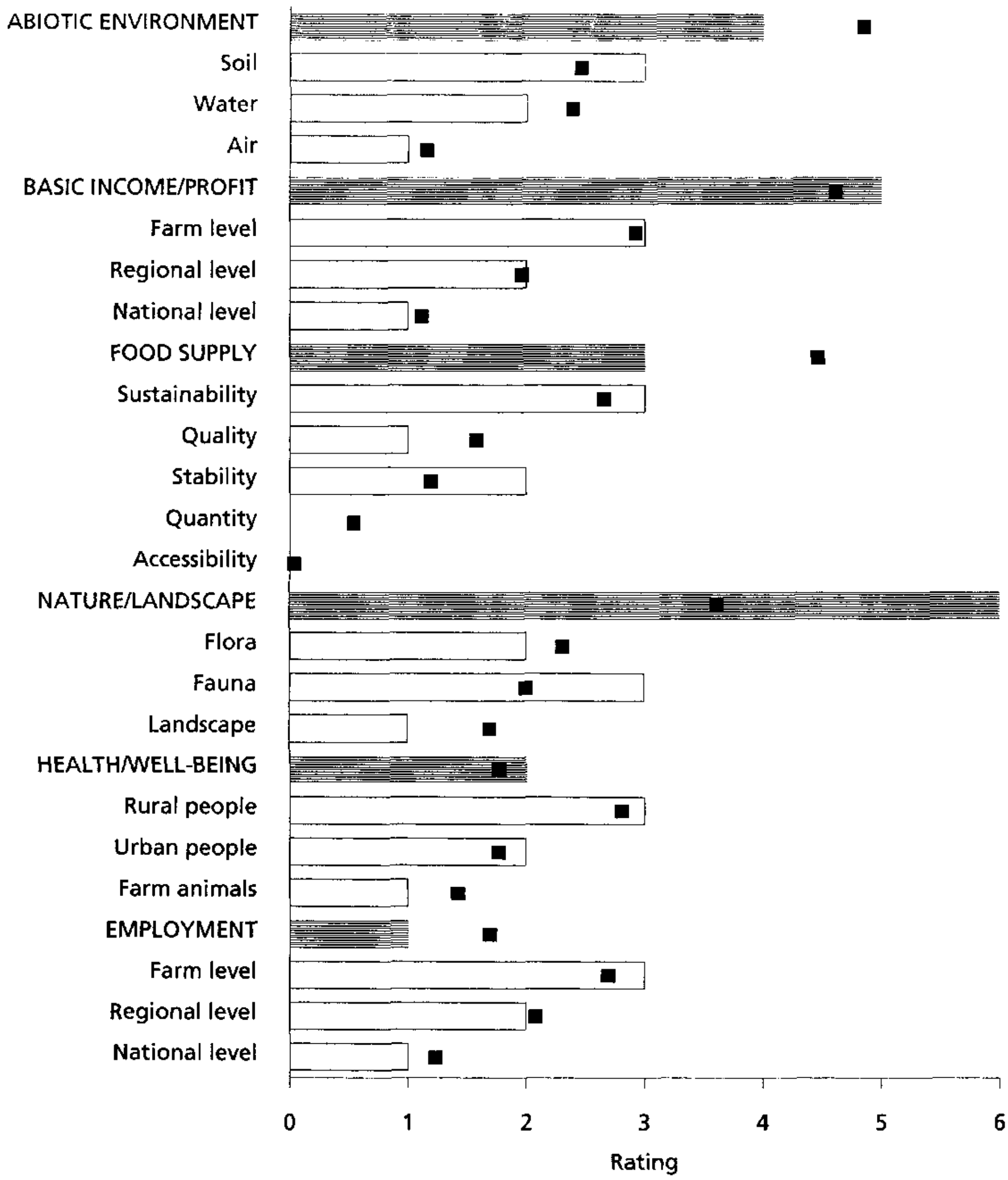

Figure 1.1.12 Hierarchy of objectives in IAFS prototyping in Alnarp (S 2) (squares - average of 13 European IAFS prototypes)

In Alnarp (South Sweden) nature/landscape is the main objective, ahead of basic income/profit and abiotic environment.
In nature/landscape special emphasis is on soil and epigeaeic fauna, in order to increase the species diversity of the agro-ecosystem. Encouragement and conservation of invertebrate animals, predatory insects living on the plants and the microflora living in the topsoil and on the plants, is assumed to reduce the need for pesticides. A moderate use of N fertilisers, minimum soil cultivation and a prudent use of pesticides will contribute to the diversification of fauna and flora.
Basic income/profit will be supported by cost minimisation, as a result of a general reduction in the input of fertilisers, pesticides, fuel and machinery.
Furthermore, minimisation of the inputs will alleviate the pressure on the abiotic environment, with less pollution of soil, water and air.

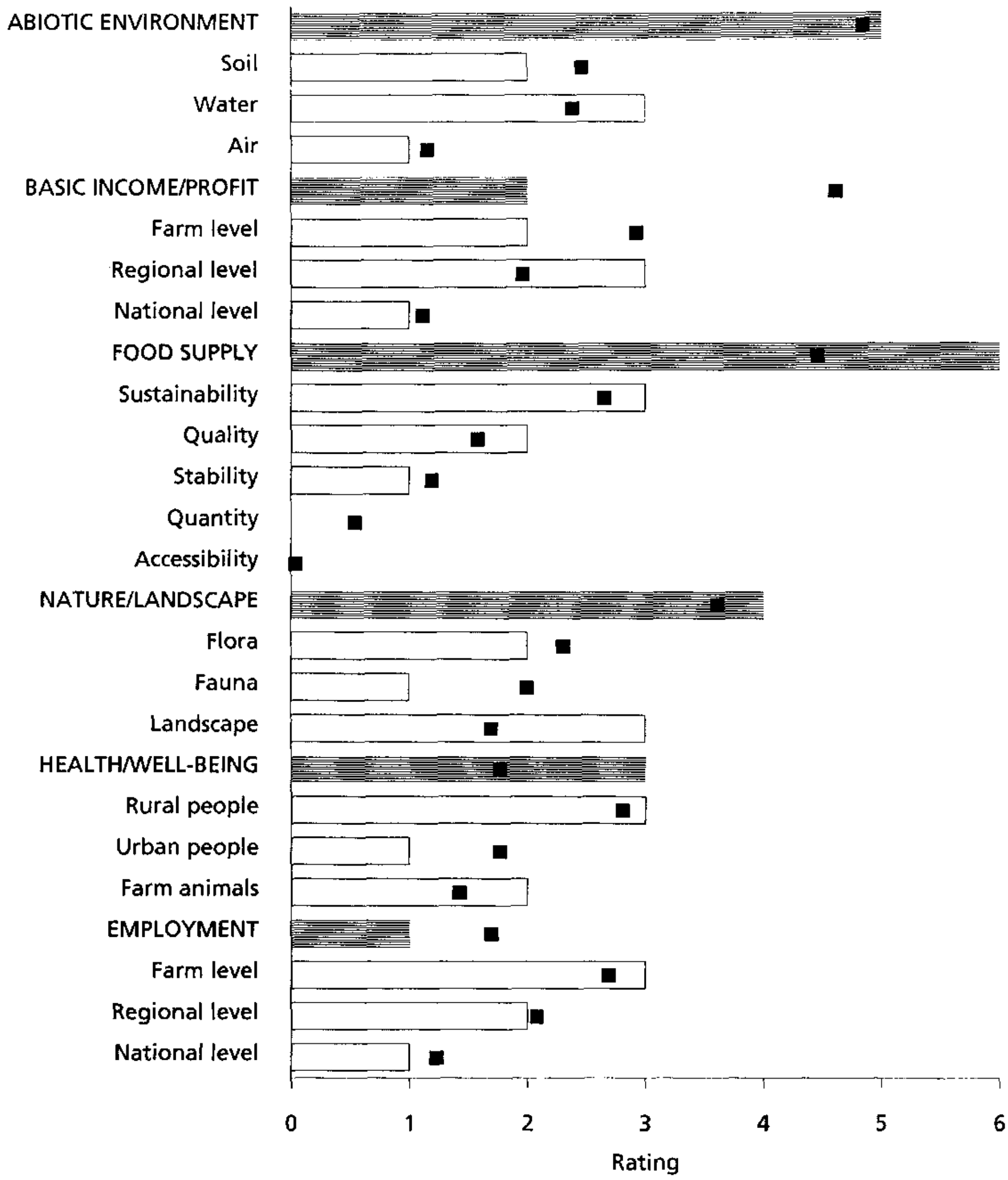

Figure 1.1.13 Hierarchy of objectives in IAFS prototyping in Burgrain (CH 1) (squares - average of 13 European IAFS prototypes)

In Burgrain (near Lucerne/Zurich) food supply is the main objective, ahead of abiotic environment and nature/landscape.
In food supply, the focus is on sustainability.
In abiotic environment, priority is on protecting water against nutrients from the high stocking rates and high manure inputs in the area. Therefore, optimum application of manure in arable crops is being developed.
In nature/landscape, hedges have been planted and ecological reservoirs have been created, to increase beneficials, to replace pesticides.

4.2 EAFS

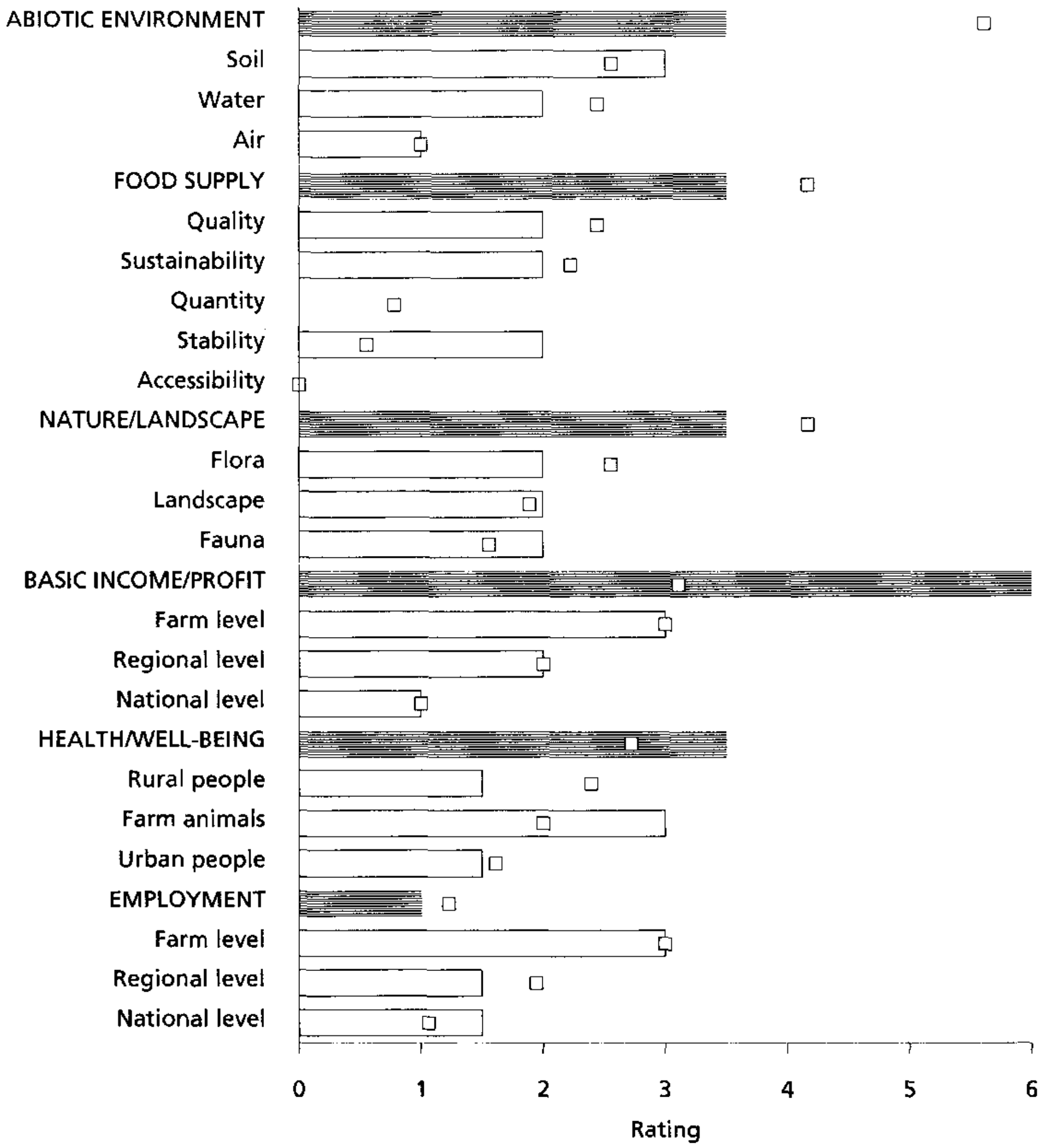

Figure 1.2.1 Hierarchy of objectives in EAFS prototyping in Lautenbach (DE 1) (squares - average of 9 European EAFS prototypes)

In Lautenbach (near Stuttgart) basic income/profit is the main objective, whilst the other general objectives are considered to be of practically equal importance.
In basic income/profit, there is a clear focus on the farm level, which is related to prototyping on a commercial farm.
In the other general objectives, there is little hierarchy between the specific objectives. Exclusion of mineral fertilisers and pesticides and restriction of N input will benefit the abiotic environment. Diversification of crops and non-crop vegetation will contribute to ecosystem stability.

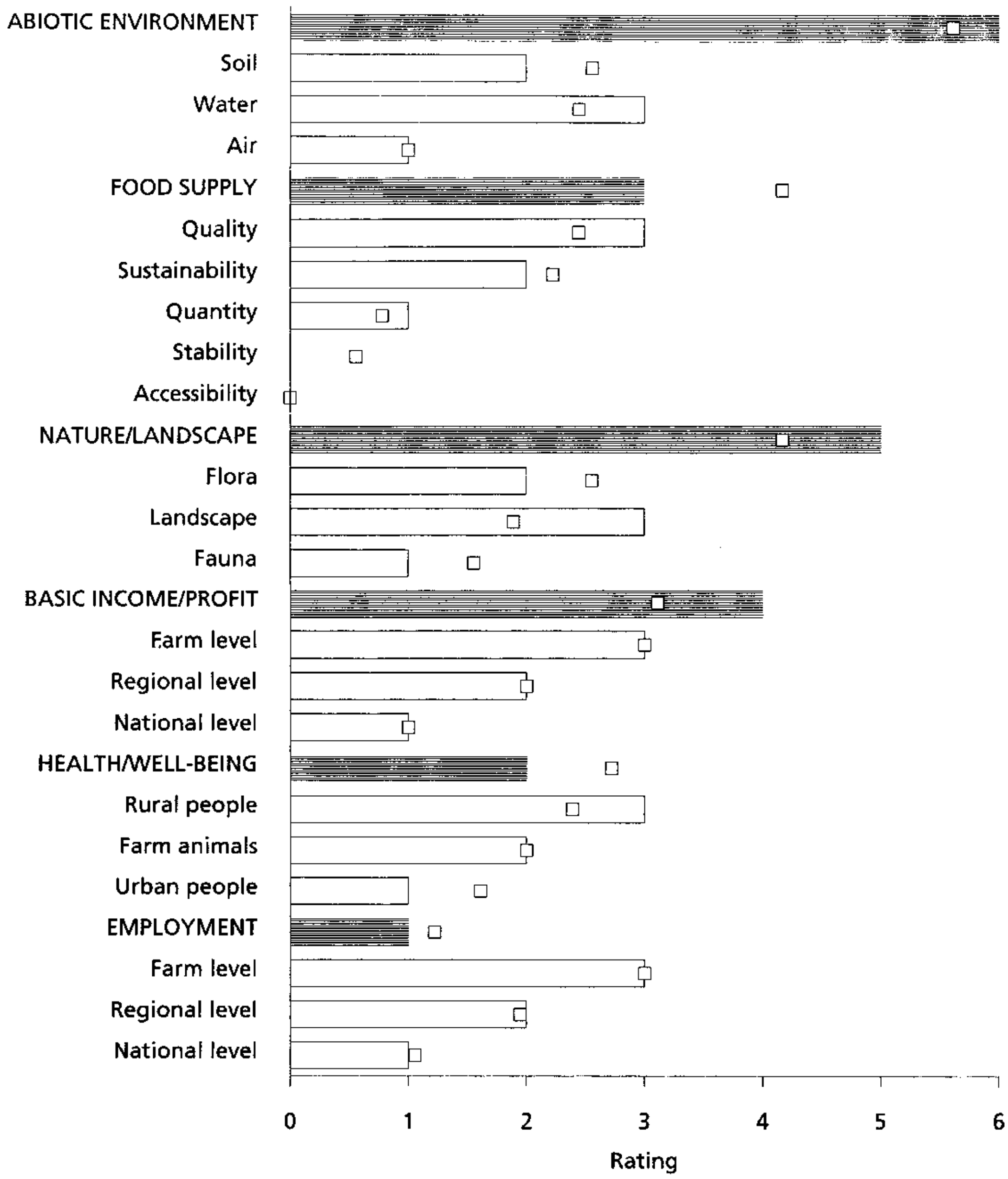

Figure 1.2.2 Hierarchy of objectives in EAFS prototyping in Göttingen for Reinshof (DE 2a) and Marienstein (DE 2b) (squares - average of 9 European EAFS prototypes)

In Göttingen the abiotic environment is the main objective, ahead of nature/landscape and basic income/profit.
In abiotic environment most attention is paid to the protection of groundwater. Nitrate leaching can be a serious problem in ecological farming systems too, either because of cultivation of leguminous crops or of oilseed rape, or in the first years after conversion to biological farming, because of heavy mineral fertilisation over a long preceeding period. Protection of soils against erosion is scarcely less important because of the need for intensive tillage for weed control.
In nature/landscape the focus is on landscape. In contrast to integrated farming systems there is no need to cultivate only a few field crops on large fields. So in ecological farming systems there should be a chance for a greater crop rotation diversity, combined with an ecological infrastructure.
In basic income/profit the focus is on securing a lasting profit at farm level. In practice, crop planning is market-oriented and flexible. In the project, short-term reactions to market changes are not possible because of the remit to investigate the ecological effects of low-input farming.

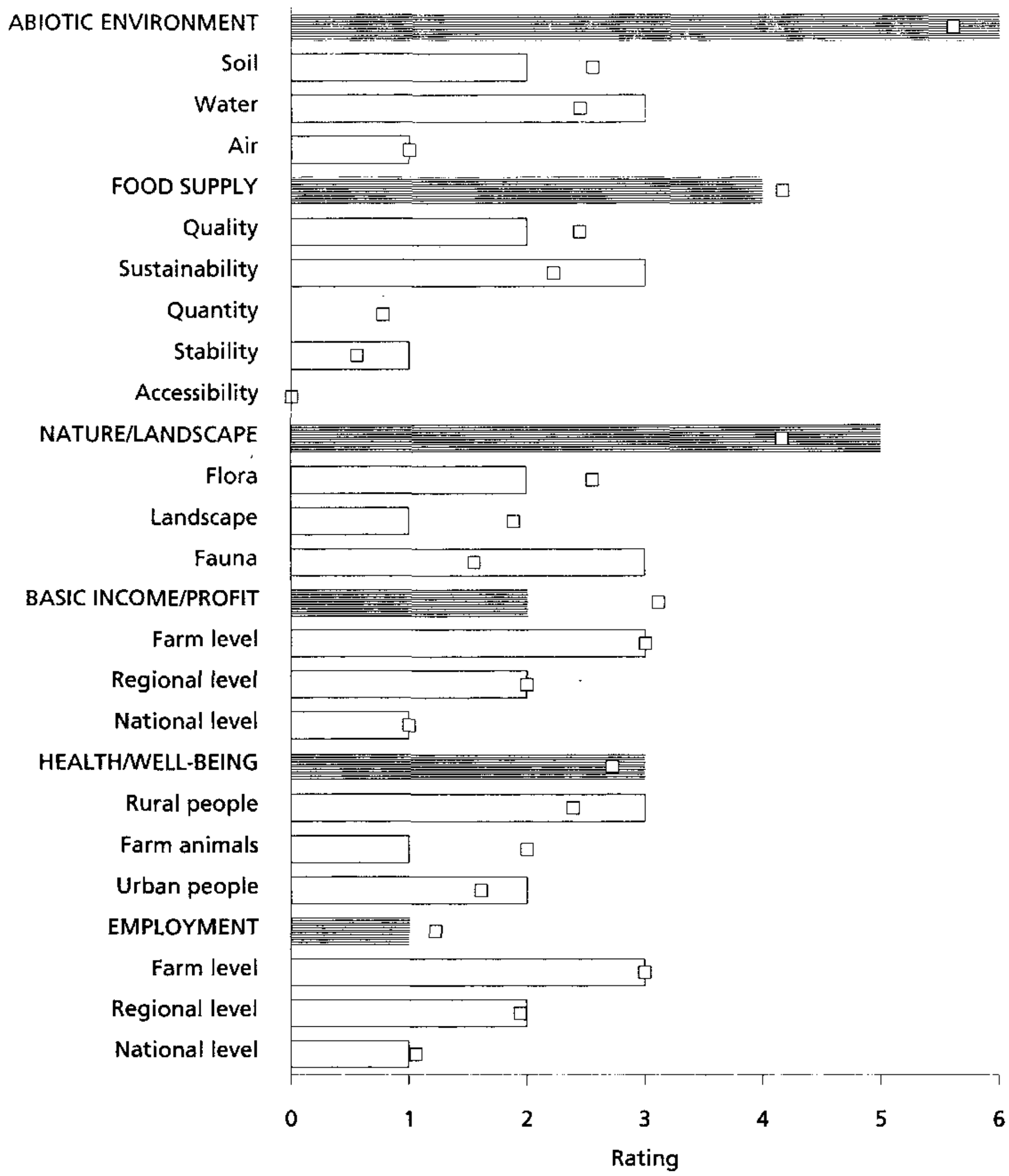

Figure 1.2.3 Hierarchy of objectives in EAFS prototyping in Foulum (DK 1) (squares - average of 9 European EAFS prototypes)

In Foulum (North Jutland) abiotic environment is the main objective, ahead of nature/landscape and food supply.
In abiotic environment the focus is on water. The loss of nutrients, especially nitrogen and phosphorus, leads to pollution of shallow waters (including coastal waters) and of groundwater (including drinking water).
In nature/landscape the focus is on fauna. Saprophytes and polyphagous predators are two elements of great importance for the success of ecological farming. Bio-indicators (fellow players in the complex agro-ecosystem) will guide treatments in the fields.
In food supply the focus is on sustainability and quality, by care for soil fertility in the long term by crop rotation and management of soil organic matter to stabilise soil life and soil structure.

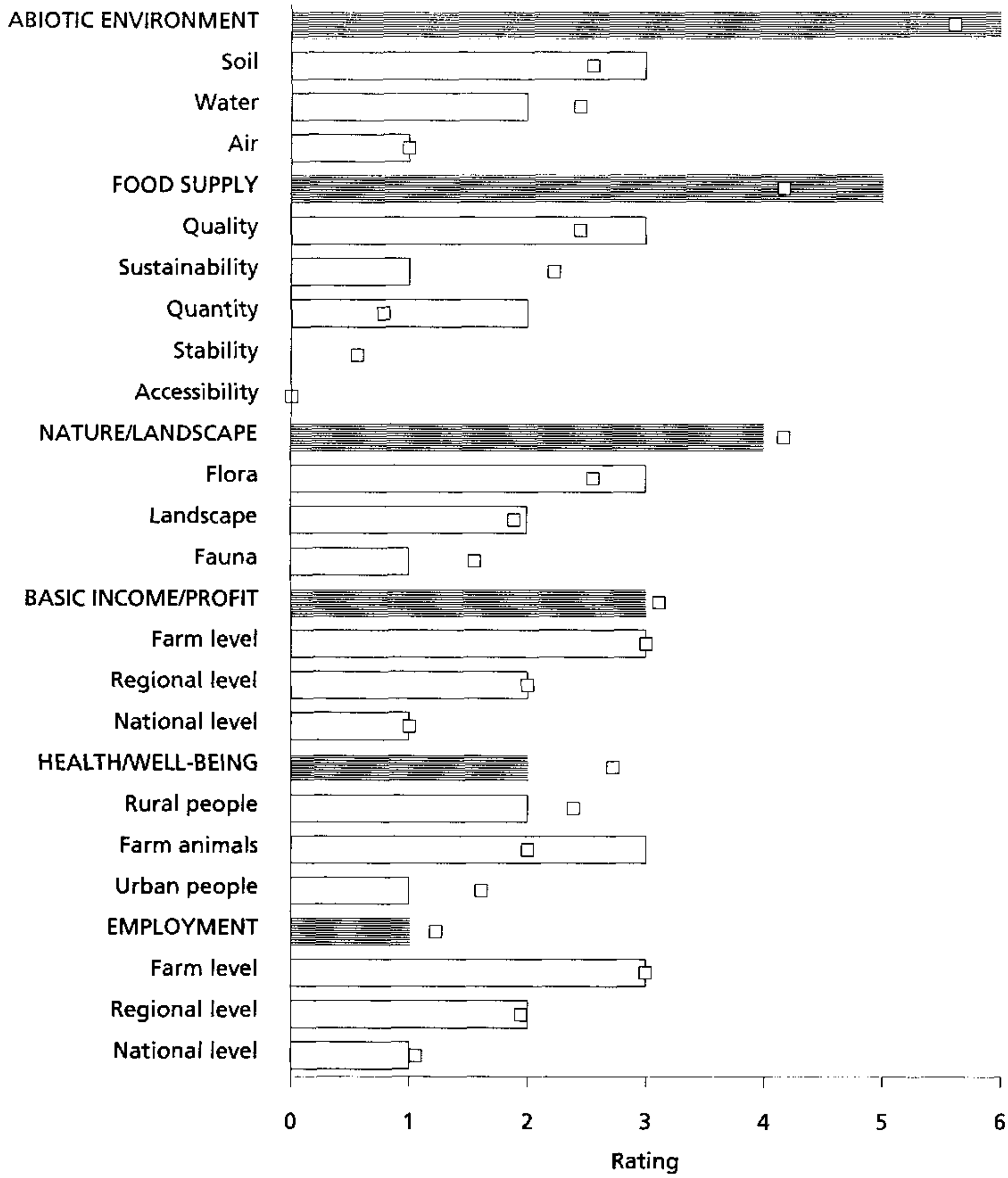

Figure 1.2.4 Hierarchy of objectives in EAFS prototyping in Johnstown (IRL 1) (squares - average of 9 European EAFS prototypes)

At Johnstown (near Wexford) abiotic/environment is the main objective, followed by food supply and nature/landscape.
In abiotic environment the focus is on the soil. A clean soil within which important biological interactions can take place to supply nutrients to crops and to control pests and diseases is a first priority. Groundwater and shallow water receive less attention, since they are less at risk in arable farming in Ireland.
In food supply the focus is on quality. Quantity is less emphasised, though it must sustain farm income/profit.
In nature/landscape the focus is on flora. A greater diversity of flora increases the diversity of fauna and improves the landscape.

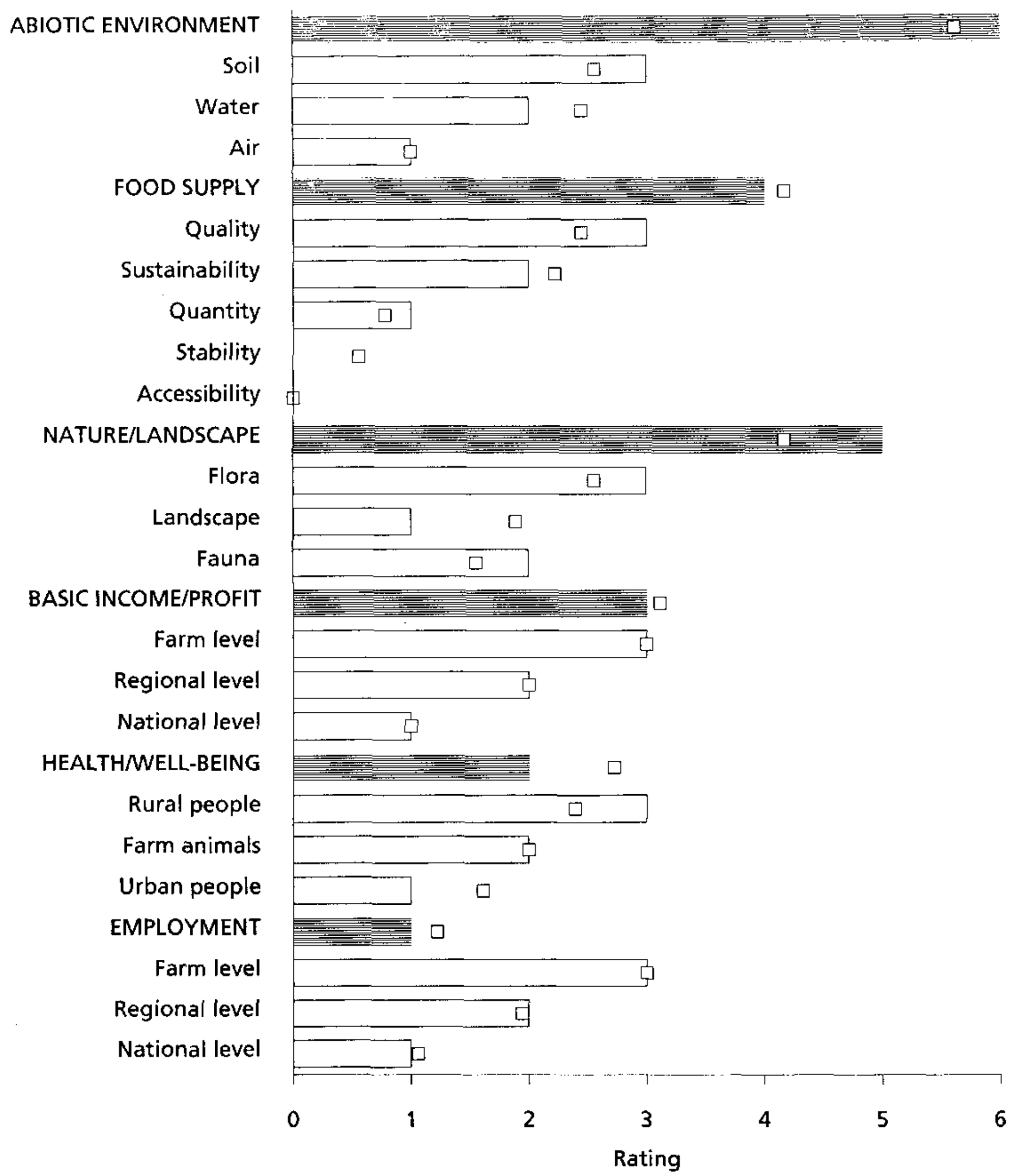

Figure 1.2.5 Hierarchy of objectives in EAFS prototyping in Montepaldi (I 1) (squares - average of 9 European EAFS prototypes)

In Montepaldi (Toscany) abiotic environment is the main objective, ahead of nature/landscape and food supply.
Although pesticides and synthetic fertilisers have been abandoned, abiotic environment remains of primary importance since organic fertilisers and N-fixing crops easily result in the accumulation and eventually leaching of nutrients.
In nature/landscape the focus is on flora by development of an ecological infrastructure (ditches, field margins).
In food supply the aim is to achieve an optimum balance between quantity and quality of produced food, based on the use of alternative technologies.

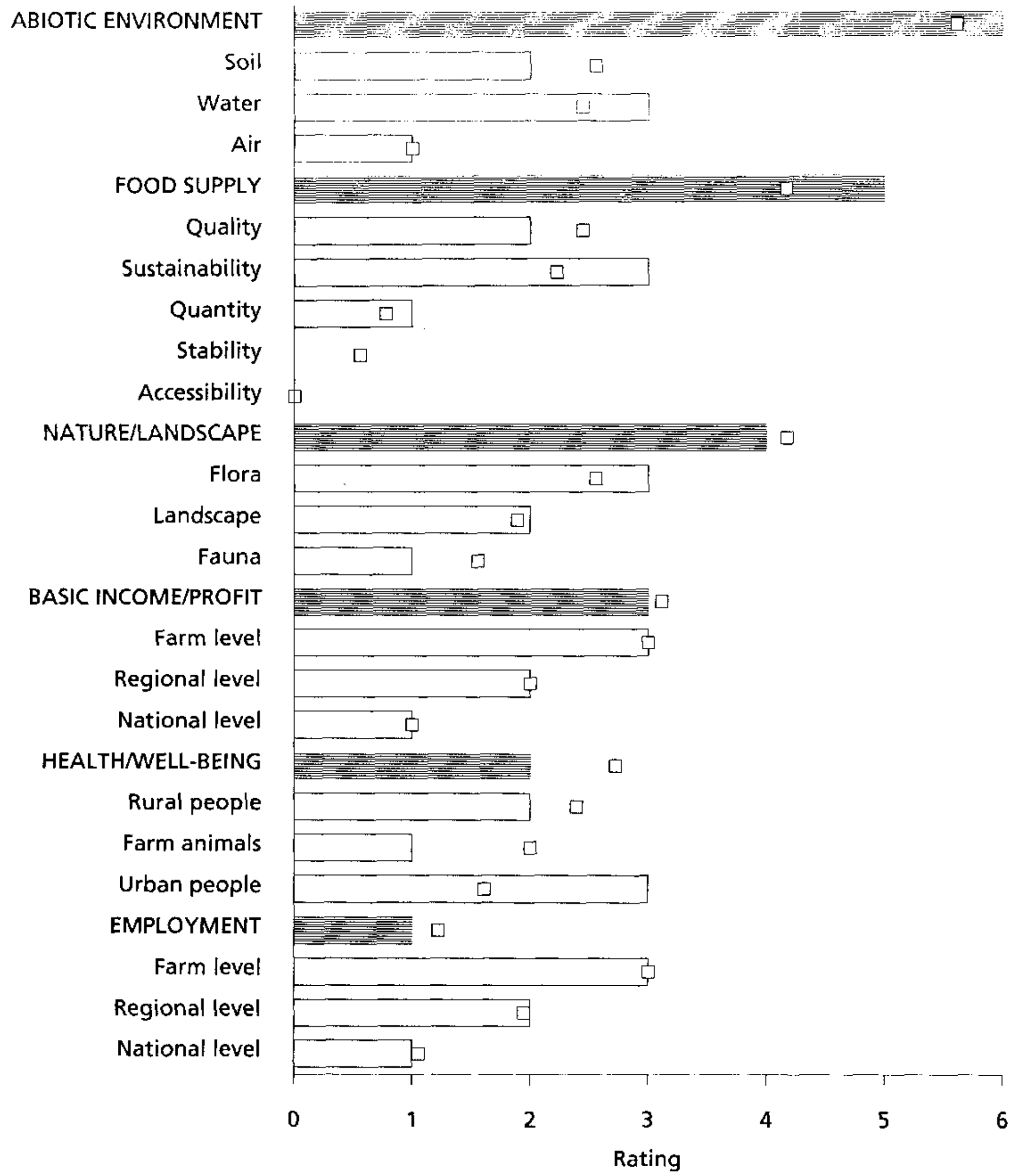

Figure 1.2.6 Hierarchy of objectives in EAFS prototyping in Nagele (NL 1) (squares - average of 9 European EAFS prototypes)

In Nagele (central clay region) abiotic environment is the main objective, ahead of food supply and nature/landscape.
As in IAFS prototyping, the focus in abiotic environment is on water. Nutrient supply based on manure requires special attention, to control nitrate leaching.
In food supply, the focus is on sustainability in terms of soil fertility and saving of energy and non-renewable resources, e.g. by recycling manure.
In nature/landscape, the focus is on flora, as in NL2, in which we are one of the 10 participating farms.

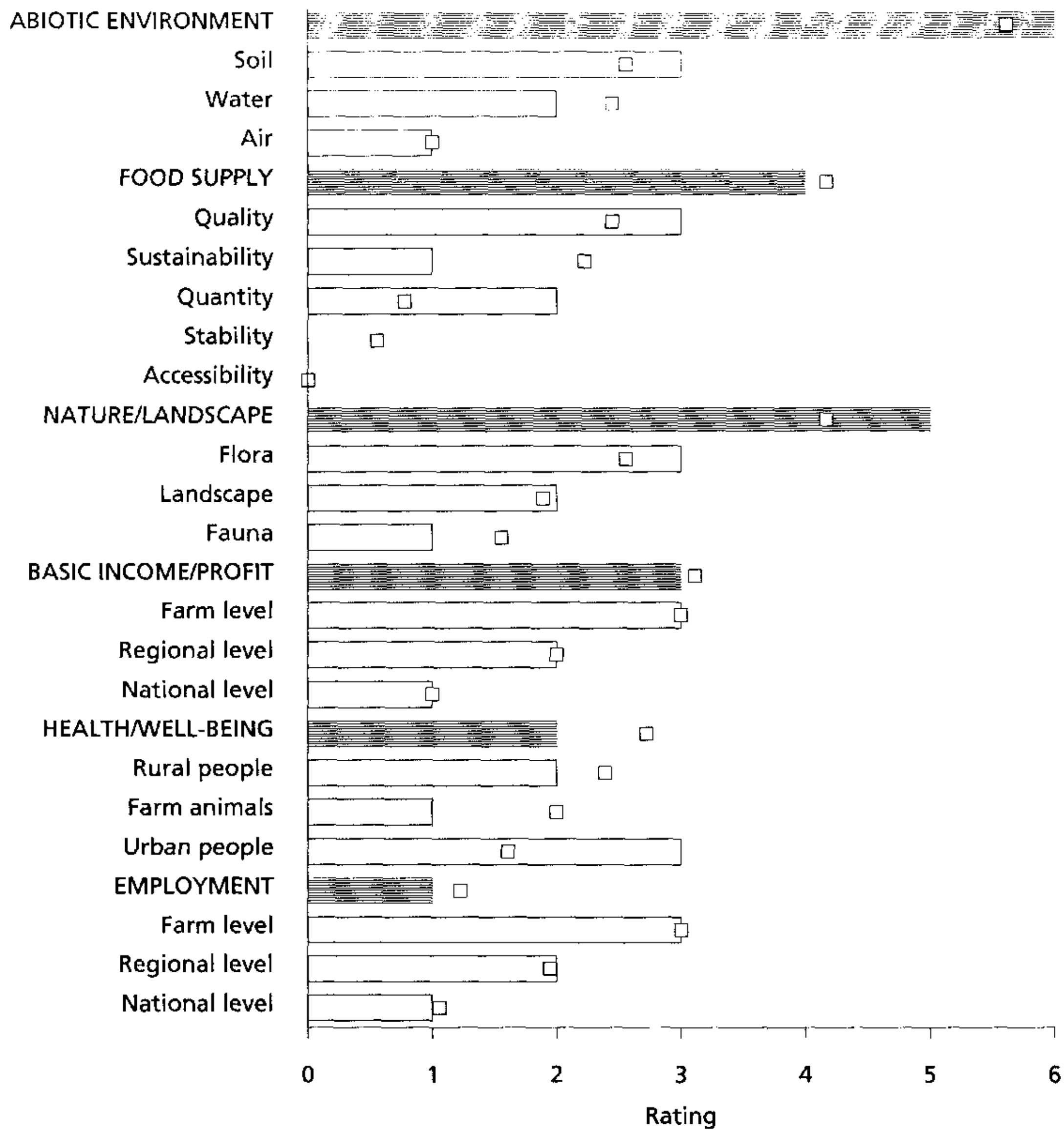

Figure 1.2.7 Hierarchy of objectives in EAFS prototyping in Flevoland (NL 2) (squares - average of 9 European EAFS prototypes)

In Flevoland (central clay region) abiotic environment is the main objective, ahead of nature/ landscape and food supply.
Although pesticides have been abandoned, abiotic environment remains of primary concern since soil fertility in EAFS is chiefly maintained by recycling organic waste, especially manure. Because organic fertilisers generally contain nutrients in ratios which do not correspond with the crop needs, accumulation and eventually leaching of certain nutrients can only be avoided by sophisticated nutrient management focusing on agronomically desired and ecologically acceptable nutrient reserves in the soil.
Nature/landscape is the second main objective, since current organic farming has no explicit guidelines and technology for this increasingly scarce commodity. An ecological infrastructure will overcome this shortcoming and stimulate ecologically-aware consumers to switch to ecological products. In Flevoland, development of an ecological infrastructure will focus on vegetation of the ditch sides, attractive to man and animals.
Food supply is the third main objective, with the focus on an optimum balance of quantity and quality, as an indispensable basis for basic income/profit and health/well-being. This balance, called quality production, requires new and sophisticated technology, including a multifunctional crop rotation as a major substitute for external inputs, notably pesticides.

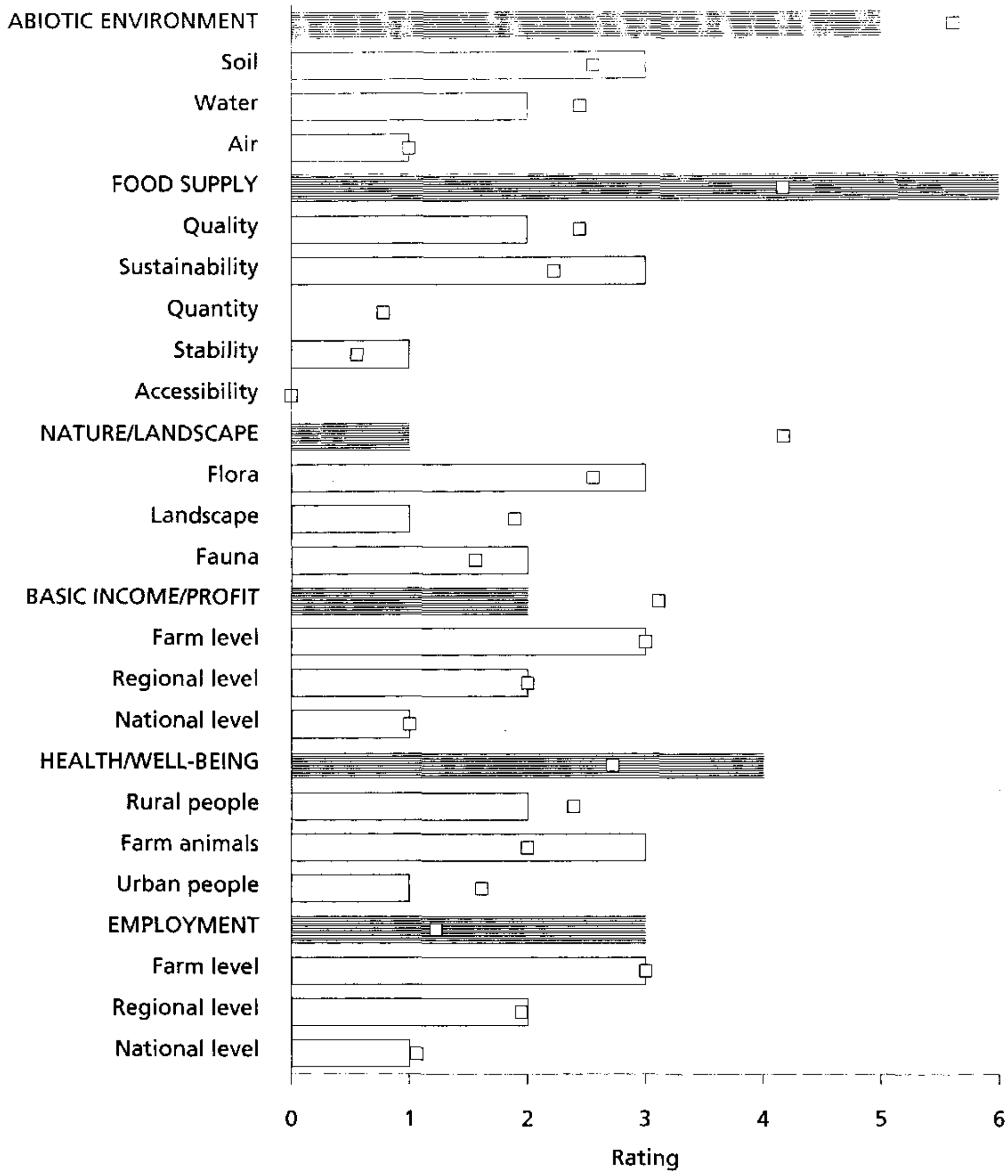

Figure 1.2.8 Hierarchy of objectives in EAFS prototyping in Logården (S 1)
(squares - average of 9 European EAFS prototypes)

In Logården (Southwest Sweden) food supply is the main objective, ahead of abiotic environment and health/well-being.
In food supply the focus is on sustainability by optimum management of the heavy clay soil (40-50 % clay), aimed at optimum structure and biological activity in the topsoil. In addition, plant and animal production are integrated and self-sufficiency in feedstuffs is being pursued, to the benefit of long term soil fertility and energy-efficient farming.
In abiotic environment the focus is on the soil, by avoiding pesticides and by a balanced nutrient management. Furthermore, the recycling of urban waste is being considered.
In health/well-being the focus is on the farm animals by means of a special programme for indoor environment and animal health.

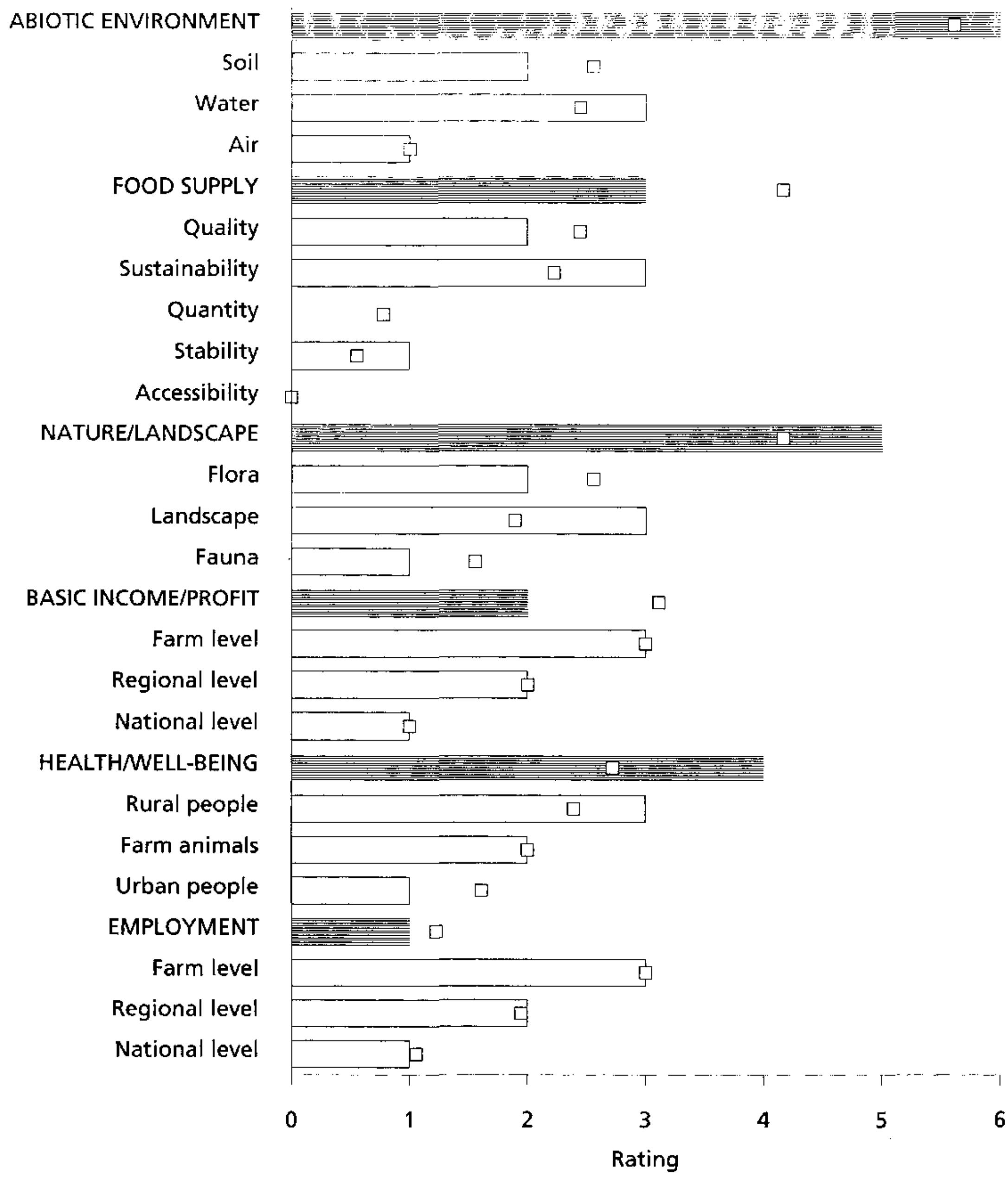

Figure 1.2.9 Hierarchy of objectives in EAFS prototyping in Burgrain (CH 1) (squares - average of 9 European EAFS prototypes)

In Burgrain (near Lucerne/Zürich) abiotic environment is the main objective, ahead of nature/ landscape and health/well-being.
In abiotic environment the emphasis is on protecting surface water and groundwater against leaching, especially of nitrate. As no mineral fertilisers are used, manure is to be applied in an optimum way using new and better machinery.
In nature/landscape, habitat development for natural enemies of pests has higher priority than in IAFS, since pesticides are no longer to be used. Mechanical weed control is being developed to preserve the environment from any exposure to herbicides, although this is difficult in an area with 1100 mm yr^{-1} precipitation.

5 European I/EAFS parameters and methods

Following the procedure described in 2.2 and 2.3, the creative leaders of the ongoing I/EAFS projects, supported by the participants with projects in preparation, prepared provisional shortlists of parameters and methods during the 1993 workshop, using a threshold of at least 5 current or future users. Using these shortlists, each team established appropriate sets of parameters and methods for its prototype (s) in the months after the workshop, on the basis of which a definitive shortlist of parameters and methods has been drawn up. The elaboration and standardisation of these parameters and methods, as foreseen in the second progress report, will mean a major step forwards to further European cooperation in I/EAFS development. Of course, it does not exclude the use of locally appropriate parameters and methods, as will appear from the presentation of the individual projects in Chapter 6.

5.1 Provisional parameters

The criteria of being integrating or being indispensable for a single objective and supported by at least 5 participants, resulted in a provisional shortlist of parameters containing 14 parameters integrating 2 or more general objectives (A category), and 7 additional parameters for 1 or 2 specific objectives (B category) (Table 3).

5.2 Provisional methods and techniques

The criteria mentioned in 5.1 also resulted in a provisional shortlist of methods and techniques being drawn up. It contains 12 methods integrating 2 or more general objectives (A category), and 0 additional methods for 1 specific objective (B category) (Table 4).

5.3 Definitive parameters and methods

Using the provisional lists of parameters and methods (Tables 3-4), the teams of the ongoing projects established a definitive set of parameters and methods for their prototypes after the workshop. These are presented in Chapter 6. Based on these data a definitive shortlist of parameters and methods has been drawn up to cover all the ongoing projects (Table 5). As a result, all A category parameters in the provisional list have been maintained, except for pH. However, none of the 7 parameters of the B category could pass the threshold of being accepted in >5 prototypes and hence were discarded. For the same reason, 5 A-category methods in the provisional list were discarded: MCL, BNF, OSM, ULV and IWEC. The discarded parameters and methods will be considered as local parameters until the next inventory at the 1995 workshop.
The accepted parameters and methods will be elaborated in 1994 and presented in the second progress report, early 1995.

Table 3. Provisional shortlist of I/EAFS parameters according to interest from participants (>5)

Name	Definition (quantified objectives)	Objectives covered *	Participants interested
A. Parameters integrating 2 or more general objectives			
PAB, KAB (PK Annual Balances)	external PK inputs / product PK outputs (P input/P output < x, K input/K output < y)	1.4, 4.1, 4.2, 5, 6	21
NS (Net Surplus)	yield minus all costs, including an 'equal' payment for all labour hours (NS > 0)	2, 3, 6.2	19
OMAB (Organic Matter Annual Balance)	OM inputs/OM outputs (OMAB > x)	1.4, 3, 4.1	18
SCI (Soil Cover Index)	12 months mean soil coverage (0 < SCI < 1)	1.4, 4, 5, 6	16
EI (Ecological Infrastructure)	% of farm managed as nature habitat and corridor, incl. buffer strips (EI > x%)	5, 6	15
EEP (Environment Exposure to Pesticides)	active ingredients kg ha^{-1} * vapour pressure or DT50 or KOM (EEP for air, soil, groundwater: < xa, xs, xw)	4, 5, 6	15
PAR, KAR (PK Available Reserves)	agronomically desired and environmentally acceptable range of PK soil reserves (x < PAR < y, x < KAR <y)	1.1, 1.2, 1.4, 4.1, 4.2, 5, 6	13
PH (pH)	agronomically desired and environmentally acceptable pH range (x < pH < y)	1.1, 1.2, 1.4, 4.1, 4.2, 5, 6	12
EE (Energy Efficiency)	energy output (produce)/energy input (machinery, fertiliser, pesticides) (EE > x)	1.4, 4, 5, 6	12
PI (Pesticide Index)	pest. appl. $year^{-1}$ $farm^{-1}$ / same in conventional reference systems (PI < x)	4, 5, 6	11
NAR (N Available Reserves)	environmentally acceptable range of N_{min} soil reserves (0-100 cm) at start of leaching period, (NAR < 45 kg ha^{-1} sand, NAR < 70 kg ha^{-1} clay)	4.2, 5, 6	8
NGW, NDW (N Groundwater/Drainage water)	environmentally acceptable content of N_{min}. in ground or drainage water (for example NGW or NDW < 11.2 mg l^{-1} = EU norm drinking water)	4.2, 5, 6	7
QPI (Quality Production Index)	(achieved price kg^{-1}/top quality price kg^{-1}) * (marketed kg ha^{-1}/field grown kg ha^{-1}) (0 < QPI < 1)	1.1, 1.2, 2, 3	7
PSD (Plant Species Diversity)	number of target plant species / farm in ecological infrastructure (PSD > x)	5, 6	7
B. Additional parameters for 1 or 2 specific objectives			
SB (Soil Biodiversity)	detritivore biomass and species, predator species (targets ?)	1.4, 5.2	11
EW (Earthworms)	biomass and species, (targets?)	1.4, 5.2	11
FE (Farm Employment)	labour hours $hectare^{-1}$ (> x)	2.1	11
SCA (Soil Cover in Autumn)	% soil covered, end of October (> x %)	1.4	8
SSC (Soil Structure and Compaction)	?	1.4	8
EFD (Epigaeic Fauna Diversity)	beneficial indicator species (invertebrates) (targets?)	1.4, 5.2	8
SR (Soil Respiration)	CO_2, ATP, cellulose decomposition (target?)	1.4	7

* See table 2 for specification

Table 4. Provisional shortlist of I/EAFS methods according to interest from participants (>5)

Name	Definition	Objectives covered *	Participants interested
A. Methods integrating 2 or more general objectives			
MCR (Multifunctional Crop Rotation)	preservation of soil fertility; physically, chemically and biologically to sustain quality production with minimum external inputs (fertilisers, pesticides)	1, 2, 3, 4	21
INM, ENM (Integr./Ecol. Nutrient Management, cover crops, recycling of organic waste and biol. N fixation included)	development and maintenance of agronomically desired and ecologically acceptable soil reserves of nutrients to sustain quality production, primarily through recycling of organic residues.	1, 4, 5, 6	20
ICP (Integrated Crop Protection)	prevention and control of pests, diseases, weeds to sustain quality production with minimum (or even zero) pesticide use based on thresholds and decision support systems for interventions	1, 2, 3, 4, 5, 6	16
MSC (Minimum Soil Cultivation)	maintenance of physical and biological soil fertility, with avoidance of weed problems	1.4, 4.1	16
EIM (Ecological Infrastructure Management)	development and maintenance of a network of linear elements (hedges, ditches, field margins) enabling wild species to establish and migrate and people to recreate	5, 6	15
MCL (Mixing Crops and Livestock)	maintenance of soil fertility; diversification of crop rotation; pest/disease/weed prevention	1, 2, 3, 4, 5, 6	13
EEPS (Environment Exposure-based Pesticides Selection)	step-wise reduction of EEP by targeted substitution of volatile, persistent and mobile pesticides	4, 5, 6	13
BNF (Biological N-Fixation)	saving fossil energy, less air pollution in N fertiliser production	1.4, 4.3	10
OSM (Optimum Soil Management)	preservation of physical and chemical soil characteristics, reduction of expenses (incl. cover crops)	1, 2, 3, 4	10
FSO (Farm Structure Optimisation)	achievement and maintenance of a net surplus ≥ 0, through adjusting the farm size, taking into account yields, costs and labour inputs achieved in the E/IAFS prototyping	2, 3, 6.2	8
ULV (Utilization of Local Varieties)	maintenance of diversity; improvement of local quality production; diminishing of pest risks through resistance; independence from market supply	1.2, 1.4, 5, 6.2	7
IWEC (Integrated Weed and Erosion Control)	adjustment of weed and erosion control by minimum soil tillage, herbicides and specific varieties	1.1, 1.4, 5, 6	6

* see table 2 for specification

Table 5. Definitive short list of multi-objective parameters and methods * in I/EAFS prototyping 1993 (> 5 prototypes)

Parameters Name	Prototypes	Methods Name	Prototypes
NS (Net Surplus)	17	**MCR** (Multifunctional Crop Rotation)	20
EI (Ecological Infrastructure)	17	**INM, ENM** (Integr./Ecol. Nutrient Management, cover crops, recycling of organic waste and biol. N fixation included)	19
NAR (N Available Reserves)	17		
EEP ** (Environment Exposure to Pesticides)	13	**EIM** (Ecological Infrastructure Management)	17
PI ** (Pesticide Index)	12	**FSO** (Farm Structure Optimisation)	12
PAB, KAB (PK Annual Balances)	11	**ICP** (Integrated Crop Protection)	10
QPI (Quality Production Index)	11	**MSC** (Minimum Soil Cultivation)	9
PSD (Plant Species Diversity)	11	**EEPS** (Environment Exposure-based Pesticides Selection)	6
SCI (Soil Cover Index)	10		
OMAB (Organic Matter Annual Balance)	10		
PAR, KAR (PK Available Reserves)	8		
NGW, NDW (N Groundwater/Drainage Water)	8		
EE (Energy Efficiency)	7		

* See tables 3-4 for specification

** Contrary to EEP, PI is only useful if reference CAFS is available.

6 Parameters and methods as Part 2 of the prototype's identity card

The set of multi-objective parameters and methods used in each prototype, to quantify and achieve the 10 major specific objectives as established in the Parts 1 of the prototype's identity cards (Figs 1.1.1-1.1.13 and 1.2.1-1.2.9) is presented as identity card Part 2 in alphabetic order of the country codes. In addition, the creative leaders and their team have provided a brief explanation of Part 2 of their identity card, showing where and to what extent their prototype differs from the others in parameters and methods. Tables 6.1.1-6.1.13 present the IAFS prototypes, Tables 6.2.1-6.2.9 present the EAFS prototypes.
For colleagues with projects in preparation, it must be stressed that *in the prototyping stage it is not necessary to compare I/EAFS prototypes with each other or with conventional reference systems!* Prototypes are simply to be developed until the desired results as expressed in the multi-objective parameters (Tables 6.1-6.2) have been adequately achieved. The next stage is to evaluate and optimise the prototypes with a group of pilot farmers, taking into consideration the regional range of soil, climate and management conditions. Only at this stage can the feasibility and competitiveness of the new farming systems be statistically evaluated, using comprehensive replicates of systems, abiotic environment and management.

6.1 IAFS

Table 6.1.1 Quantifying and achieving objectives in IAFS prototyping in Lautenbach (DE 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Basic income/Profit - Farm level	1.1 Income > DM 70,000 yr^{-1} $employee^{-1}$	1.1 MCR. Inclusion of N-fixing/ Mycorrhiza-adapted crops. Ideotypes for low nutrient inputs.
2. Food supply - Sustainability	2.1 OMAB ≥? 2.2 SB = maximum	
3. Food supply - Stability	3.1 yield variation < x $crop^{-1}$	3.1 Alternation of varieties/ Variety mixtures. see 1
4. Nature/Landscape - Flora	4.1 PSD = ? $farm^{-1}$	4.1 EIM
5. Nature/Landscape - Fauna	see 2.1	see 1, 4
6. Nature/Landscape - Landscape	6.1 EI = 5-10 %	see 5
7. Abiotic environment - Soil	7.1 input/output heavy metals < 1 7.2 PI ≤ 0.5 7.3 Erosion < 1 t $ha^{-1}yr^{-1}$ 7.4 NAR < 50 kg N ha^{-1}	7.1 INM 7.2 MSC see 1
8. Basic income / Profit - Reg. level	see 1	see 1
9. Basic income / Profit - Nat. level	see 1	see 1
10. Abiotic environment - Water		see 7
	Total parameters: 6 EU, 4 local	Total methods 4 EU, 1 local

In Lautenbach the major 10 objectives are quantified in 10 multi-objective parameters, of which 4 (1.1, 3.1, 7.1, 7.3) are not on the European list (Table 3).
Parameter 1.1 specifies the target for basic income and equals NS>0, if the farmer is the only labour force present.
Parameter 3.1 expresses the concern to maintain yield stability, which may be reduced by lowering external inputs.
Parameter 7.1 marks the intention to avoid accumulation of heavy metals.
Parameter 7.3 specifies the target for erosion prevention, very important in an undulating landscape.
The major 10 objectives as quantified in 10 parameters are achieved by 5 methods, of which 1 (3.1) is not on the European list (Table 4).
Method 3.1 is a major substitute for pesticides if crop rotation cannot be optimised for economic reasons.

Table 6.1.2 Quantifying and achieving objectives in IAFS prototyping in Göttingen for Reinshof (DE 2a) and Marienstein (DE 2b)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment - Water	1.1 EEP-water < EEP of CAFS 1.2 Pesticide Groundwater (PGW) < EU-norm drinking water 1.3 NGW < EU norm drinking water 1.4 NAR (0-90 cm) < 50 kg ha^{-1} 1.5 SCI > 0 for at least 11 months	1.1 - 1.2 ICP, EEPS 1.3 - 1.4 INM 1.1 - 1.5 MCR
2. Basic income/Profit - Farm level	2. NS > 0	2. FSO
3. Nature/Landscape - Flora	3.1 EI > 5 % of crop area 3.2 PSD > PSD of CAFS	3. EIM
4. Abiotic environment - Soil	4.1 EEP-soil < EEP of CAFS 4.2 OMAB > 1 4.3 SER (Soil Erosion Rate) < 1 t ha^{-1} yr^{-1} see 1.4	4. OSM, IWEC, MSC see 1
5. Basic income/Profit - Reg. level	5.1 see 2 and 6.1	see 2
6. Employment - Farm level	6.1 Arable farms < 1 labourer 200 ha^{-1} Mixed farms < 1 labourer 100 ha^{-1}	see 2
7. Nature/Landscape - Fauna	7.1 EFD > EFD of CAFS 7.2 EW > EW of CAFS 7.2 SB > SB of CAFS	see 1 (ICP,MCR) see 3 and 4 (MSC)
8. Food supply - Quality	8.1 QPI > x $crop^{-1}$ 8.2 PI < PI of CAFS	8.1 ULV see 1, 3, 4
9. Abiotic environment - Air	9.1 EEP-air < EEP of CAFS	see 1, 3, 4
10. Employment - Reg. level	see 6	see 2
	Total parameters: 14 EU, 2 local	Total methods: 10 EU, 0 local

In Göttingen the major 10 objectives are quantified in 16 multi-objective parameters, of which 2 (1.2, 4.1) are not on the European list (Table 3).
Parameter 1.2 specifies the maximum of overall pesticide emission into the groundwater.
Parameter 4.1 indicates soil erosion is to be minimised, to protect the soil and the surrounding watercourses.
The major 10 objectives as quantified in 16 parameters are achieved by 10 multi-objective farming methods, all on the European list (Table 4).
Of these 10, Minimum Soil Cultivation, Integrated Crop Protection and Ecological Infrastructure Management have been developed or codeveloped in this project and will be described in the next progress report by this team, with the parameters to evaluate and optimise their effectiveness for achieving the objectives set.

Table 6.1.3 Quantifying and achieving objectives in IAFS prototyping in Foulum (DK 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Food supply - Sustainability	1.1 OMAB > 1 1.2 SB not diminishing	1.1 MCR 1.2 INM
2. Abiotic environment - Water	2.1 NDW < 11.2 mg l^{-1}	see 1
3. Food supply - Quality	3.1 O ≤ OPI < 1	see 1
4. Nature/landscape - Fauna	4.1 EW see 1.2 4.3 EFD = ?	4.1 ICP
5. Abiotic environment - Soil	5.1 SCA > 65 % 5.2 PAB, KAB = 1	5.1 OSM
6. Health/Well-being - Rural people	6.1 EEP = 0 (in the long term)	6.1 EEPS
7. Nature/Landscape - Flora	7.1 PSD not diminishing	7.1 EIM
8. Food supply - Stability	see 1.1	see 1
9. Basic income/Profit - Farm Level	9.1 NS > 0	see 1
10. Health/Well-being - Urban people	see 6	see 1, 6
	Total parameters: 11 EU, 0 local	Total methods: 6 EU, 0 local

In Foulum the major 10 objectives are quantified in 11 multi-objective parameters and achieved by 6 multi-objective methods, all on the European lists (Tables 3-4).

Table 6.1.4 Quantifying and achieving objectives in IAFS prototyping in Boigneville (F 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Food supply - Sustainability		
2. Basic income/Profit - Farm level	2.1 Net farm income (excl. labour) > 150 ECU ha^{-1} yr^{-1}	
3. Food supply - Quantity		
4. Abiotic environment - Water	4.1 NGW < 11.2 mg l^{-1} 4.2 PI ≤ 0.5 4.3 SCA > ? %	MCR
5. Basic income/Profit - Reg. level	see 2	
6. Nature/Landscape - Flora	6.1 PSD > 30 $farm^{-1}$	EIM
7. Abiotic environment - Soil	7.1 PAB < 1.1 ; KAB < 1.1 see 4.2	
8. Food supply - Quality	protein content > 11.5 % - winter wheat > 14 % durum wheat 9 % < spring barley < 11 %	cultivar choice, split N applications
9. Nature/Landscape - Landscape	see 6	see 6
10. Health/Well-being - Rural people		
	Total parameters: 6 EU, 2 local	Total methods: 3 EU, 2 local

No initial version available in accordance with format; to be elaborated after Table 6.1.4 has been finalised.

Table 6.1.5 Quantifying and achieving objectives in IAFS prototyping in Courseulles (F 2)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Basic income/Profit - Farm level	1.1 NS ≥ NS of CAFS	FSO
2. Abiotic environment - Water	2.1 NAR < NAR of CAFS 2.2 N input < 0.9 N input of CAFS 2.3 PI < 0.65	2.1 ICP 2.2 N Balance Method
3. Food supply - Sustainability	3.1 EW ≥ EW of CAFS EFD ≥ EFD of CAFS see 2, 5	see 2
4. Basic income/Profit - Reg. level	see 1	see 1
5. Abiotic environment - Soil	5.1 PAB ≤ 1.1 and KAB ≤ 1.1 see 2.2 and 2.3	see 2
6. Nature/Landscape - Fauna	see 3.1	see 2
7. Food supply - Quantity	7.1 Yield ≥ 0.85 yield of CAFS	
8. Basic income/Profit - Nat. level	see 1	see 1
9. Nature/Landscape - Flora	SCI	9.1 cover crops
10. Health/Well-being - Rural people	see 1, 2, 5	see 1, 2, 5
	Total parameters: 8 EU, 2 local	Total methods: 2 EU, 2 local

In Courseulles, the major 10 objectives are quantified in 10 multi-objective parameters, of which 2 (2.2 and 7.1) are not on the European list (Table 3).
Parameter 2.2 marks our effort to alleviate the current N pollution of groundwater by arable farming.
Parameter 7.1 sets a limit to extensification, to protect food supply of France.
The major 10 objectives as quantified in 10 parameters are achieved by 4 multi-objective methods, of which 2 (2.2 and 9.1) are not on the European list (Table 4).
Method 2.2 is the crop-specific fine tuning of external N input as available and mineralising N in the field.
Method 9.1 is the targeted use of cover crops to achieve a multi-functional green cover of the farm outside the cropping season.

Table 6.1.6 Quantifying and achieving objectives in IAFS prototyping in Montepaldi (I 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment - Soil	1.1 PI > 0.5 ? and related to toxicity class 1.2 NAR < 70 kg ha^{-1}	1.1 - 1.3 MCR INM ICP BNF EEPS IWEC
2. Basic income/Profit - Farm level	2.1 NS > 0 2.2 Equity Index > ?	2. FSO
3. Abiotic environment - Water	see 1.1-1.2	see 1.1-1.3 (MCR, INM, ICP)
4. Nature/Landscape - Flora	4.1 EI > 5 % 4.2 PSD > ? $farm^{-1}$	4. EIM
5. Basic income/Profit - Reg. level	see 2.1, 2.2, 4.1, 4.2	see 2, 4
6. Employment - Reg. level	see 2.1, 2.2, 4.1, 4.2	see 2, 4
7. Nature/Landscape - Landscape	see 4.1, 4.2, 5, 6	see 2, 4
8. Food supply - Sustainability	8.1 OMAB > 1 see 1, 2	see 1.1-1.3 (MCR, INM, ICP) see 2-4
9. Employment - Farm level	see 2.1, 2.2	see 2
10. Abiotic environment - Air	see 1.1, 1.3	see 1.1-1.3 (MCR, INM, ICP, BNF)
	Total parameters: 6 EU, 1 local	Total methods: 8 EU, 0 local

In Montepaldi the major 10 objectives are quantified in 7 multi-objective parameters, of which 1 (2.2) is not on the European list (Table 3).
Parameter 2.2 marks our effort to allow rural income keep pace with urban income, since it is of strategic significance for the viability of Tuscany, strongly dependent on an attractive landscape for tourism and agro-tourism.
The major 10 objectives as quantified in 7 parameters are achieved by 8 multi-objective farming methods, all on the European list (Table 4).

Table 6.1.7 Quantifying and achieving objectives in IAFS prototyping in Nagele (NL 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment - Water	1.1 EEP-water < Xw 1.2 $30 < PAR < 50$ * 1.3 $18 < KAR < 26$ * 1.4 NAR ≤ 70 kg ha^{-1} 1.5 NDW < 11.2 mg l^{-1} (EU norm)	1.1 ICP, EEPS 1.2 - 1.5 INM 1.1 - 1.5 MCR
2. Basic income/Profit - Farm level	2.1 NS > 0 2.2 QPI (target per crop 1-x)	2.1 FSO see 1
3. Food supply - Sustainability	3.1 EE > x see 1.2, 1.3	see 1
4. Abiotic environment - Air	4.1 EEP-air < Xa see 1.4, 3.1	see 1
5. Basic income/Profit - Reg. level	see 2.1, 2.2	see 2
6. Nature/Landscape - Flora	6.1 EI >5 % farm area	EIM
7. Food supply - Quality	see 2.2	see 1
8. Employment - Farm level	see 2.1, 2.2	see 2
9. Abiotic environment - Soil	9.1 EEP-soil < Xs see 1	see 1
10. Nature/Landscape - Landscape	10.1 SCI > 0.7 see 6.1	see 6 and 1 (MCR)
	Total parameters: 10 EU, 0 local	Total methods: 6 EU, 0 local

* see legends Table 6.2.7.

In Nagele the major 10 objectives are quantified in 10 multi-objective parameters and achieved by 6 multi-objective farming methods, all on the European lists (Tables 3-4).
Of the 6 methods, Environment Exposure-based Pesticides Selection, Farm Structure Optimisation and Integrated Nutrient Management have been developed in this project and will be described in the next progress report by this team, with the parameters to evaluate and optimise their effectiveness for achieving the objectives set.

Table 6.1.8 Quantifying and achieving objectives in IAFS prototyping in LIFE (UK 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment - Soil	1.1 NAR (0-90 cm) $\leq$ 60 kg ha^{-1} 1.2 N input < 0.75 *N input of CAFS 1.3 PAB < 1, KAB < 1 1.4 OMAB > 1 1.5 SR: Cellulose Decomposition > CD of CAFS	1.1 - 1.5 MCR 1.1 - 1.3 INM 1.1, 1.4, 1.5 MSC 1.2, 1.4 BNF
2. Basic income/Profit - Farm level	2.1 NS > 0 2.2 Energy Use < EU of CAFS 2.3 PI < 0.5 PI of CAFS	2.1 - 2.3 ICP, IWEC see 1 (MCR, INM)
3. Nature/Landscape - Fauna	3.1 EW (biomass) > EW of CAFS 3.2 EFD > EFD of CAFS	see 1 (MCR, MSC)
4. Abiotic environment - Water	4.1 NGW $\leq$ 11,2 mg l^{-1} (EU-norm drinking water)	see 1 (MCR, MSC, INM)
5. Basic income/Profit - Reg. level	see 2.1-2.3	
6. Food supply - Quality	6.1 Wheat Quality: Protein Content > 11 % Hagberg Falling Number (HFN) > 230 Specific Weight > 76 kg hl^{-1} 6.2 Barley Quality: N content < 1.8 %	see 1 (INM, MSC) see 2 (ICP)
7. Nature/Landscape - Flora	7.1 EI > 5 % 7.2 SCA > 80 % (December)	7.1 EIM see 1 (MCR)
8. Food supply - Stability	8.1 Target Yield = 0.85 of CAFS	see 1 (MCR, INM)
9. Abiotic environment - Air	see 1.1-1.2, 2.2-2.3	see 2 (ICP)
10. Employment - Reg. level	see 2	see 2
	Total parameters: 11 EU, 5 local	Total methods: 7 EU, 0 local

In Long Ashton the major 10 objectives are quantified in 16 multi-objective parameters, of which 5 (1.2, 2.2, 6.1, 6.2 and 8.1) are not on the European list (Table 3).
Parameters 1.2 and 2.2 mark our efforts to force back the current overuse of N and energy. Parameters 6.1, 6.2 and 8.1 set limits to the low input of N and pesticides, which may endanger quality and yields of cereals.
The major 10 objectives as quantified in 16 parameters are achieved by 7 multi-objective farming methods, all on the European list (Table 4).
Of these 6, Integrated Crop Protection and Minimum Soil Cultivation have been developed in this project in cooperation with DE1, and will be described in the next progress report by these 2 teams, with the parameters to evaluate and optimise their effectiveness for achieving the objectives set.

Table 6.1.9 Quantifying and achieving objectives in IAFS prototyping in LINK (UK 2)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Basic income/Profit - Farm level	1.1 NS > 0 1.2 QPI $\geq$ x crop^{-1}	1. FSO, MCR, ICP
2. Food supply - sustainability	2.1 x < PAR < y ; PAB < 1 2.2 x < KAR < y ; KAB < 1 2.3 x < pH < y 2.4 NAR 2.5 EE > x	2. INM, OSM, MSC see 1 (MCR, ICP)
3. Abiotic environment - Soil	3.1 PI < 1 3.2 EEP-soil < x see 2.1, 2.2, 2.5	EEPS see 1-2 (ICP, INM, OSM)
4. Basic income/Profit - Reg. level	see 1	see 1 (FSO)
5. Food supply - Stability	see 1.1	see 1(MCR)
6. Nature/Landscape - Fauna	6.1 EFD	see 1-2 (ICP, OSM, EEPS)
7. Abiotic environment - Water	7.1 EEP-water < x_w see 2.4	see 1-2 (INM, ICP)
8. Employment - Farm level	8.1 FE $\geq$?	see 1 (FSO)
9. Nature/Landscape - Flora	9.1 EI > 5 %	9.1 EIM
	9.2 Actual and potential (seed bank) diversity of non crop-species ha^{-1}	see 1 (ICP)
10. Basic income/Profit - Nat. level	see 1	see 1 (FSO)
	Total parameters: 14 EU, 1 local	Total methods: 8 EU, 0 local

In LINK the major 10 objectives are quantified in 15 multi-objective parameters, of which 1 (9.2) is not on the European list (Table 3).
Parameter 9.2 specifies the resulting plant species diversity above and below the ground in the IAFS fields.
The major 10 objectives as quantified in 15 parameters are achieved by 8 multi-objective methods, all on the European list (Table 4).

Table 6.1.10 Quantifying and achieving objectives in IAFS prototyping in Suitia (FIN 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Food supply - Sustainability	1.1 EE > ? 1.2 OMAB > ? 1.3 SSC 1.4 EFD 1.5 SB 1.6 Soil Microbial Biomass (SMB)	MCR, BNF, INM, ICP
2. Basic income/Profit - Farm level	2.1 NS > 0	see 1
3. Food supply - Stability	3.1 yield variation (YV) < YV of CAFS	see 1
4. Abiotic environment - Soil	4.1 NAB ≤ 1 4.2 EEP	see 1
5. Basic income/Profit - Nat. level	5.1 see 2	
6. Nature/Landscape - Flora	6.1 EI > 5 %	EIM
7. Abiotic environment - Water	7.1 SCI > 0.5 7.2 NAR (0-90 cm) < 30 kg ha^{-1} see 6.1	see 1 and 6
8. Food supply - Quality	8.1 QPI > $crop^{-1}$	see 1
9. Nature/Landscape - Landscape	9.1 see 6.1 and 7.1	see 6
10. Health/Well-being - Rural people	see 1.1-8.1	
	Total parameters: 12 EU, 2 local	Total methods: 5 EU, 0 local

In Suitia, the major 10 objectives are quantified in 14 multi-objective parameters, of which 2 (1.6, 3.1) are not on the European list (Table 3).
Parameter 1.6 specifies the role of soil microbes in maintaining soil fertility.
Parameter 3.1 underlines the importance of maintaining yield stability in IAFS prototypes.
The major 10 objectives as quantified in 14 parameters are achieved by 5 multi-objective methods, all on the European list.

Table 6.1.11 Quantifying and achieving objectives in IAFS prototyping in Logården (S 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Food supply - Sustainability	1.1 PAB < ? 1.2 x < PAR < y 1.3 x < pH < y 1.4 EE > x 1.5 SSC 1.6 SOMAB > x 1.7 SB 1.8 SR	1. MCR, INM, MSC, ICP, EIM
2. Abiotic environment - Soil	2.1 0 < SCI < 1 2.2 PI < x 2.3 NAR < ? see 1.1, 1.2, 1.3, 1.5	see 1
3. Food supply - Stability		see 1
4. Basic income/Profit - Farm level	4.1 NS > 0 4.2 FE > ? 4.3 Machinery Input < x $ha^{-1}yr^{-1}$ see 3.1	see 1
5. Abiotic environment - Air	see 1.1, 2.1, 2.2	see 1
6. Employment - Farm level	see 3.1, 4.1	see 1
7. Basic income/Profit - Reg. level	see 3.1	see 1
8. Food supply - Quality	8.1 0 < QPI < 1	see 1
9. Employment - Reg. level	see 3.1, 4.1	see 1
10. Health/Well-being - Farm animals	see 8.1	10.1 Animal health and well-being programme
	Total parameters: 14 EU, 1 local	Total methods: 5 EU, 1 local

In Logården, the major 10 objectives are quantified in 15 multi-objective parameters, of which only 1 (4.3) is not on the European list (Table 3).
Parameter 4.3 sets a limit to our effort to achieve self-sufficiency in energy supply and reduction of herbicide use, which may endanger income/profit of the enterprise by high investments in machines.
The major 10 objectives as quantified in 15 parameters are achieved by 6 multi-objective methods, of which 1 (10.1) is not on the European list (Table 4).
Method 10.1 concerns the objective to improve health/well-being of the cattle kept indoors permanently.

Table 6.1.12 Quantifying and achieving objectives in IAFS prototyping in Alnarp (S 2)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Nature/Landscape - Fauna	1.1 SB 1.2 Index of Ecotoxicity	MCR, MSC, ICP, INM
2. Basic income/Profit - Farm level	2.1 NS > 0 2.2 Machine Input < 110 ECU $ha^{-1}yr^{-1}$	see 1
3. Abiotic environment - Soil	3.1 EE > x 3.2 PKAB ≤ 1 3.3 EEP-soil < x_s 3.4 PI < 0.7 3.5 NAR (0-90 cm) < 30 kg ha^{-1}	see 1 3.3 EEPS
4. Nature/Landscape - Flora	4.1 SCI > 0.8	see 1
5. Basic income/Profit - Reg. level	see 2.1	see 1
6. Food supply- Sustainability	6.1 OMAB > 1 6.2 SSC	see 1
7. Abiotic environment - Water	7.1 EEP-water < x_w see 3.2-3.5	see 1, 3.3
8. Food supply - Stability	8.1 Yield variation (CV) < 15 %	see 1
9. Nature/Landscape - Landscape	EI > 5 %	
10. Health/Well-being - Farm animals	see 1.2	
	Total parameters: 12 EU, 3 local	Total methods: 5 EU, 0 local

In Alnarp the major 10 objectives are quantified in 15 multi-objective parameters, of which 3 (1.2, 2.2 and 8.1) are not on the European list (Table 3).
Parameter 1.2 sets limits to the use of pesticides to save non-target fauna, in addition to EEP (3.3).
Parameter 2.2 specifies the low input of machines, to save energy and costs.
Parameter 8.1 puts a limit to the low-input approach, to prevent yield instability. The major 10 objectives as quantified in 15 parameters are achieved by 5 multi-objective methods, all on the European list (Table 4).

Table 6.1.13 Quantifying and achieving objectives in IAFS prototyping in Burgrain (CH 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Food supply - Sustainability	1.1 OMAB > 1 1.2 EW > EW of CAFS 1.3 SR > SR of CAFSP	1. MCR, ENM
2. Abiotic environment - Water	2.1 PI < x 2.2 PAB < 1.2 2.3 Max. N Input < 150 kg ha^{-1}	see 1
3. Food supply - Quality	3.1 ?	3. ICP see 1
4. Nature/Landscape - Landscape	4.1 SCA * ≥ 50 % 4.2 EI = 5 %	4. EIM
5. Abiotic environment - Soil	see 2	5. MSC see 3
6. Health/Well-being - Rural people	6.1 NS > 0	
7. Nature/Landscape - Flora	see 4.2	see 4
8. Food supply - Stability		see 3
9. Basic income/Profit - Reg. level	9.1 see 1.1-8.1	9. FSO see 1-4
10. Health/Well-being - Farm animals	10.1 see 1.1-1.3	10. see 1
	Total parameters: 8 EU, 1 local	Total methods: 6 EU, 0 local

* sown meadows, green fallow (100), cover crops including maize with undersowing, winter rape (80), winter barley, triticale, rye (50), winter wheat (40), fallow with chopped maize straw (20), uncultivated field after cereals (20), bare fallow (0).

In Burgrain the major 10 objectives are quantified in 9 multi-objective parameters, of which 1 (2.3) is not on the European list (Table 3).
Parameter 2.3 is the legal guideline in the area to protect the environment against N losses.
The major 10 objectives as quantified by 9 parameters are achieved by 6 multi-objective methods, all on the European list (Table 4).

6.2 EAFS

Table 6.2.1 Quantifying and achieving objectives in EAFS prototyping in Lautenbach (DE 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Basic income/Profit - Farm Level	1.1 Basic income > IAFS	1.1 MCR 1.2 On-farm sales
2. Basic income/Profit - Reg. level	see 1.1	
3. Abiotic environment - Soil	see IAFS 7	see 1.1 and 4.1
4. Food supply - Sustainability	?	4.1 ENM see 1
5. Food supply - Quality	?	
6. Abiotic environment - Water	see IAFS 7	see 1.1 and 4.1
7. Nature/Landscape - Flora	7.1 EI = 5-10 % 7.2 PSD > ? $farm^{-1}$	7.1 EIM 7.2 Sowing target species 7.3 Moderate weed management in field margins
8. Nature/Landscape - Fauna	?	see 1.1, 7
9. Nature/Landscape - Landscape	see 7	see 7
10. Basic income/Profit - Nat. level	see 1.1	
	Total parameters: 4 EU, 3 local	Total methods: 3 EU, 3 local

No initial version available in accordance with format; to be elaborated after Table 6.2.1 has been finalised.

Table 6.2.2 Quantifying and achieving objectives in EAFS prototyping in Göttingen for Reinshof (DE 2a) and Marienstein (DE 2b)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment - Water	1.1 EEP-water = 0 1.2 NAR (0-90 cm) < 50 kg ha^{-1} 1.3 NGW < EU-norm drinking water 1.4 SCI > 0 for at least 11 months	1.1 - 1.4 MCR 1.2 - 1.3 ENM
2. Nature/Landscape - Landscape	2. EI > 5 % of crop area	2. EIM
3. Basic income/Profit - Farm level	3.1 NS > 0	3. FSO
4. Abiotic environment - Soil	4.1 EEP-soil = 0 4.2 SER (Soil Erosion Rate) < 1 t ha^{-1} yr^{-1} 4.3 OMAB > 1 see 1.2	4. MSC see 1
5. Nature/Landscape - Flora	5. PSD > PSD of IAFS see 2	see 2, 4
6. Food supply - Quality	6.1 QPI > x $crop^{-1}$ see 1.1, 4.1	6.1 ULV 6.2 Recovery of Peasants Knowledge see 1 (ENM), 2
7. Basic income/Profit - Reg. level	see 3	see 3
8. Food supply - Sustainability	see 4.2, 4.3	see 1, 2, 4
9. Abiotic environment - Air	9.1 EEP-air = 0 see 1.1, 4.1	see 1
10. Health/Well-being - Rural people	10. see 1.1, 1.3, 2, 3, 4.1, 5, 6	see 1, 2, 3, 4, 6
	Total parameters: 10 EU, 1 local	Total methods: 6 EU, 1 local

In Göttingen the major 10 objectives are quantified in 11 multi-objective parameters, of which 1 (4.2) is not on the European list (Table 3).
Parameter 4.2 indicates soil erosion is to be minimised to protect the soil and its fertility.
The major 10 objectives as quantified in 11 parameters are achieved by 7 multi-objective farming methods, of which 1 (6.2) is not on the European list (Table 4).
Method 6.2 concerns the recovery of traditional peasants' knowledge, to the benefit of quality production.
Of the 7 EU methods, Minimum Soil Cultivation and Ecological Infrastructure Management have been developed or codeveloped in this project and will be described in the next progress report by this team, with the parameters to evaluate and optimise their effectiveness for achieving the objectives set.

Table 6.2.3 Quantifying and achieving objectives in EAFS prototyping in Foulum (DK 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment - Water	1.1 NDW < 11.2 mg l^{-1}	1. MCR
2. Nature/Landscape - Fauna	2.1 SB not diminishing 2.2 EW 2.3 EFD = ?	see 1
3. Food supply - Sustainability	3.1 OMAB > 1	3. MCL
4. Abiotic environment - Soil	4.1 SCA > 65 %	
5. Nature/Landscape - Flora	5.1 PSD not diminishing	
6. Health/Well-being - Rural people	6.1 EEP = 0	
7. Food supply - Quality		
8. Basic income/Profit - Farm level	8.1 NS > 0	
9. Abiotic environment - Air	see 6	
10. Health/Well-being - Urban people	see 6	
	Total parameters: 9 EU, 0 local	Total methods: 3 EU, 0 local

In Foulum the major 10 objectives are quantified in 9 multi-objective parameters and achieved by 3 multi-objective methods, all on the European lists (Tables 3-4).

Table 6.2.4 Quantifying and achieving objectives in EAFS prototyping in Johnstown (IRL 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment - Soil	1.1 EEP = 0 1.2 NAR < 70 kg ha^{-1} 1.3 PAR: 3 < Pw-count < 15 * 1.4 KAR: 100 < K-count < 250 *	MCR, ENM
2. Food supply - Quality	2.1 QPI > x $crop^{-1}$	see 1
3. Nature/Landscape - Flora	3.1 PSD: Grass Spp 100 m^{-1} hedgerow > 10 Herb Spp 100 m^{-1} hedgerow > 10 Tree Spp 100 m^{-1} hedgerow > 10	EIM
4. Abiotic environment - Water	4.1 NGW < 11.2 mg l^{-1} (EU norm)	see 1
5. Food supply - Quantity	5.1 Cereal Yields > 0.7 Nat. average see 2.1	FSO see 1
6. Basic income/Profit - Farm level	6.1 NS > 0	see 5
7. Nature/Landscape - Landscape	7.1 EI > 5 % see 3.1 7.2 > 2 m Field Margin in all Fields	see 1
8. Food supply - Sustainability	see 1.1-4.1 , 2.1, 4.1	see 1
9. Health/Well-being - Farm animals	9.1 Optimum Stocking Rate (OSR) see 1.1-1.4, 4.1	see 5
10. Basic income/Profit - Reg. level	see 5.1	
	Total parameters: 9 EU, 3 local	Total methods: 4 EU, 0 local

* Morgans soil extract

In Johnstown the major 10 objectives are quantified in 12 multi-objective parameters, of which 3 (5.1, 7.2 and 9.1) are not on the European list (Table 3).
Parameter 5.1 sets limits to the extensification, in order to protect the quantity of food supply.
Parameter 7.2 specifies the layout of the ecological infrastructure to assure its needed size and continuity to the benefit of landscape.
Parameter 9.1 sets limits to the stocking rate, to the benefit of health/well-being of the cattle and sheep in the mixed prototype system.
The major 10 objectives as quantified in 12 parameters are achieved by 4 multi-objective methods, all on the European list (Table 4)

Table 6.2.5 Quantifying and achieving objectives in EAFS prototyping in Montepaldi (I 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment - Soil	1.1 EEP = 0 1.2 NAR < 70 kg ha^{-1} 1.3 PAB < ?, KAB < ? 1.4 OMAB > 1	1.1, 1.2, 1.4 MCR 1.2, 1.4 BNF 1.2, 1.3, 1.4 ENM
2. Nature/Landscape - Flora	2.1 EI > 5 % 2.2 PSD > 50 $farm^{-1}$	2.1, 2.2 EIM
3. Abiotic environment - Water	see 1.1-1.4	
4. Food supply - Quality	4.1 x < QPI < y $crop^{-1}$ see 1-4	see 1.1-1.4 ULV
5. Nature/Landscape - Fauna	see 1.1-1.4, 2.1	see 1.1-1.4
6. Basic income/Profit - Farm level	6.1 NS > 0 see 1, 2, 4	6.1 FSO see 1.1-1.4
7. Food supply - Sustainability	see 1, 2, 3, 5, 6	see 1.1-1.4, 6.1
8. Health/Well-being - Rural people	see 1, 2, 4	see 1.1-1.4, 6.1
9. Basic income/Profit - Reg. level	see 1-2, 6.1	see 1.1-1.4, 6.1
10. Abiotic environment - Air	see 1.1, 1.2	see 1.1-1.4
	Total parameters: 9 EU, 0 local	Total methods: 6 EU, 0 local

In Montepaldi the major 10 objectives are quantified in 9 multi-objective parameters and achieved by 6 multi-objective methods, all on the European lists (Tables 3-4).

Table 6.2.6 Quantifying and achieving objectives in EAFS prototyping in Nagele (NL 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment - Water	1.1 EEP-water = 0 1.2 20 < PAR < 30 * 1.3 18 < KAR < 26 * 1.4 NAR ≤ 70 kg ha^{-1} 1.5 NDW < 11,2 mg l^{-1}	MCR, ENM
2. Food supply - Sustainability	2.1 EE > ? see 1.2, 1.3	see 1
3. Abiotic environment - Soil	3.1 EEP-soil = 0 see 1.1 to 1.4	see 1
4. Nature/Landscape - Flora	4.1 EI > 5 % farm area 4.2 Target PSD > 50 $farm^{-1}$ 4.3 Target Species Distribution > 10 ditch $section^{-1}$ (100m)	EIM
5. Food supply - Quality	5.1 QPI (target per crop)	see 1
6. Basic income/Profit - Farm level	6.1 NS > 0 see 5.1	6.1 FSO see 1, 4
7. Nature/Landscape - Landscape	7.1 SCI > 0.8 see 4.1 to 4.3 7.2 > 10 flowers m^{-1} ditch bank (April-Oct) 7.3 Target Bird Species diversity/distribution > ?	see 4
8. Abiotic environment - Air	8.1 EEP-air = 0 see 1.1, 1.4, 2.1	see 1
9. Basic income/Profit - Reg. level	see 1.1-7.3	see 1, 4, 6
10. Health/Well-being - Urban	see 1.1-7.3	see 1, 4
	Total parameters: 11 EU, 3 local	Total methods: 4 EU, 0 local

* see legends Table 6.2.7

In Nagele the major 10 objectives are quantified in 14 multi-objective parameters and achieved by 4 multi-objective methods.
For further details see NL2, in which the EAFS prototype of NL1 is one of the 10 pilot farms.

Table 6.2.7 Quantifying and achieving objectives in EAFS prototyping in Flevoland (NL 2)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment-Soil	1.1 EEP-soil = 0 1.2 $20 < PAR < 30$ * $PAB > 1$ if $PAR < 20$ $PAB < 1$ if $PAR > 30$ ** 1.3 $x < KAR < y$ * $KAB > 1$ if $KAR < x$ $KAB < 1$ if $KAR > y$ ** 1.4 NAR (0-100 cm) < 70 kg ha^{-1}	1.1 - 1.4 MCR 1.2 - 1.4 ENM
2. Nature/Landscape - Flora	2.1 EI > 5 % farm area 2.2 Target PSD > 50 $farm^{-1}$ 2.3 Target Species Distribution > 10 ditch $section^{-1}$ (100 m)	2. EIM (target species sowing included)
3. Food supply - Quality	3.1 QPI > x $crop^{-1}$	see 1
4. Abiotic environment - Water	4.1 EEP-water = 0 4.2 NDW < 11.2 mg l^{-1} (EU-norm) see 1	see 1
5. Nature/Landscape - Landscape	5.1 SCI > 0.8 see 2 5.2 > 10 flowers m^{-1} ditch bank (April-Oct) 5.3 Bird Species Diversity > ?	see 2 (bird habitats included)
6. Basic income/Profit - Farm level	6.1 NS > 0 see 3	6.1 FSO see 1 and 2
7. Food supply - Quantity	see 3	see 1 and 2
8. Health/Well-being - Urban people	see 1-6	see 1 and 2
9. Basic income/Profit - Reg. level	see 1-6	see 1, 2 and 6
10. Abiotic environment-Air	10.1 EEP-air = 0 see 1	see 1
	Total parameters: 12 EU, 3 local	Total methods: 4 EU, 0 local

* Pw and K counts are the usual parameters of Available Reserves of P and K in the Netherlands. For K the optimum range depends on clay and organic matter contents and varies from farm to farm.
** If actual PAR or KAR is in optimum range, PAB or KAB = 1.

In Flevoland the major 10 objectives are quantified in 15 multi-objective parameters, of which 3 (2.3, 5.2 and 5.3) are not on the European list (Table 3).
Parameter 2.3 specifies the distribution of the target plant species in the ecological infrastructure. Target species are defined as plants attractive to man by conspicuous flowers and in addition to animals (notably beneficial insects and birds) by supply of food (pollen, nectar, seeds and berries) or shelter.
Parameter 5.2 specifies the richness in flowers to be achieved in the ecological infrastructure, which is crucial both to the attractiveness for man and animals.
Parameter 5.3 concerns birds as conspicuous elements of fauna and landscape, to be elaborated for breeding and migratory species, and also for sub-habitats (ditches, fields, yard).
The major 10 objectives as quantified in 15 parameters are achieved by 4 multi-objective methods, all on the European list (Table 4).
Of these 4, Multifunctional Crop Rotation, Ecological Nutrient Management and Ecological Infrastructure Management have been developed in this project and will be described by this team in the next progress report, with the parameters to evaluate and optimise their effectiveness for achieving the objectives set.

Table 6.2.8 Quantifying and achieving objectives in EAFS prototyping in Logården (S 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Food supply - Sustainability	1.1 PAB < ?	1. MCR ENM EIM
	1.2 x < PAR < y 1.3 x < pH < y 1.4 EE > x 1.5 SSC 1.6 OMAB > x 1.7 SB 1.8 SR	
2. Abiotic environment - Soil	2.1 0 < SCI < 1 2.2 NAR < ? see 1.1-1.3	see 1
3. Food supply - Quality	3.1 0 < QPI < 1	see 1
4. Health/Well-being - Farm animals	see 3.1	4.1 Animal Health and Well-being Program
5 Abiotic environment - Water	see 1.1, 2.1, 2.2	see 1
6 Employment - Farm level	6.1 NS > 0 6.2 FE > ? 6.3 Machinery Investment ha^{-1}	see 1
7 Health/Well-being - Rural people	see 1.1-6.1	see 1
8 Food supply - Stability	see 6.1-6.3	see 1
9 Employment - Reg. level	see 6.1-6.3	see 1
10 Basic income/Profit - Farm level	see 6.1-6.3	see 1
	Total parameters: 13 EU, 1 local	*Total methods: 3 EU, 1 local*

In Logården the major 10 objectives are quantified in 14 multi-objective parameters, of which only 1 (6.3) is not on the European list (Table 3).
Parameter 6.3 sets a limit to our effort to achieve self-sufficiency in energy supply and substitution for herbicides, which may endanger income/profit of the enterprise by high investments in machinery.
The major 10 objectives as quantified in 14 parameters are achieved by 4 multi-objective methods, of which 1 (4.1) is not on the European list (Table 4).
Method 4.1 concerns the objective to improve health/well-being of the cattle kept indoors permanently.

Table 6.2.9 Quantifying and achieving objectives in EAFS prototyping in Burgrain (CH 1)

Major objectives ranked	Major objectives quantified in multi-objective parameters	Major objectives achieved by multi-objective farming methods
1. Abiotic environment - Water	1.1 EEP-water = 0 1.2 PI = 0 1.3 PAB < 1.2 1.4 Maximum N Input < 150 kg ha^{-1}	1. MCR, ENM
2. Nature/Landscape - Landscape	2.1 EI ≥ 5 % 2.2 PSD > ?	2. EIM
3. Abiotic environment - Soil	3.1 EEP-soil = 0 3.2 SSC 3.3 SCA > 50 % *	3. MSC, IWEC, MCL see 1
4. Health/Well-being - Rural people	4.1 NS > 0	see 1-3
5. Nature/Landscape - Flora	5.1 EI ≥ 5 %	see 2
6. Food supply - Sustainability	6.1 OMAB > 1 6.2 EW > EW of CAFS 6.3 SR > EW of CAFS	6. OSM see 1, 3
7. Health/Well-being - Farm animals	?	
8. Food supply - Quality	8.1 Residue-free food of high natural value	see 1
9. Basic income/Profit - Farm level	9.1 see 1.1 - 8.1	9.1 FSO see 1-6
10 Abiotic environment - Air	10.1 EEP-air = 0 see 1.3	see 1, 3
	Total parameters: 12 EU, 2 local	Total methods: 8 EU, 0 local

* see Table 6.1.13

In Burgrain the major 10 objectives are quantified in 14 multi-objective parameters, of which 2 (1.3 and 8.1) are not on the European list (Table 3).
Parameter 1.3 is the legal guideline in the area for protection of the environment against N losses.
Parameter 8.1 specifies the quality of the food products to be achieved.
The major 10 objectives as quantified in 14 parameters are achieved by 8 multi-objective methods all on the European list (Table 4).

Table 7. Control of harmful species by crop rotation

Characteristics of harmful species	Sensitivity to crop rotation	Design of crop rotation
I Soilborne, barely mobile		
- polyphagous	+	
- oligo-or monophagous	+++	minimal crop frequencies
II Semi-soilborne, moderately mobile		
- polyphagous	-	
- oligo-or monophagous	++	minimal crop frequencies, maximal crop moves
III Airborne, highly mobile		
- polyphagous	-	
- oligo-or monophagous	+	minimal crop frequencies (at farm and regional scales)
IV Weeds	+(+)	maximal crop diversity*

* By alternation of mono-dicotyle crops, mown-lifted crops, winter-spring crops and related diversity of crop-specific control measures.

7 Agro-ecological layout of I/EAFS prototypes

This theme has been elaborated since the 1993 workshop and will be discussed in the 1994 workshop.

7.1. Basic purpose of crop rotation

After the 3 initial steps (making a hierarchy of objectives; expressing the top 10 specific objectives in multi-objective parameters; and establishing the multi-objective methods needed to achieve the top 10), you may proceed to lay out actual prototype systems for a first year. A basic question is which crops to grow and in which rotation. The answer should be reached by taking into consideration the regional and local soil, climate, infrastructure, and related possibilities of production, processing and marketing. Since conventional rotations seem to fit well in the regional situation, it is tempting to adopt them. However, this would be a serious mistake, because they are usually short rotations of high-yielding crops needing much equipment, chemicals and support energy to maintain soil fertility. If these controversial inputs are to be minimised, a multi-functional crop rotation has to be designed to replace them (Vereijken, 1992).
The basic task of I/EAFS designers, to replace physico-chemical methods by biological methods and techniques, requires an appropriate concept of a farming system:
a farming system is an agro-ecological unity consisting of a set of steadily interacting and rotating crops and possibly livestock, together with their accompanying (beneficial or harmful) flora and fauna.
The designer's task can thus be specified as to design a rotation with a maximum of positive interactions and a minimum of negative interactions between the crops. These interactions strongly influence physical, chemical and biological fertility of the soil and consequently vitality and productivity of the crops. This chapter focuses on the agro-ecologically optimal layout of prototypes i.e. the layout that contributes to biological soil fertility by controlling harmful species by crop rotation and encouraging beneficial species.

7.2. Control of harmful species by crop rotation

Wild species in arable crops vary from permanently present, strictly soilborne and barely mobile species to temporarily present, airborne, and highly mobile species. An intermediate group can be described as permanently or temporarily present, semi-soilborne and moderately mobile species.
Soilborne species are of course the most sensitive to crop rotation. However, species within this group vary from those that are not crop specific (polyphagous), so barely sensitive to those that are crop specific (monophagous or oligophagous), so very sensitive. Consequently, of the soilborne group, only the harmful oligophagous and monophagous species can effectively be controlled by limiting crop frequencies in the rotation, but harmful polyphagous species should also be controlled by beneficial species and by supporting measures (including pesticides).
Semi-soilborne species, especially those that are crop specific, are moderately sensitive to crop rotation. As a result, harmful oligophagous and monophagous harmful species in this group can largely be controlled by crop rotation, if every year their host crops are moved to a new field, too far away for them to follow.
Airborne species are the least sensitive to crop rotation. Harmful polyphagous species in this group can only be controlled by beneficials and supporting measures, but harmful oligophagous and monophagous species can also be controlled by growing cultivars that are wholly or partially resistant. However, crop rotation or, more specifically, crop diversification, may substantially contribute to control of airborne harmful oligophagous and monophagous species, if it is generally applied on a regional scale.
Sensitivity of weeds to crop rotation primarily depends on their capacity to compete with the crops for supply of light, water and nutrients. The competitiveness of weeds also depends on their capacity to escape or to recover from the crop-specific control measures by the farmer. As a result, rotations with little crop diversity generally provide a more stable and favourable habitat for weeds than rotations with great crop diversity. For example, cereal-dominated rotations offer an excellent habitat for various grass weeds. However, this habitat will considerably deteriorate if rotational set-aside or a dicotyle crop is inserted, and the resulting potential of control measures is fully exploited.

7.3 Control of harmful species by beneficial species and ecological infrastructure

From Table 7 it can be inferred, that beneficial species are needed especially to control harmful polyphagous species, whether soilborne or semi-soilborne, and airborne species from causing economic damage. A wide range of measures is available to enhance beneficial soilborne species, such as bacteria, fungi, nematodes and arthropods in order to suppress harmful soilborne species, but this should be considered in a later stage of designing. In the initial stage (designing the crop rotation and the layout of the prototype system including the ecological infrastructure), only the habitats of semi-soilborne and airborne beneficials is to be optimised, in terms of continuous supply of food and shelter. This is especially necessary in arable farming systems characterised by annual monocultures involving serious discontinuities in time and space for semi-soilborne and airborne beneficials such as predatory and parasitic arthropods.
Therefore, arable farming systems provide an optimal habitat for these beneficials if the fields/crops form an agro-ecological unity (continuity in space) and if an ecological infrastructure which enables the beneficials to overwinter and recover in spring is laid out around the fields (continuity in time).

7.4 Agro-ecological criteria for layout of I/EAFS

Based on the foregoing considerations, a set of agro-ecological criteria is proposed for an optimal layout of I/EAFS:

(1) *Field adjacency = 1*
All fields of a farming system should be adjacent to each other, to obtain an agro-ecological unity as a prerequisite for an agro-ecological identity.

(2) *Field size ≥ 1 ha*
To obtain a prototype farming system with sufficient agro-ecological identity, the fields as sub-units have to be a minimum size.

(3) *Field length/width ≤ 4*
Round or square fields contribute optimally to the agro-ecological identity of a farming system. Therefore, a maximum is to be set to the length/width ratio of fields, to limit the loss in identity.

(4) *Crop rotation blocks ≥ 4 (IAFS) or ≥ 6 (EAFS)*
The shorter the crop rotation, the greater the biotic stress on the crops and the need for external inputs to control that stress. Therefore, crop rotation is required based on 4 (IAFS) or 6 (EAFS) rotation blocks, at least (temporal dimension of crop rotation).

(5) *Adjacency of subsequent blocks = 0*
Harmful semi-soilborne species are to be prevented from following their host crop by a crop rotation without any adjacency of subsequent blocks to ensure crops are not just moved to an adjacent field from year to year.

(6) *Share of cereals ≤ 0.5 (IAFS) or ≤ 0.3 (EAFS)*
The larger the share of cereals in rotation, the greater the biotic stress and the need for external inputs for this, the largest crop group in European arable farming. Therefore, the crop rotation should have a maximum of 0.5 (IAFS) or 0.3 (EAFS) of cereals.

(7) *Ecological Infrastructure ≥ 5 % of I/EAFS area*
To bridge the gap between 2 growing seasons, airborne and semi-soilborne beneficials need an appropriate ecological infrastructure of at least 5 % of the farm area.

In Chapter 8 the layouts of current prototypes are evaluated on the basis of these criteria.

8 Layout as Part 3 of prototype's identity card

Because of the crucial importance of an agro-ecologically optimal layout, as pointed out in Chapter 7, the layouts of prototypes in the 16 ongoing projects are presented in a certain format to provide the Parts 3 of the identity cards. They can then be evaluated by the set of agro-ecological criteria, as proposed in 7.4.

8.1 Standardisation of layouts

To date, designers of farming systems have presented the layout of their prototypes in various ways. As a result, layouts are often incomplete, unclear and very difficult to evaluate. Therefore the following format has been developed to present the layouts in a standardised way and to enable them to be evaluated.

- The layout should be presented exactly to scale (as indicated) showing the exact position of systems and fields.
- The systems should be indicated by standardised shading: Ecological (EAFS) = light, Integrated (IAFS) = grey and Conventional reference (CAFS) = dark.
- The ecological infrastructure is to be indicated by a bold line, irrespective of whether it is a herbaceous strip, a hedge or a forest margin.
- The rotations should be presented as successive blocks (numbered I, II, III etc.) and their crops (temporal dimension). The allocation of these blocks in the fields displays not only the situation in 1993 but also the patterns of crop movement over the years, because in 1994 block number II that was in field X in 1993 will be moved to field Y which was occupied by block number I in 1993 and so on (spatial dimension).
- The legends list the size (in hectares) of the farming systems present, showing possible variants of systems as rotations a and b and the share of cereals of each rotation (b is always the most extensified).

The layouts of the prototypes in the 16 ongoing projects are presented in this format in Figs. 2.1-2.16. There appears to be a wide variation, and therefore there should be a critical evaluation, especially for newcomers with projects in preparation.

8.2 Agro-ecological evaluation of layouts

Most layouts of prototypes in ongoing projects cannot meet one or more of the 7 agro-ecological criteria (Table 8). In 1993, agro-ecologically valid IAFS layouts are only present in DE 2a and S 1, and with minor revision also in DE 2b, DK 1, NL 1, FIN 1 and S 2. Agro-ecologically valid EAFS layouts are only present in NL 1 and NL 2 and with minor revision also in IRL 1. All other layouts can only meet the agro-ecological criteria by major revision. In 6 projects namely DE 1, F 1, F 2, UK 1, UK 2 and CH 1, such a revision is practically impossible. They have a more or less randomised layout aimed at comparison of systems, but this conflicts with the concept of the farming system as an agro-ecological unity. Nevertheless, if the creative leaders concerned keep in mind the shortcomings resulting from the lack of agro-ecological unity and identity, the evaluation and optimisation of the prototypes can be continued on pilot farms.

Table 8 Agro-ecological evaluation of layouts of prototypes in ongoing projects 1993 *

Criteria concerted action (explained in 7.4)		DE 1 Lauten-bach	DE 2a Reinshof	DE 2b Marien-stein	DK 1 Foulum	F 1 Boig-neville	F 2 Cour-seulles	IRL 1 Johns-town	I 1 Monte-paldi	NL 1 Nagele	NL 2 Flevo-land	UK 1 LIFE	UK 2 LINK	FIN 1 Suitia	S 1 Logården	S 2 Alnarp	CH 1 Burgrain
Field adjacency																	
IAFS	**1**	0	1	1	1	0.5	0		1	1		0.2	0.5	1	1	1	0
EAFS	**1**	1	1	1	1			1	1	1	1				1		0
Field size (ha)																	
IAFS	**≥ 1**	6.0	3.6	2.4	1.5	3.0	2.0		1.3	2.0		2.4	3.5	2.5	4.0	3.0	0.7
EAFS	**≥ 1**	1.5	1.7	1.6	1.5			4.0	1.3	3.7	5.3				3.1		0.7
Field length/width																	
IAFS	**≤ 4**	7	2	2	2	2	5		7	2		4	2	3	3	2	8
EAFS	**≤ 4**	15	2	3	4			2	7	2	2				3		8
Crop rotation blocks																	
IAFS	**≥ 4**	3	4	4	4	3	5		4	4		5	5	5	7	6	6
EAFS	**≥ 6**	4	4	4	6			7	4	6	6				7		6
Subsequent blocks adjacency																	
IAFS	**0**	0	0	0.3	0.5	0.3	0		0.8	0.5		0	0.2	0	0	0.3	0.2
EAFS	**0**	0.5	0.3	0.3	0.8			0.4	0.8	0	0				0.9		0.2
Share of cereals																	
IAFS (variants b)	**≤ 0.5**	0.7	0.5	0.5	0.3	0.7	0.25		0.5	0.25		0.6	0.4	0.5	0.5	0.5	0.5
EAFS	**≤ 0.3**	0.25	0.5	0.5	0.4			0.2	0.3	0.33	0.3				0.5		0.5
Ecological Infrastructure																	
IAFS	**≥ 5%**	3	7	7	?	?	1		?			6	3	3	6	3	5
EAFS	**≥ 5%**	7	7	7	?			12	?	5	5				6		5
Overall validity of layout																	
IAFS		-	+	±	±	-	-		-	±		-	-	±	+	±	-
EAFS		-	-	-	-			±	-	+	+				-		-

* See Figures 2.1 - 2.16

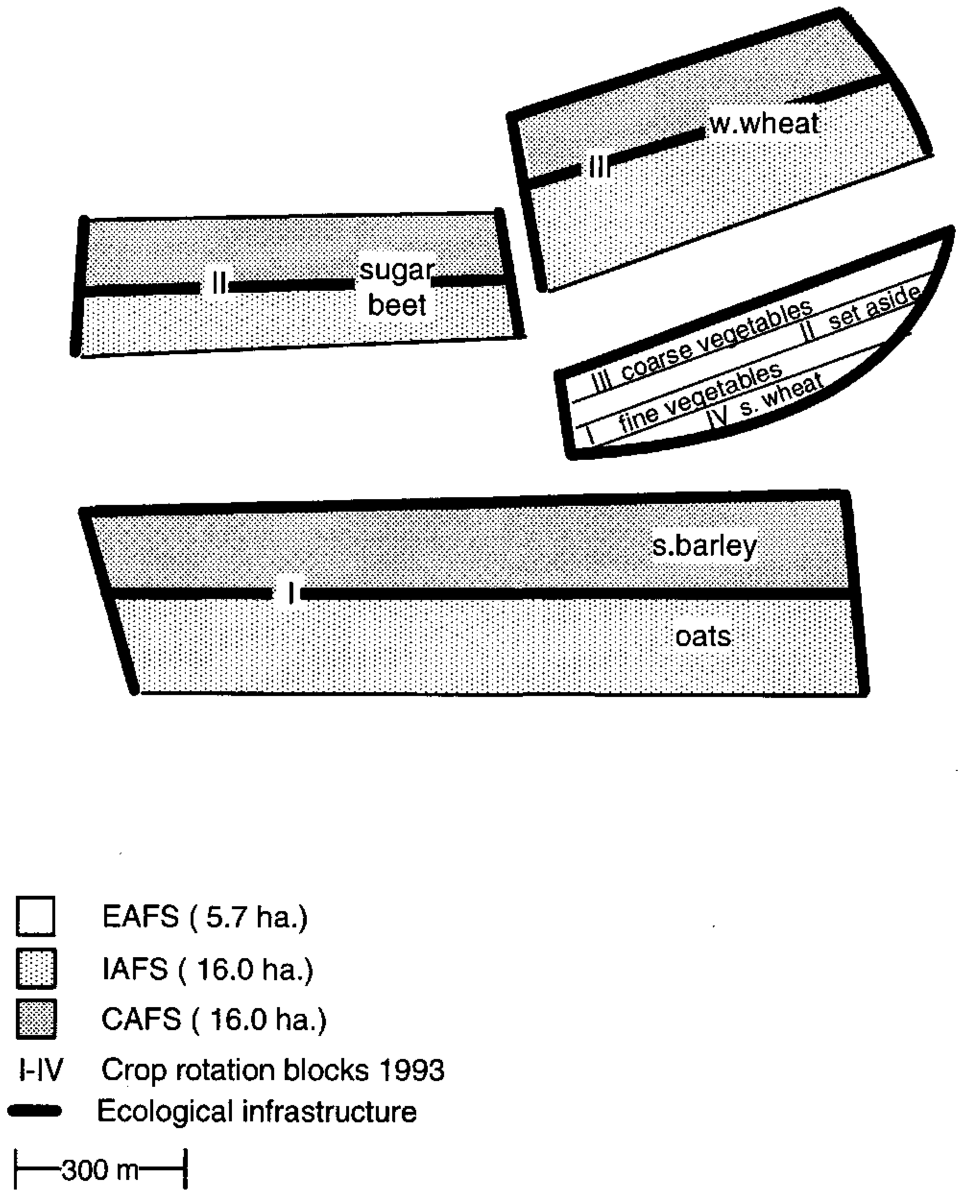

Figure 2.1 Experimental farm Lautenbach (DE 1)

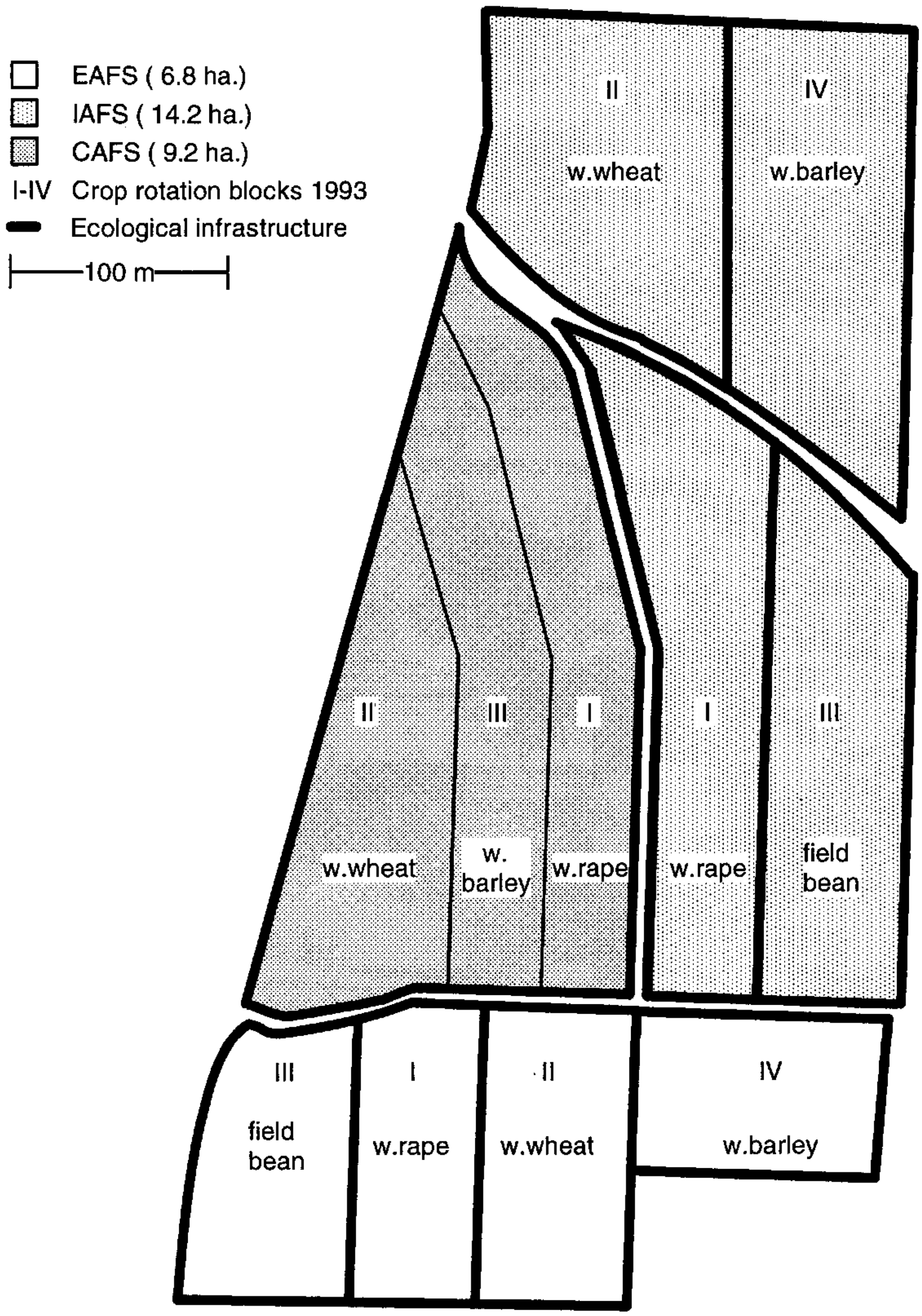

Figure 2.2 Experimental farm Reinshof (DE 2a)

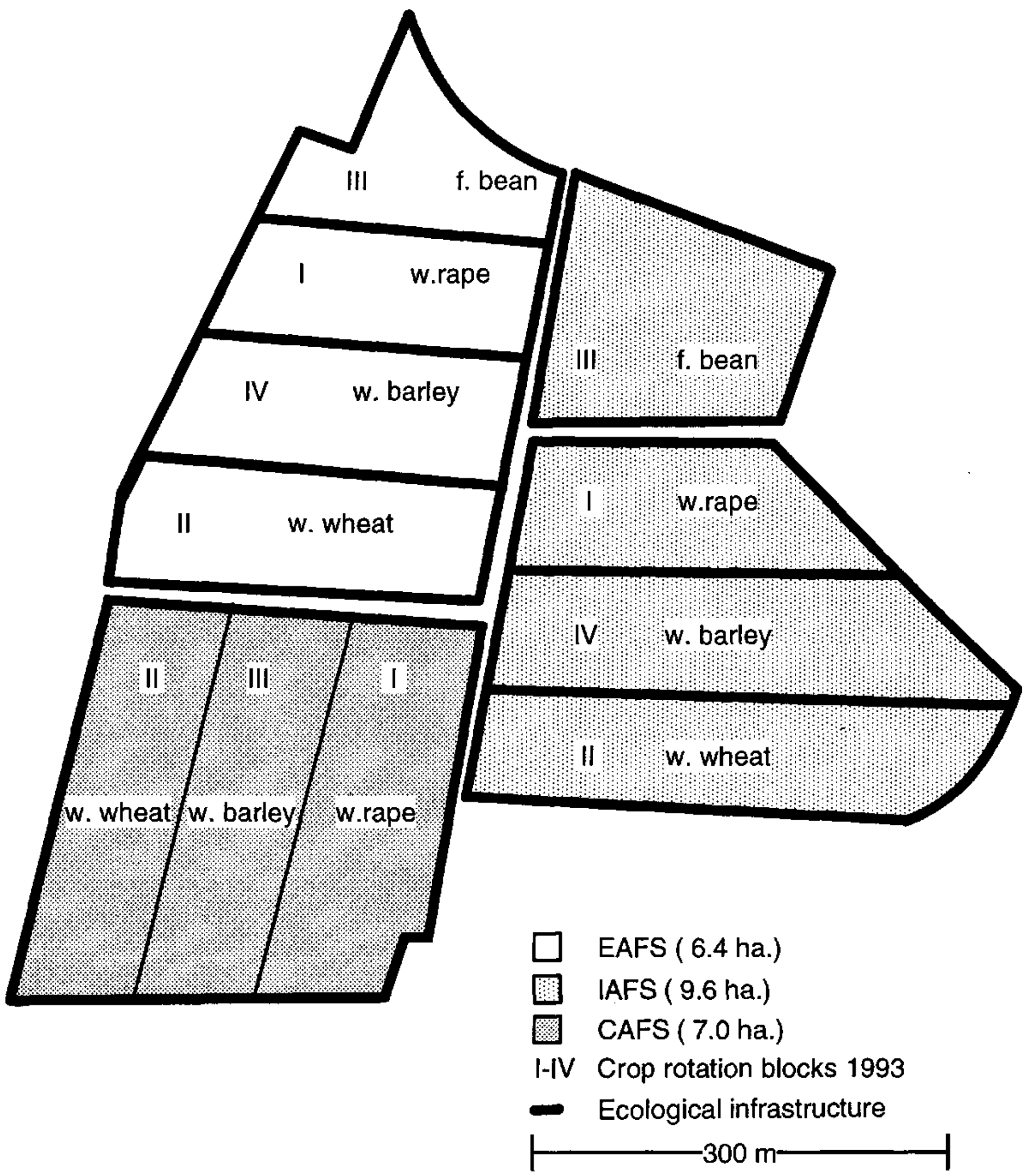

Figure 2.3 Experimental farm Marienstein (DE 2b)

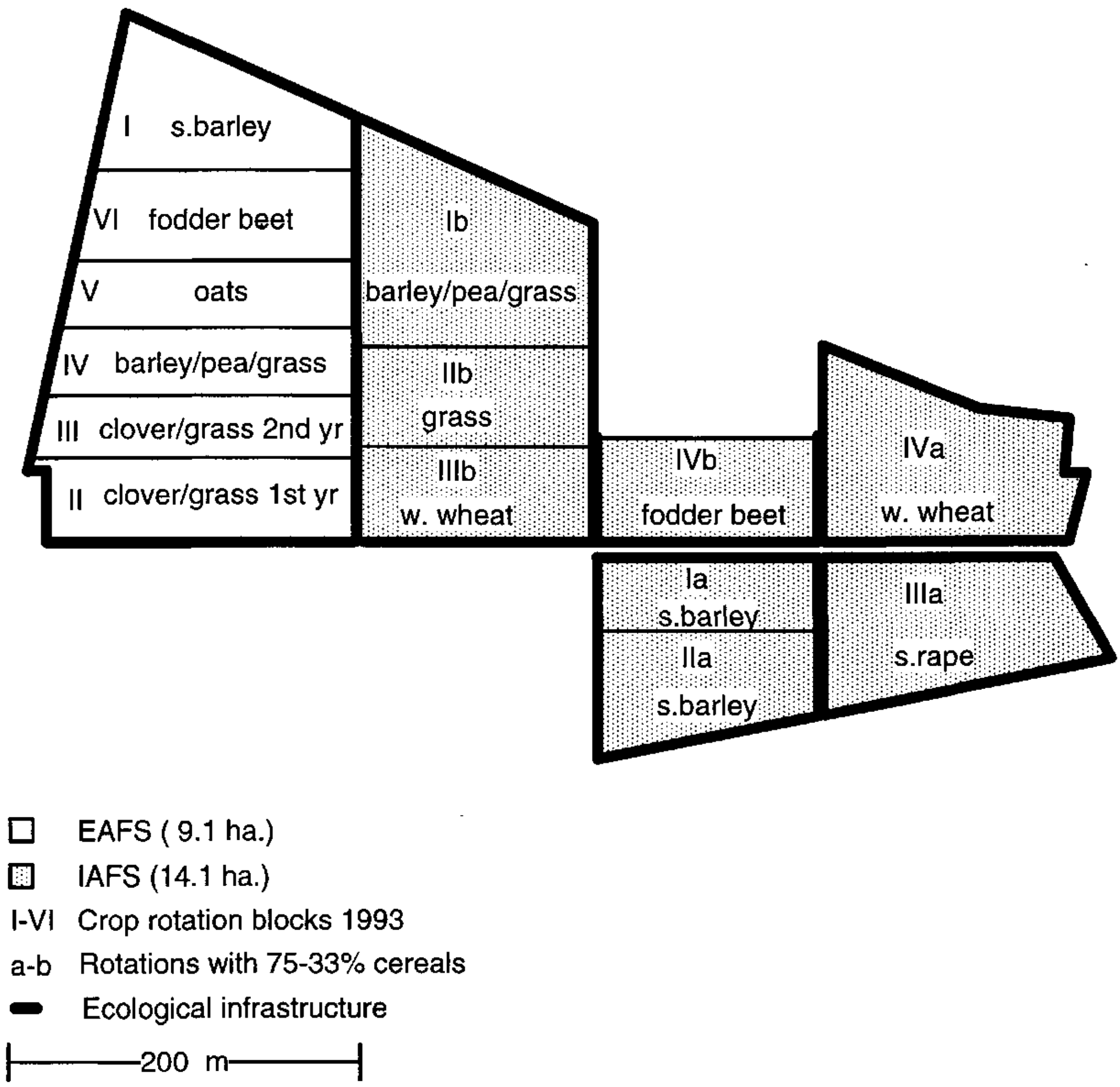

Figure 2.4 Experimental farm Foulum (DK 1)

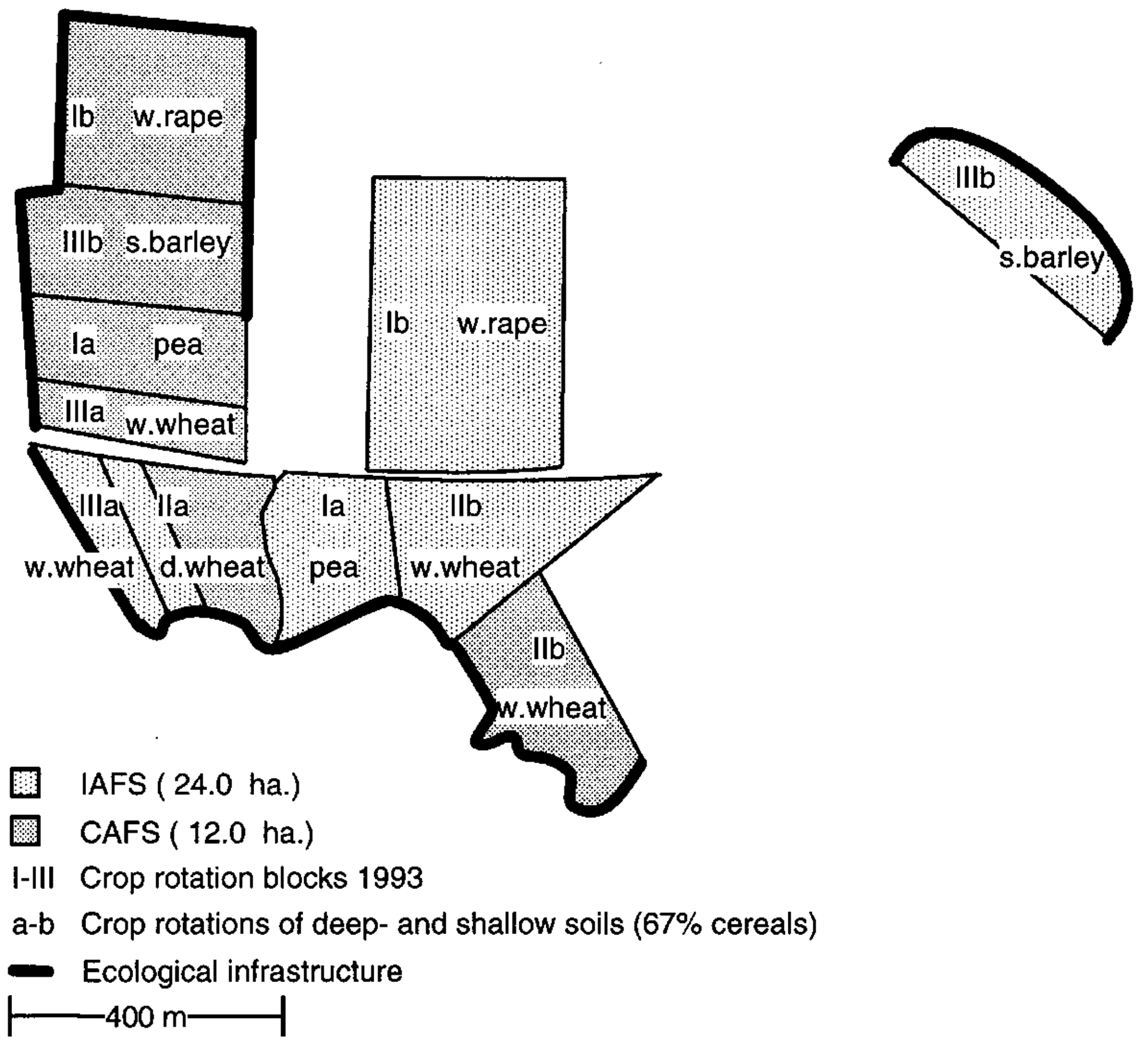

Figure 2.5 Experimental farm Boigneville (F 1)

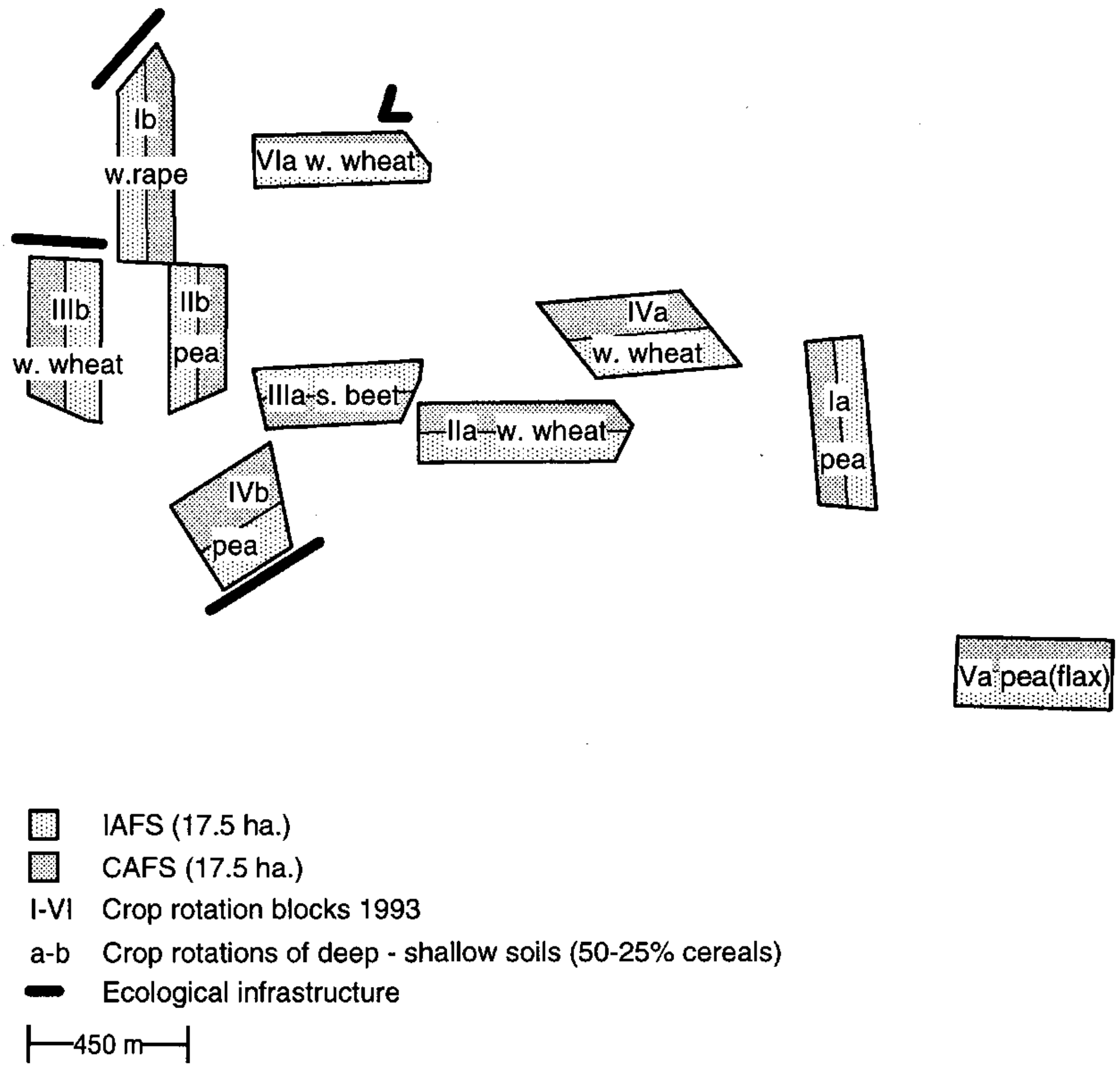

Figure 2.6 Experimental farm Courseulles (F 2)

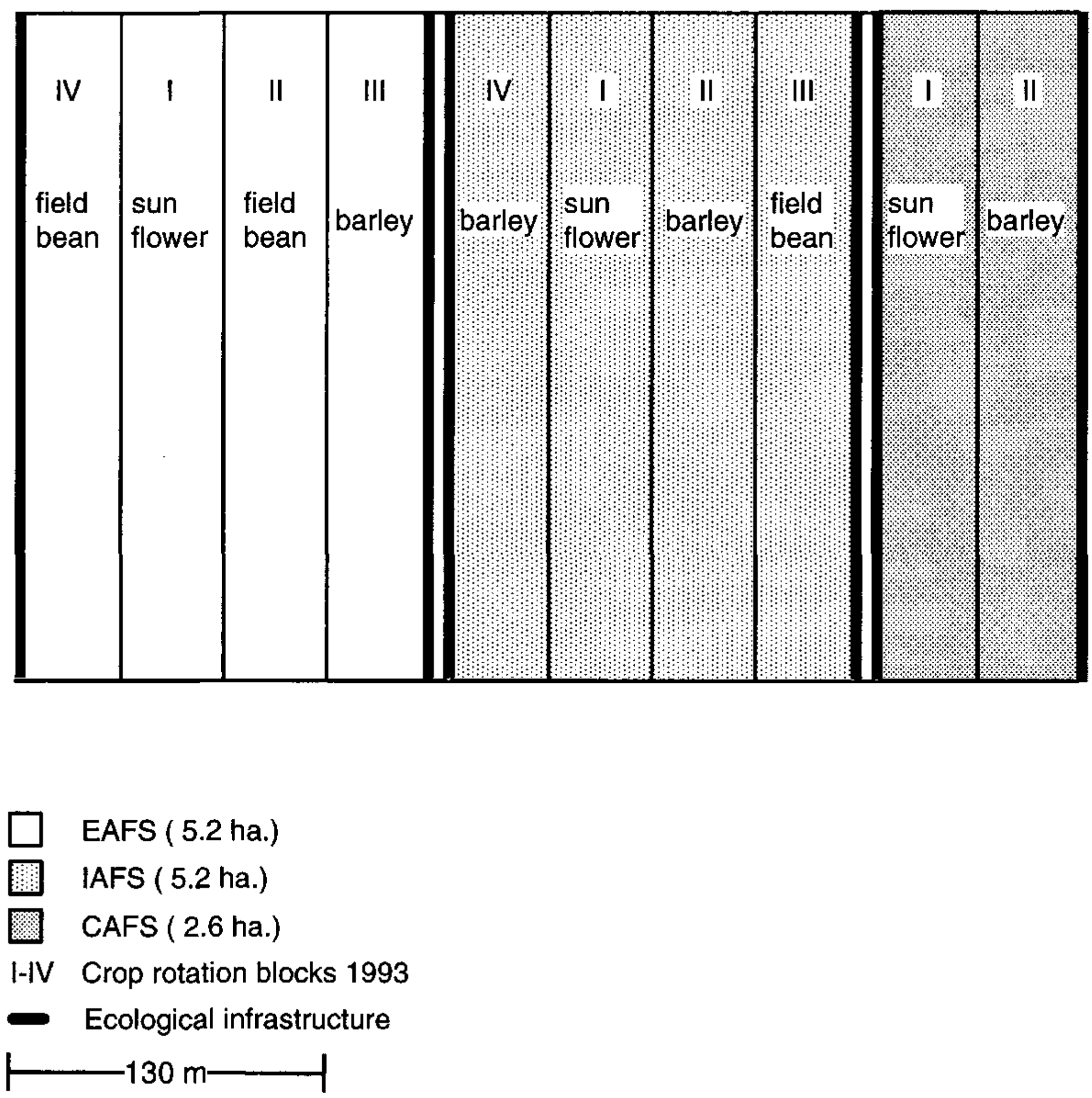

Figure 2.7 Experimental farm Montepaldi (I 1)

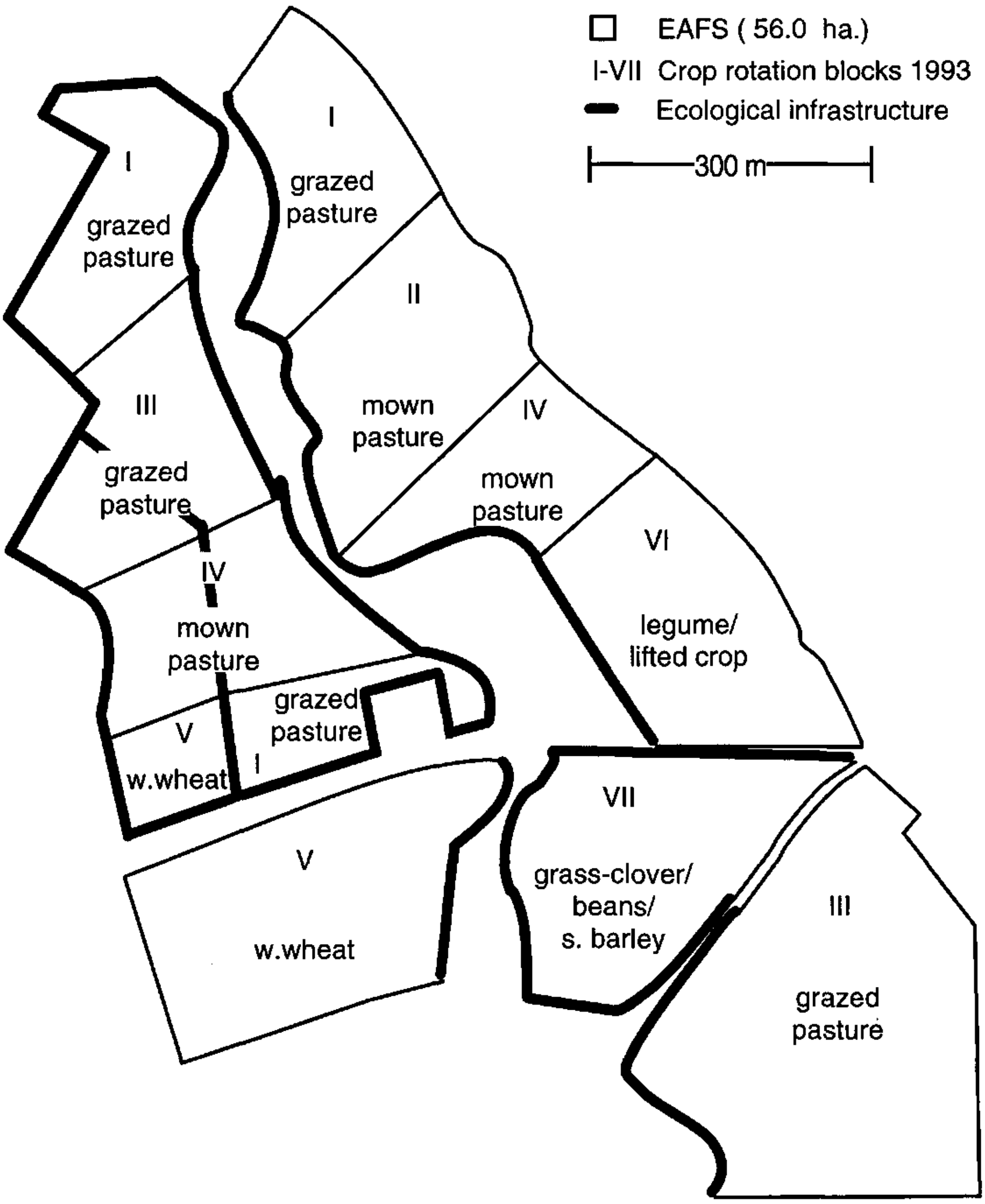

Figure 2.8 Experimental farm Johnstown (IRL 1)

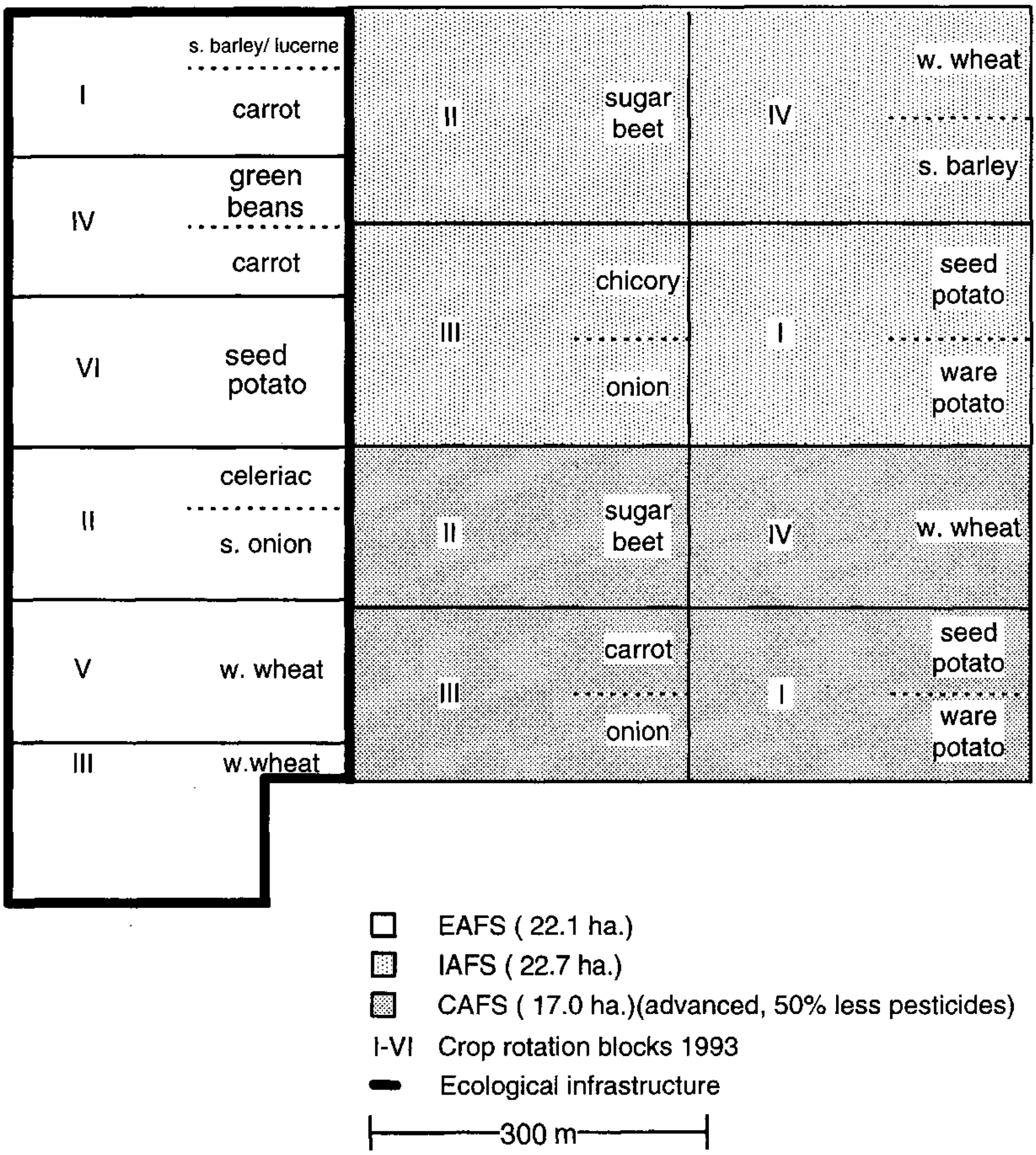

Figure 2.9 Experimental farm Nagele (NL 1)

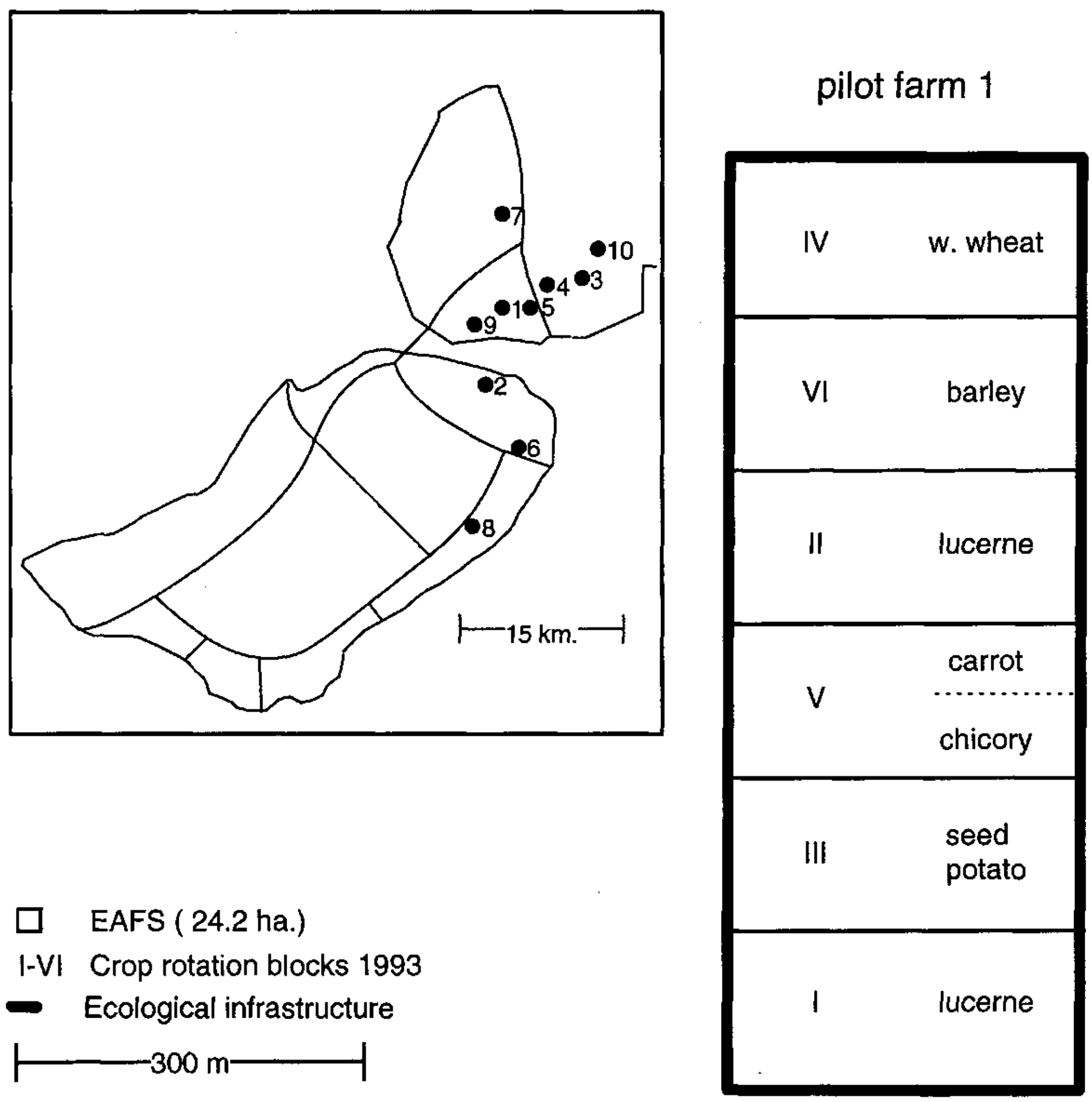

Figure 2.10 Flevoland pilot farms (NL 2)

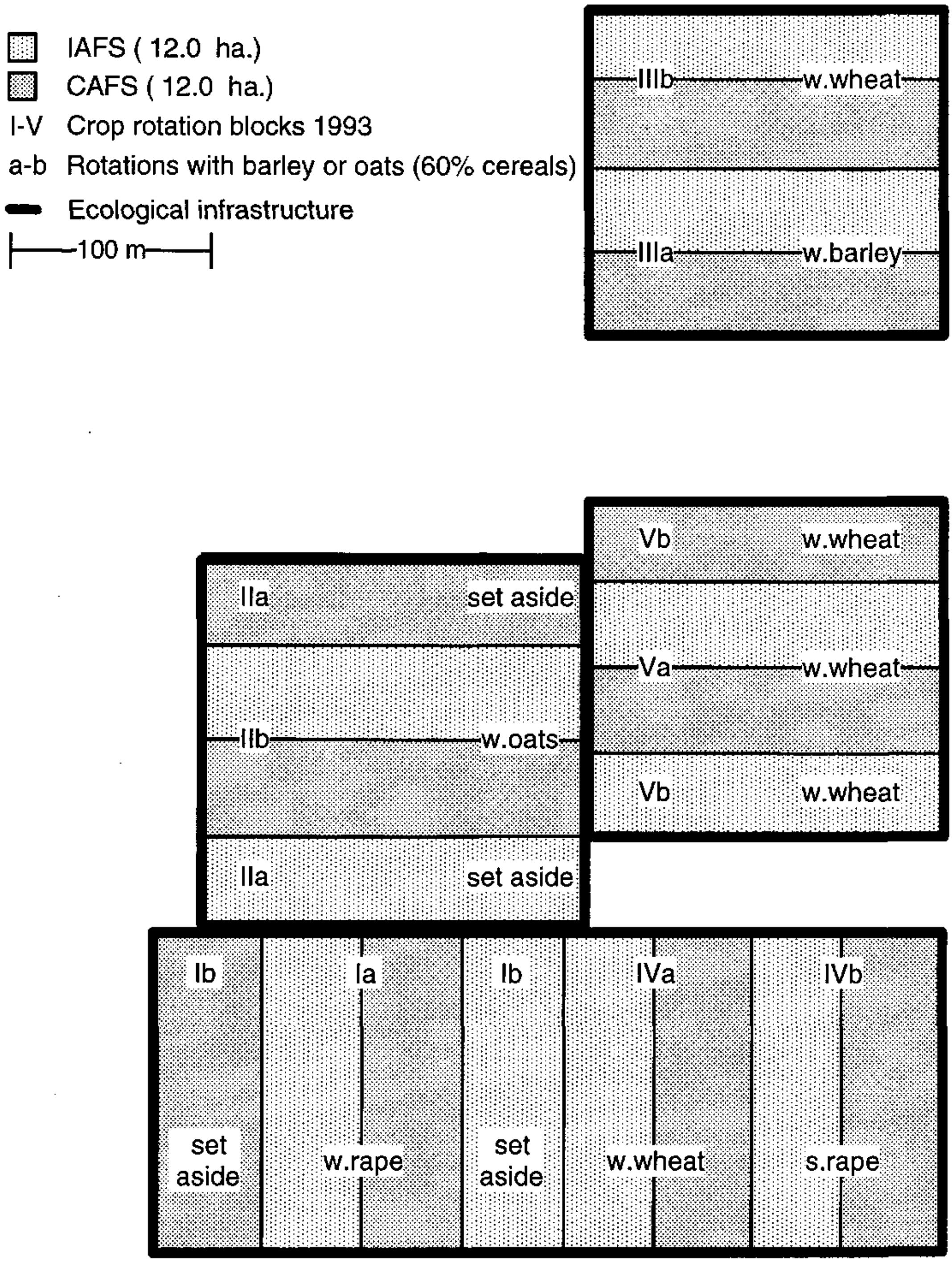

Figure 2.11 Experimental farm LIFE (UK 1)

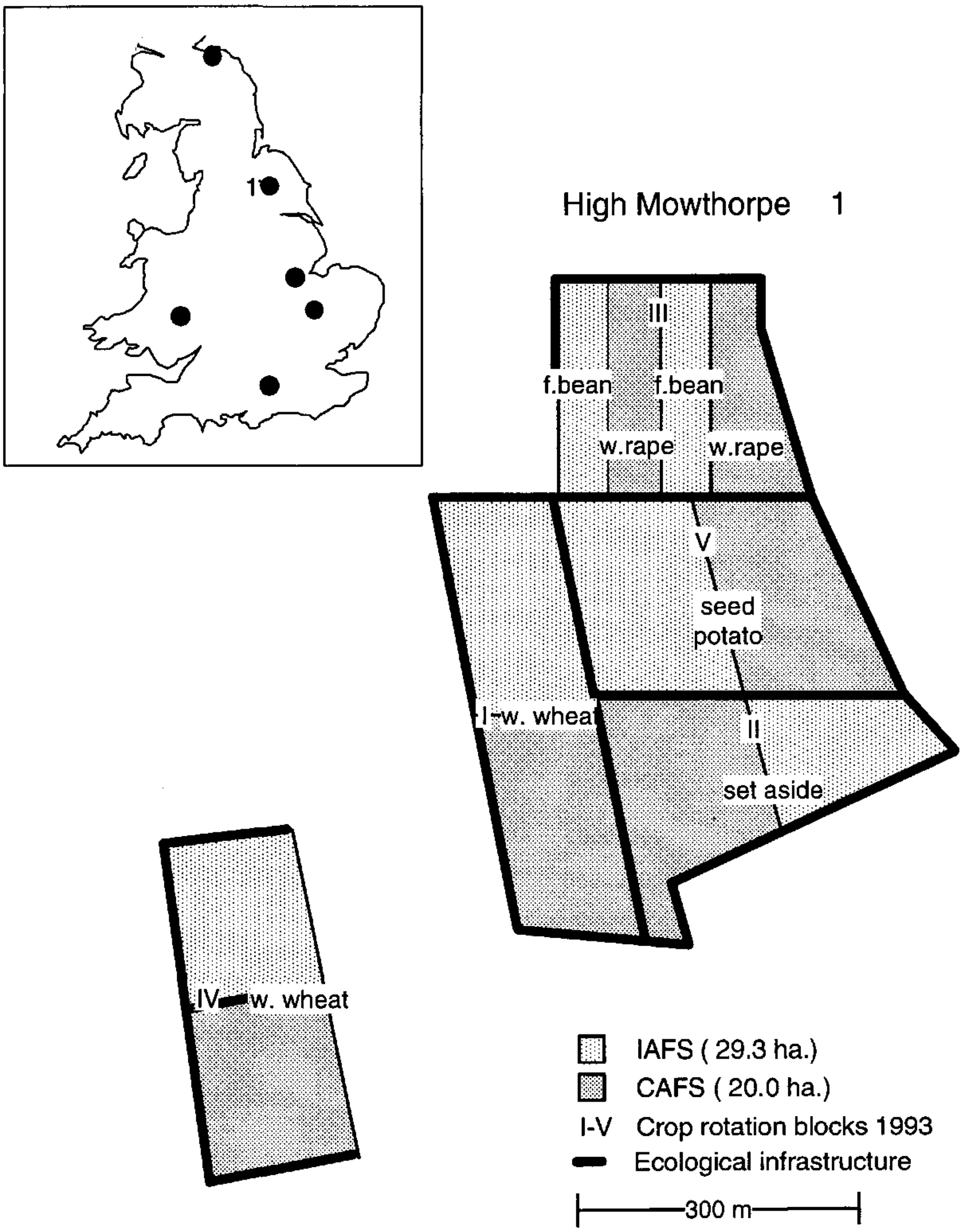

Figure 2.12 Experimental farms LINK (UK 2)

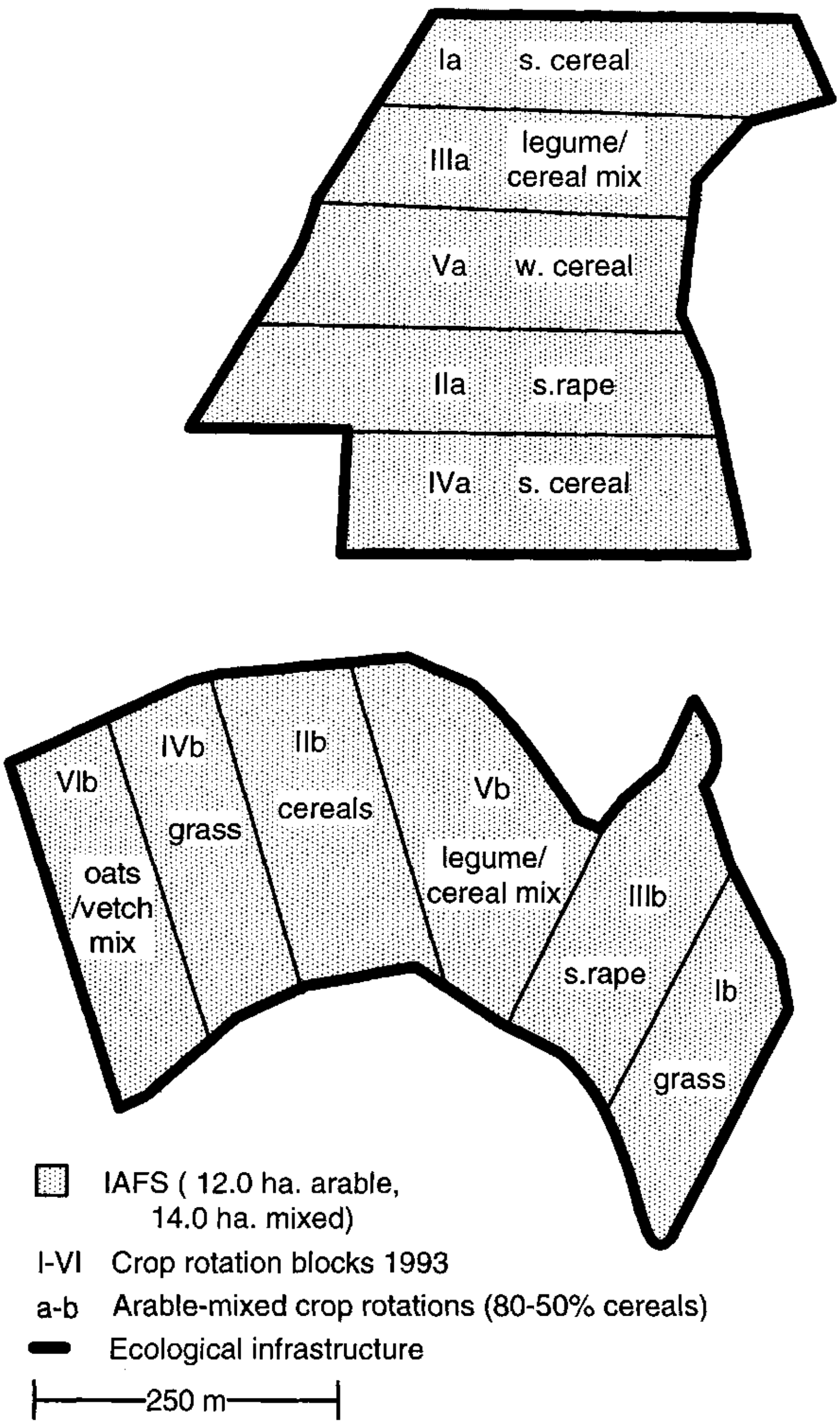

Figure 2.13 Experimental farm Suitia (FIN 1)

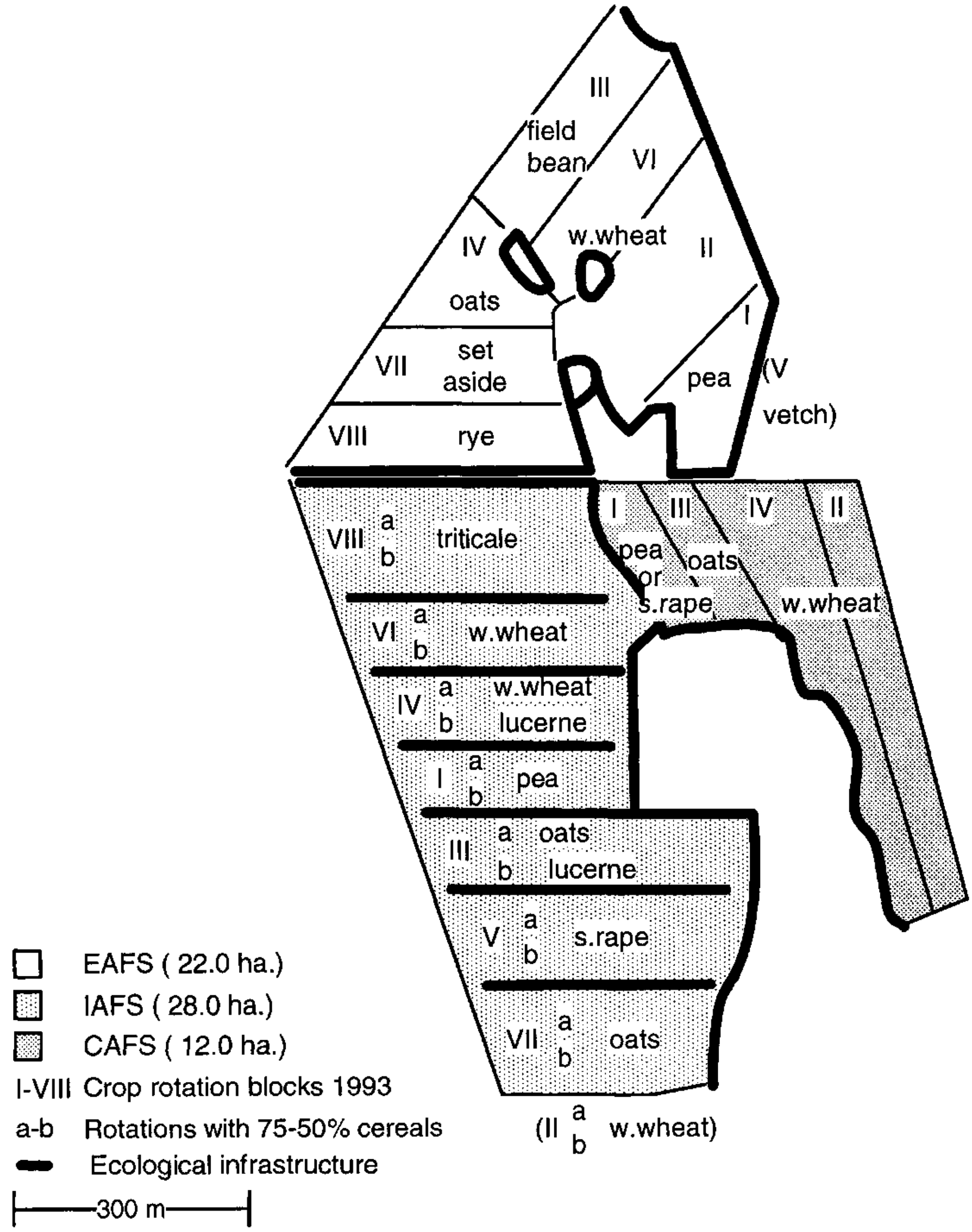

Figure 2.14 Experimental farm Logården (S 1)

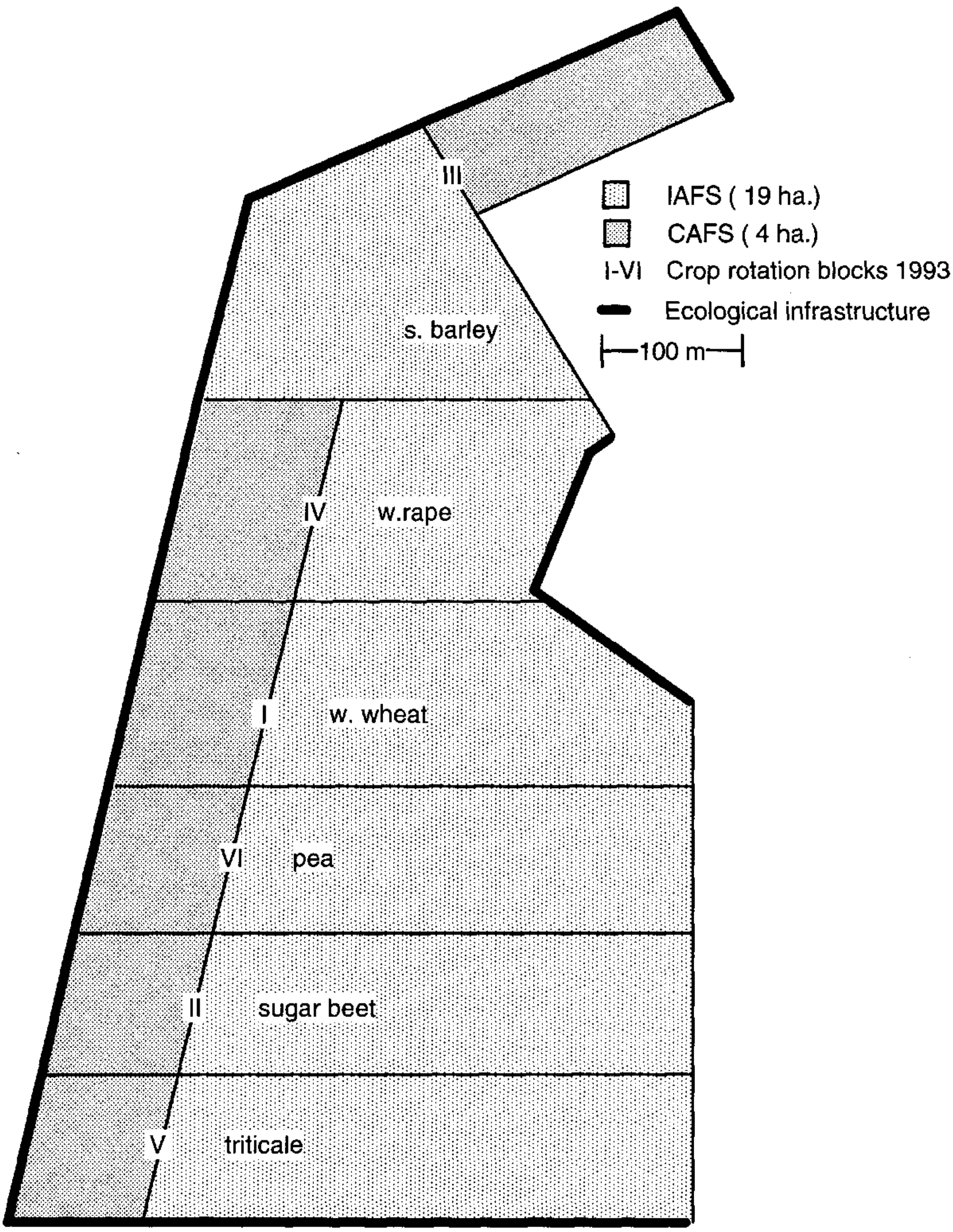

Figure 2.15 Experimental farm Alnarp (S 2)

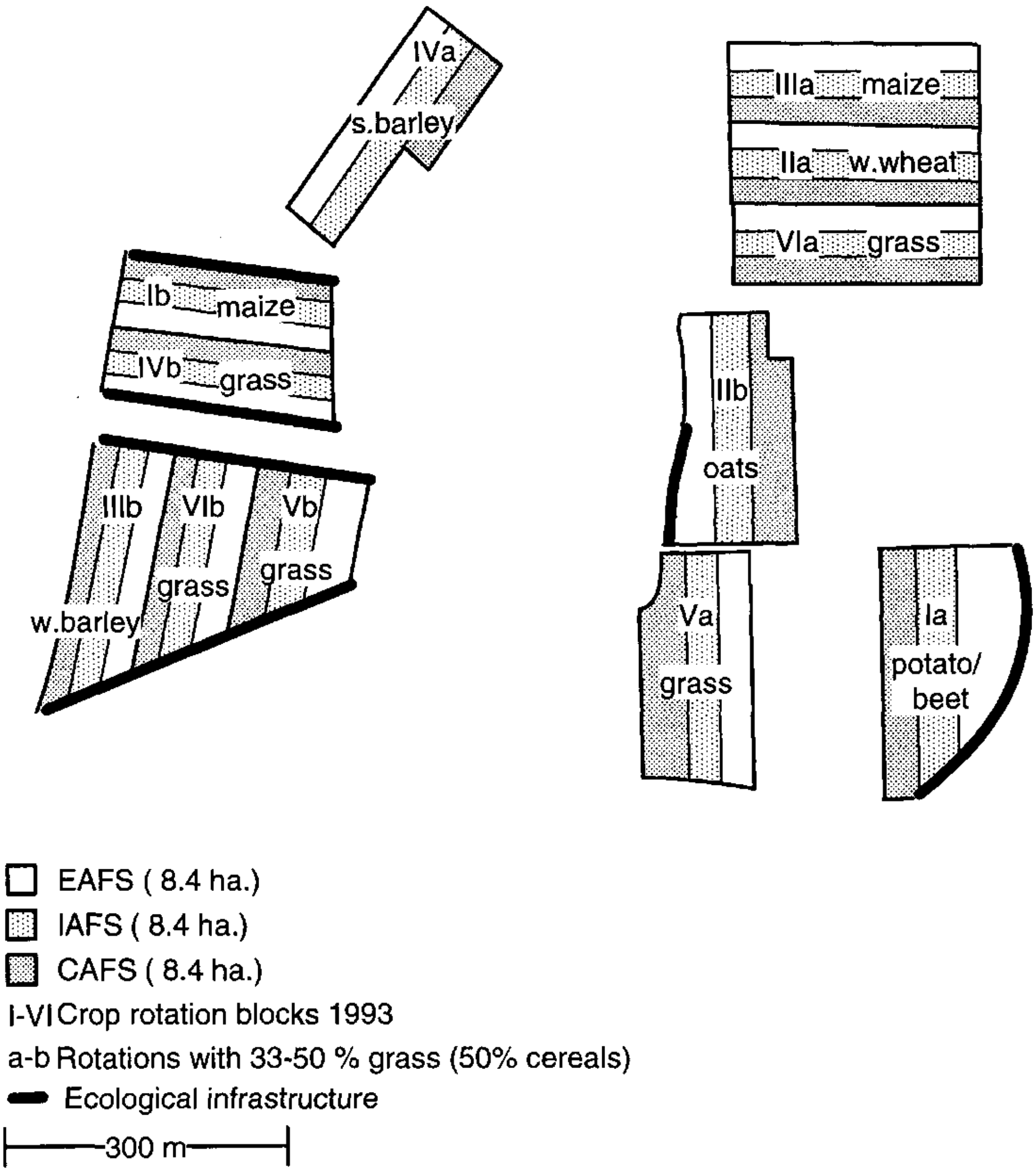

Figure 2.16 Experimental farm Burgrain (CH 1)

9 Focus on IAFS prototyping in Nagele experimental farm (NL 1)

F.G. Wijnands

9.1 IAFS and national policy

In the Netherlands, IAFS prototypes have been developed region-wise on three experimental farms with region-specific crop rotations and cropping systems (Wijnands & Vereijken, 1992). The farms are located in Nagele (since 1979) in the central clay region, in Borgerswold (since 1986) in the Northeastern sand region and in Vredepeel (since 1989) in the Southeastern sand region ; these represent the major soil types in Dutch arable farming.
Stimulated by initial results from Nagele (Vereijken, 1989), the Dutch government has adopted a policy of restructuring and sanitising national agriculture (Anon, 1990; Anon, 1991). Various targets have been set. In arable farming and outdoor horticulture the pesticide inputs must be heavily reduced (to 50 % of the 1985-1988 average by 2000) and mobile and persistent pesticides are to be removed from the list of authorised pesticides. Concerning nutrients, the volatilization of ammonia must be reduced to 70 % of the 1985 average by 2000 and so must the losses in N and P to the North Sea. In addition, quality criteria have been set for N and P in surface water (2.2 mg N l^{-1} and 0.15 mg P l^{-1}) and in groundwater (11.2 mg N-NO_3 l^{-1}). The use of manure has been restricted in terms of dosage (P norm) and period and way of application. Legislation including permissible levels of soil mineral N in autumn and levies on surpluses on nutrient balance sheets is being considered, to restrict the leaching of NO_3 to the groundwater and the accumulation of P in the soil.
In response to this policy, the agricultural industry in the Netherlands has had to adopt the quality of the environment as a major objective and has had to incorporate it into the conventional objectives of income and profit. The government considers such integrated farming systems as the best way to achieve a competitive, sustainable and safe agriculture. The targets of government policy are for at least 30 % of Dutch farmers to be practising integrated farming in 1994, rising to 100 % by 2000. To achieve this, a project has been set up to disseminate IAFS prototypes by pilot groups (Wijnands, 1992). In this chapter the focus is on the development of an IAFS prototype for the clay regions.

9.2 Prototyping for clay regions

Arable production in the Netherlands is concentrated in the Southwestern, Central and Northern clay regions, which are generally well drained and very fertile. The small farm size (25- 50 ha) encourages farmers to grow cash crops in short rotations needing heavy inputs. Potato is the most profitable, followed by sugar beet and vegetables such as onion and cabbage. Cereals are financially less attractive but are needed as break crops. Most rotations are for only three or four years. Consequently, beet and potato cyst nematodes cause serious problems, forcing farmers to fumigate soil regularly as a curative or preventive measure. The most important crop in the central clay region is ware potato and in the Northern clay region it is seed potato. In the Southwest, rotations are somewhat diversified by crops as flax, poppies and pulses.
The IAFS prototype for clay has been developed since 1979 on the "Development of Farming Systems" (DFS) experimental farm at Nagele (central clay region). The farm is 72 ha and the soil is heavy sandy marine clay (24 % clay). Three farming systems were studied until 1991: integrated (IAFS), conventional (CAFS), and ecological (EAFS). In 1991 the experimental layout was drastically revised. Because of the promising IAFS results and the subsequent progress in policy, the conventional reference system was no longer needed. It was therefore replaced by an IAFS meeting the policy aims of 2000 (advanced CAFS in Fig. 2.9). Subsequently a new IAFS prototype was designed, aimed at further reducing in inputs of pesticides and nutrients.

9.3 Multi-objective methods

In Chapter 6 (Table 6.1.7) it was noted that 6 multi-objective farming methods are used to achieve the 10 major objectives in IAFS prototyping. Briefly, they are:

1) Multifunctional Crop Rotation (MCR), which is aimed at conserving soil fertility in physical, chemical and biological terms to sustain quality production with minimal external inputs (fertilisers, pesticides). A potato cropping frequency of 1:4 is considered an acceptable compromise between a sound rotation (1:5 or 1:6) and more profitable short rotations (1:3) with more biotic stress and therefore requiring more inputs. From 1986 to 1990, CAFS and IAFS had the same crop rotation (Table 9.1).

Table 9.1 Crop rotation of IAFS and CAFS 1986-1990

1.	½ ware, ½ seed potato
2.	various (½ pea, ¼ carrot, ¼ onion)
2.	sugar beet
4.	winter wheat

2) Integrated Crop Protection (ICP), which is aimed at the prevention and control of biotic stress, so that quality production can be sustained with minimum pesticide use. It comprises various methods and techniques:
   - Non-chemical control of soilborne pests and pathogens, notably potato cyst nematodes by a sufficient cropping frequency of 1:4, consistent volunteer control and pathotype-specific use of resistant cultivars based on intensive sampling of fields.
   - Reduced fungicide input combined with resistant and tolerant cultivars and moderate fertilisation. For instance, potato cultivars, that are less susceptible to potato blight (*Phytophthora infestans*) are grown.
   - Mechanical weed control mainly based on hoeing techniques with additional band spraying of herbicides, if needed.
3) Environment Exposure-based Pesticides Selection (EEPS), which is aimed at stepwise reduction of EEP by targeted substitution of volatile, persistent and mobile pesticides. Work on developing this started in 1993. Previously, pesticides were selected less systematically, only avoiding persistent and mobile pesticides from the "black" list for areas of groundwater protection.
4) Integrated Nutrient Management (INM), which is aimed at the development and maintenance of agronomically desired and ecologically acceptable soil reserves of nutrients to sustain quality production. It comprises various methods and techniques:
   - Environmentally safe and agronomically efficient use of manure as a basic source of nutrients and organic matter.
   - Minimal additional N input to minimise N losses to surfacewater and groundwater (N Drainage Water)and to support ICP.
   - PK Annual input/output Balances (PAB, KAB) at farm level to maintain the desired ranges of PK-Available Reserves of the soil (PAR, KAR).
5) Ecological Infrastructure Management (EIM), which is aimed at the development and maintenance of a network of linear elements (hedges, ditches, field margins) enabling wild species to establish and migrate and people to recreate. Before 1993, EIM was confined to improved management of the ditches (non-disturbing, removing mown material) and to replacing the rows of trees in the yard by mixed hedges.
6) Farm Structure Optimisation (FSO), which is aimed at achieving and maintaining a Net Surplus (NS) (labour equally paid) through optimising the farm size, taking into account updated yields, costs and labour inputs achieved in IAFS prototyping. The first time FSO was used was in the 1986-1990 economic evaluation.

9.4 Results 1986-1990

Integrated Crop Protection (ICP)

Table 9.2 specifies the ICP interventions. Compared to CAFS the annual input of pesticides in kg ha^{-1} active ingredients in IAFS was reduced by 65 %, excluding nematicides and by 90 % if nematicides are included (Table 9.3).
Herbicide input in IAFS was largely replaced by mechanical control and by band spraying or low dose techniques (Table 9.2). Per herbicide application, the amount of active ingredient used was 25 to 50 % less. The labour demand increased because the band spraying and mechanical interventions took more time than full field herbicide spraying. In the seed and ware potato crops it was not necessary to use herbicide for weed control. Growing winter wheat at wider inter-row spacing (26 cm) enabled herbicides to be replaced by mechanical control.

Table 9.2 ICP interventions $crop^{-1}$ in IAFS 1986-1990 (abs. = absolute, rel. = IAFS/CAFS)

	weeds				pest/diseases	total
	mech.	therm	chem.	total	chemical	
abs.	2.0	0.2	1.5	3.7	1.9	5.6
rel.	2.20	-	0.60	1.05	0.45	0.70

Table 9.3 Annual input of pesticides (kg ha^{-1}, active ingredients) in IAFS 1986-1990 (abs. = absolute, rel. = IAFS/CAFS)

	herbicides		fungicides		insecticides		growth regulators		nematicides		total	
	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.	abs.	rel.
ware potato*	0.7	0.28	8.9	0.45	0.0	0	-	-	-	0	9.0	0.07
seed potato*	2.0	0.44	4.3	0.31	0.3	0.38	-	-	-	0	6.6	0.04
sugar beet	1.3	0.34	0.0	1.00	0.1	0.33	-	-	-	-	1.4	0.35
winter wheat	1.2	0.32	0.3	0.13	0.0	0	0.0	0	-	-	1.6	0.24
pea	2.1	0.64	0.6	0.55	0.2	0.50	-	-	-	-	2.9	0.60
winter carrot	1.4	0.40	0.0	0	1.3	0.35	-	-	-	-	2.7	0.34
sown onion	2.7	0.30	2.5	0.29	0.0	0	1.8	0.78	-	-	7.0	0.35
System averages	1.4	0.35	2.0	0.36	0.2	0.40	0.1	0.33	-	0	3.7	0.09

* chemical defoliage included in herbicides

Table 9.4 Number of interventions and fungicide input (kg active ingredients ha^{-1}) for Phytophthora control in IAFS 1986-1990 (abs. = absolute, rel. = IAFS/CAFS)

	ware potato		seed potato	
	abs.	rel.	abs.	rel.
interventions	6.3	0.55	2.6	0.48
act.ingredients	8.9	0.46	4.2	0.35

Fungicide input was reduced by using resistant cultivars, moderate nitrogen supply, control thresholds and decision support systems. Most reduction at farm level was achieved in potato (Table 9.3, 9.4). Fungicide input in onion was largely reduced by supervised control based on monitoring initial infestation by Botrytis squamosa and weather conditions
(Table 9.3). Growth regulators were only used in sowed onions to inhibit sprouting during storage. Insecticide input was minimal due to low insect pressure and the use of control thresholds,

reduced-dose techniques and band spraying. In IAFS soil fumigants against potato cyst nematodes were not needed by a combination of non-chemical measures, particularly resistant varieties.

Integrated Nutrient Management

In accordance with INM, organic manure is the main nutrient source and NK fertilisers are only used in addition. Thus, INM reduces use of energy (especially in N) and use of non-renewable resources (especially P) to the benefit of the sustainability of the system (Table 9.5).

Table 9.5 NPK Annual Balances of IAFS 1986-1990 (abs. = absolute, rel. = IAFS/CAFS).

	absolute			relative		
	N	P	K	N	P	K
Inputs:						
mineral fertiliser	44	0	55	0.37	0	0.47
organic manure	102	32	69	1.16	1.03	1.05
N fixation	19	-	-	0.90	-	-
deposition	35	1	5	1.00	1.00	1.00
total input	200	33	129	0.76	0.75	0.69
total output	131	24	119	0.86	0.86	0.88
input/output*	1.53	1.38	0.92	0.88	0.88	0.67

* NAB, PAB, KAB

Table 9.6 PK Available Reserves (PAR, KAR) and organic matter content in IAFS 1986-1990 (abs. = absolute, rel. = IAFS/CAFS).

	PAR*		KAR**		Organic matter %	
	abs.	rel.	abs.	rel.	abs.	rel.
1986	35	1.09	17	1.13	2.4	1.00
1990	32	1.10	17	1.06	2.4	1.00

* Water soluble P_2O_5 in mg/kg soil; optimum is 25 <PAR <50.
** HCl-soluble K_2O in mg/kg soil; optimum is 18 <KAR <26.

From Table 9.6 it appears INM maintained PAR within the optimum range and KAR just below the optimum. From Table 9.5 it appears P Annual Balance (PAB) = 1.38 was needed to maintain PAR, but K-Annual Balance (KAB) = 0.92 was apparently too strict considering the rather low KAR. A striking efficiency of INM appears from the fact that PAR and KAR were relatively high although PAB and KAB were relatively low. It may be caused by the relatively high input of organic matter preventing P from fixation and K from leaching.

N in drainage water (NDW) was substantially lower in IAFS, notably in potato (Table 7). Only IAFS stayed at crop- and system level below the EU-norm of 11.2 mg l^{-1} NO_3-N and came at system level very near to the EU-guideline of 5.6 mg l^{-1} NO_3-N.

Table 9.7. N Drainage Water (NDW, mg l^{-1} NO_3-N) in IAFS 1986-1990 (abs. = absolute, rel. = IAFS /CAFS)

	potato	various	sugarbeet	winterwheat	average
absolute	10	10	4	6	6
relative	0.63	0.91	1.00	0.75	0.67

Farm Structure Optimisation

Based on an experimental (so sub-optimal) scale of 17 ha, on original (so outdated) prices for inputs and outputs and original (so outdated) versions of the prototype, IAFS had an insufficient net surplus (Table 9.8). Besides, financial returns were relatively now. However, IAFS perspectives can only be estimated it subsequently:

- inputs and outputs are technically updated considering the latest version of the prototype and possible non-system specific events or effects;
- inputs and outputs are economically updated considering current or expected prices;
- farm structure is optimised considering the rates of land, labour and capital, to achieve the basic income/ profit objective of net surplus ≥ 0.

Table 9.8 demonstrates that Farm Structure Optimisation is by far the major factor in achieving a sufficient net surplus, by considerably reducing the costs of labour and machines per hectare. Updating the prices of various external inputs additionally reduces some costs, but this advantage is neutralised in the total costs by increase of other costs. Updating prices of produce has overall no effect on financial returns (CAFS remains equal). Consequently, the slight improvement in financial returns of IAFS is mainly caused by updating the yield of sugar beets for non-system specific outbreak of Rhizomania.

Eventually, after some economical and technical updating of the results of prototyping 1986-1990, it can be concluded IAFS is feasible if farm structure is optimised to 60 hectares and 1 fully employed labour force, whilst current rotation is maintained. At the moment, only some 20 % of the farms in the clay regions are of that size. So, Farm Structure Optimisation on a regional scale seems indispensable for general conversion to IAFS.

Table 9.8 Economic evaluation of IAFS by original data 1986-1990 and by updated data and Farm Structure Optimisation (NLG 1000 ha-1) (abs. = absolute, rel. = IAFS/CAFS)

	Original 1986-1990 (17ha)		Updated + FSO (60 ha)	
	abs.	rel.	abs.	rel.
financial returns (a)	7.32	0.95	7.70	1.01
major costs				
- pesticides	0.24	0.33	0.29	0.38
- fertilisers	0.28	0.74	0.16	0.69
- seeds/tubers	0.98	1.24	0.75	1.07
- labour	2.34	1.07	1.48	1.07
- machinary	2.42	1.11	1.38	1.05
total costs* (b)	9.81	1.00	7.83	0.98
net surplus(a - b)	-2.48	1.17 **	-0.16	0.44 **

* other costs included

** CAFS and IAFS are < 0

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10 Conclusions and recommendations

The following conclusions and recommendations have been drawn up in the light of the results of this first year of concerted action.

10.1 Research capacity

Of the 16 ongoing projects, only DE 2a, DE 2b, NL 2 and UK 1 fulfil all criteria (Table 1). Four projects cannot meet the minimum criterion of 1 scientist year in systems development and 8 cannot meet the minimum criterion of 1 scientist full-timer overall the project. The research teams in question are strongly recommended to increase their capacity, to assure performance at European level. Furthermore, in 8 projects the leader is less than 40 % involved. The leaders in question are strongly recommended to increase their involvement or to delegate another team member, to assure an equivalent input in the concerted action.

10.2 A methodical way to design and identify prototypes

Basic design of I/EAFS implies 3 initial steps:
(1) making a hierarchy of general and specific objectives;
(2) quantifying the major objectives in appropriate parameters;
(3) establishing the methods needed to achieve the quantified objectives.
The first step seems easy, but in practice it often needs to be revised, to link up with the second and third steps. The best result is achieved if you have a clear view of both the short and long-term shortcomings of arable farming in your region and your team's potential to develop new and better systems for the short (IAFS) and long term (EAFS).
The European hierarchies of objectives of IAFS and EAFS, averaged from 13 and 9 prototypes respectively, clearly reflect the crucial differences between the two basic systems (Figs 1.1-1.2). Contrary to IAFS, EAFS prototypes place basic income/profit subordinate to abiotic environment, and rely on ecologically-aware consumers willing to pay premium prices for food products with high added value and a credible label. IAFS prototypes follow a short-term strategy and try to be competitive on the world market, based on high and efficient production, which only allows for limited care for not-marketable objectives such as environment, nature/landscape and sustainability of food supply.
The project-wise hierarchies of objectives with a brief explanation by the research teams involved clearly show the major similarities and differences in a standardised way and seem very useful as Part 1 of a European identity card for I/EAFS prototypes (Figs 1.1.1-1.1.13 and 1.2.1-1.2.9). Therefore it is recommended that newcomers present the objectives of their prototypes in a similar way.
Steps 2 and 3 can also be followed in a standardised way, if provisional European shortlists of parameters and methods have already been made (Tables 3 and 4). A definitive shortlist of parameters and methods can be prepared afterwards (Table 5). The project-wise sets of parameters and methods covering the major 10 specific objectives, with a brief explanation by the research teams involved clearly show the major similarities and differences in a standardised way and seem very useful as Part 2 of a European identity card for I/EAFS prototypes (Tables 6.1.1-6.1.13 and 6.2.1-6.2.9). Therefore, it is recommended to newcomers to present the parameters and methods of their prototypes in a similar way.
If the identity cards Part 1 and Part 2 of the 22 prototypes in the ongoing projects are considered, large differences can be observed in progress on the methodical way of designing, especially in the consistency in the links between objectives, parameters and methods and the quality of the explanation. Therefore, all research teams are strongly recommended to keep improving the basics of their prototypes.

10.3 Agro-ecological layout of prototypes

From the concept of a farming system as an agro-ecological unity a set of 7 agro-ecological criteria is proposed for an optimal layout of I/EAFS. Most layouts of prototypes in ongoing projects cannot meet one or more of these criteria (Table 8). The research teams in question are recommended to revise their layout as far as possible and to bear in mind the shortcomings of their prototypes resulting from the lack of agro-ecological unity and identity.

Research teams with projects in preparation are strongly recommended to avoid an analytical layout aimed at comparing I/EAFS with conventional reference systems, since in various ways this conflicts with the concept of a farming system as an agro-ecological unity.

10.4 Prototyping on experimental farms or pilot farms

Currently, most prototypes are designed and developed on experimental farms. Often, a classical experimental layout is followed, including ecological and integrated prototypes and a conventional reference system. The primary purpose of such a layout is comparison: a kind of scientific arena is created to see which system is the best. Of course, the development of the prototypes can be a secondary purpose, but is far from optimally served in such a dualistic layout:

- the scale of the systems is often very small, and this may lead to agro-ecological, agronomical and economic distortions;
- the design and management of the systems is often kept static for the sake of comparison, but this conflicts with the development of prototypes based on annual evaluation and stepwise improvement.

A too small scale of prototypes can be avoided by abandoning a reference CAFS, which is not essential, and variants that are not basically different. Moreover, a static approach can be avoided and a commercial management can be pursued. Nevertheless, experimental farms will never be similar to commercial farms.

Therefore, it is recommended to develop IAFS or EAFS prototypes on pilot farms, where scale, design and management are representative of a viable agricultural enterprise. To ensure sufficient progress in prototyping, cooperation agreements between the research institute and the pilot farms is required with specification of the annual progress to be made. A group of at least 10 pilot farms is required, covering the regional range of soil, climate and management conditions, to answer the question of feasibility and competitiveness of the new systems. Since experimental farms are not appropriate to answer this question, prototyping on an experimental farm always needs a follow-up with pilot farms. In other words, prototyping on pilot farms saves time and money. The years saved by doing the design, evaluation and optimisation in the same groups of pilot farms are of vital importance for a rapid innovation of European agriculture.

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Annex I

Programme of Concerted Action AIR3-CT920755

Network of research teams on Integrated and Ecological Arable Farming Systems in EU and associated countries

1. Objectives

The general objective is to come to a representative research network on Integrated and Ecological Arable Farming Systems (I/EAFS), involving all 12 EU member-countries and essentially contributing to a sustainable development of European agriculture, based on a common methodology and an effective dissemination of the results throughout the Union.

Specific objectives are:

(A) 3 workshops on methodology and layout of new research projects, resulting in a manual on I/EAFS research (1993-1995);
(B) 4 workshops on progress of ongoing research projects, resulting in 4 progress reports (1993-1996).

2. Expertise and role of participants

The first initiative towards European cooperation in the design and development of I/EAFS was taken in 1986 by institutes in UK, DE, NL and F. They were inspired by promising results from the first two EU experimental farms in IAFS, namely Lautenbach (DE) and Nagele (NL). The outcome was a first report on the potential and limits of IAFS, presented as a comprehensive elaboration of Integrated Pest Management (Vereijken et al., 1986). Subsequently, experimental farms were started in Long Ashton (UK), Boigneville (F), Foulum, (DK) and Florence (I). The layout and initial results of these farms and some farms from EU-associated countries (A, CH) were presented in a second report (Vereijken & Royle Eds, 1989). The EU institutes involved in this first wave of I/EAFS research projects joined forces in a CAMAR project in 1990, which was scheduled to be finalized at the beginning of the current concerted action, early 1993. For this concerted action a large group of newcomers from all EC countries is being assembled around the small core of experienced participants (see annex 2). The participants must be leaders in the design, development and evaluation of prototype I/EAFS. Only 2-3 participants are being accepted per country, to maintain an effectively operating research network. Annual workshops are organized in turn by the experienced participants, to present their research projects and to have them critically but constructively evaluated, for the benefit of the prototypes to be developed in that region and elsewhere. The expertise of these participants is highlighted in subannex 1, with references.

There are three kinds of roles in this action:

- The coordinator (AB-DLO-NL, participant X_1) who will coordinate, arrange workshops, conduct inquiries and write reports.
- Participants, which also have extensive experience with IAFS such as PAGV (NL), FIPP (DE), and LARS (UK) (participants X_2-X_4)will jointly organise workshops and report in detail on their research projects.
- The other participants will input to the inquiries and workshops on methodology and results and will thus contribute to the manual and progress reports. As well, they will act as focal points within the scientific and farming communities in their countries for the flow of information on I/EAFS. The participants from non-member countries will have the same role but will receive no funding.

3. Results and evaluation criteria

(A) a manual on a commonly agreed methodology for I/EAFS research and a representative and interactive European network of I/EAFS research projects laid out and executed according to this manual;

(B) 4 progress reports presenting the participants and the state-of-the-art of their research projects, including a detailed presentation of the research projects of the main European centres and a critical review of the results for the major target groups (practitioners, policymakers and researchers).
The manual and the progress reports may be considered as hard evaluation criteria.

4. Benefits

For CAP:	the coming available of concrete results from I/EAFS in major European regions, with a more balanced approach to the societal interests involved (food supply, employment/basic income, profit, environment, nature/landscape, health/well-being) compared to the current farming systems.
For agricultural research:	a shift in activities from monodisciplinary research to interdisciplinary farming systems research, including interaction with pilot groups of farmers.

5. Work Plan of the concerted action

(A) Evaluation, improvement and standardisation of methodology in I/EAFS research

This task involves an inventory of the current methods followed by the members, based on an inquiry; 3 workshops on methodology and layout of new research projects and ultimately the publication of a manual on IAFS methodology covering three chapters:
I Prototyping on experimental farms.
II Evaluation and optimisation on pilot farms.
III Dissemination by groups or networks of pilot farms.

		time	*participant*
(A1)	*Prototyping on experimental (and pilot) farms*		
	- inventory by inquiry	1993/1	X_1, All
	- draft chapter I	1993/2	X_1,
	- workshop (Wageningen, first ½ week) to evaluate and standardise	1993/3	X_1, All
	- final chapter I	1994/4	X_1
(A2)	*Evaluation/optimisation on pilot (and experimental) farms*		
	- inventory by inquiry	1994/1	X_1, All
	- draft chapter II	1994/2	X_1
	- workshop (Wageningen, first ½ week) to evaluate and standardise	1994/3	X_1, All
	- final chapter II	1995/4	X_1
(A3)	*Dissemination by pilot groups or networks*		
	- inventory by inquiry	1996/1	X_4, All
	- draft chapter III	1996/2	X_4
	- workshop (Stuttgart or another centre, first ½ week) to evaluate and stardardise	1996/3	X_4, All
	- final chapter III	1996/4	X_4,
	- publication and distribution of manual	1997/1	X_1, All

(B) Annual elaboration and dissemination of the results in the expanding European network of I/EAFS research projects

This task involves 4 annual inventories, 4 workshops and 4 progress reports on the state of the art and main results from ongoing research. At the workshops, the draft report based on the inventory will be evaluated and the local experiment will be considered in detail, based on a detailed description of the state of the art and main results. As a result, the progress report will contain a general view of the ongoing research, with special emphasis on the experiment visited that year. Workshops 1, 2 and 4 will be combined with the 3 workshops of task A, to save time and money.

		time	*participant*
(B1)	*First progress report*		
	- inventory by inquiry	1993/1	X_1, All
	- draft report	1993/2	X_1, X_2
	- workshop (Wageningen, second ½ week) focus on prototyping (exp. farms)	1993/3	X_2, X_1, All
	- publication first report	1994/1	X_1, X_2
(B2)	*Second progress report*		
	- inventory by inquiry	1994/1	X_1, All
	- draft report	1994/2	X_1, X_2
	- workshop (Wageningen, second ½ week) focus on evaluation/optimisation (pilot farms)	1994/3	X_2, X_1, All
	- publication second report	1995/1	X_1, X_2
(B3)	*Third progress report*		
	- inventory by inquiry	1995/1	X_1, All
	- draft report	1995/2	X_1, X_3
	- workshop (Long Ashton or another centre, 3 days) focus on prototyping, evaluation/ optimisation (exp. farms and pilot farms)	1995/3	X_3, X_1, All
	- publication third report	1996/1	X_1, X_3
(B4)	Fourth progress report		
	- inventory by inquiry	1996/1	X_1, All
	- draft report	1996/2	X_1, X_4
	- workshop (Stuttgart or another centre, second ½ week) focus on dissemination (pilot groups)	1996/3	X_4, All
	- publication fourth report	1997/1	X_1, X_4

Coordination

Overall coordination, including the writing of the manual, the editing of the 4 progress reports and the organisation of 2 methodology workshops will be done by Vereijken (X_1). The organisation of the 4 workshops will be done by Vereijken (X_1) and Wijnands (X_2) (first 2 workshops), Jordan (X_3) (third?) and El Titi (X_4) (fourth?) respectively.

Communication

Communication within the network of I/EAFS researchers will be by correspondence, workshops and (if possible) electronic mail.

Dissemination

Dissemination of methodology and results will be assured by all participants who will act as national focal points and by way of 1 publication on methodology and 4 publications on the state of art. 1000 Copies of each publication will be printed and be distributed through the network of participants and EC-DG VI.

Subannex I

The methodical steps taken by the European IAFS research network to elaborate, evaluate and introduce Integrated Arable Farming Systems.

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1. Collect or develop the following components of integrated farming systems in a comprehensive and consistent way.
   1.1 environmentally safe methods of maintaining soil fertility
   1.2 varieties with broad resistance, sufficient productivity and high quality
   1.3 biological and physical methods of crop protection with chemicals as last resort, as far as allowed
   1.4 equipment, machines and buildings for a technically optimum management
   1.5 cropping systems aimed at quality and profitability
2. Compose and develop prototype systems on regional experimental farms.
   For example in Germany: Lautenbach (FIPP) and in UK: Long Ashton exp. farm (LARS). For example in the Netherlands: Nagele in the central clay district, Veendam in the peaty sand district (1986) and Vredepeel in the light sand district (PAGV). These 3 exp. farms cover the need to develop prototype systems for specific soil types in The Netherlands in a reasonable way.
3. Introduce and test the prototype systems on a small scale (for example FIPP in Germany and AB-DLO/PAGV in the Netherlands).
   3.1 regional formation of pilot groups for planned conversion from conventional to integrated farming
   3.2 monitoring and evaluation of technical, economic and environmental progress is monitored and evaluated (feed back to steps 1 + 2)
   3.3 optimising major input/output relations, to obtain generally applicable cropping and farming systems
4. Introduce integrated production systems on a large scale via extension and education
   4.1 manuals and courses for extension specialists and teachers
   4.2 appropriate teaching in agricultural schools
   4.3 courses and study groups for farmers
   4.4 appropriate cropping manuals and view-data

References

Vereijken, P., C. Edwards, A. El Titi, A. Fougeroux & M. Way, 1986. Report of the study group 'Management of farming systems for integrated control'. IOBC-WPRS Bulletin 1986/IX/2, Wageningen, 34 pp.
Vereijken, P. & D.J. Royle (Eds.), 1989. Current status of research on integrated arable farming systems in Western Europe. IOBC/WPRS Bulletin 1989/XII/5, Wageningen, 76 pp.

Annexe II
Research Network on integrated Arable Farming Systems for EU and associated countries

EU countries	**Participants workshop Wageningen 1993**		**Projects type**	**name**	**code**
BELGIUM **(B)**	1. Prof. dr Alain Peeters or ir Vincent van Bol	Université de Louvain Lab. d'Ecologie des Prairies Place Croix du Sud 2 1348 Louvain-La-Neuve Fax no. 32-10472428	EAFS 8 pilot farms	-	in prep.
DENMARK **(DK)**	1. Dr. Gunnar Mikkelsen	Research Centre Foulum Dep. Forage Crops and Potatoes Postboks 21 8830 Tjele Fax no. 45-89991839	I/EAFS 1 exp. farm	Foulum	DK 1
FRANCE **(F)**	1. Dr. Philippe Viaux	ITCF Station Experimental Boigneville F 91720 Boigneville Fax no. 33-164993039	IAFS 1 exp. farm	Boigneville	F 1
	2. Dr. Christophe Roturier	ACTA 149 rue de Bercy 75595 Paris Cedex 12 Fax no. 33-140045011	IAFS 1 exp. farm	Courseulles	F 2
	3. Dr. Philippe Girardin	INRA B.P. 507 68021 Colmar Cedex Fax no. 33-89724933	IAFS 16 pilot farms	-	in prep.
GERMANY **(DE)**	1. Dr. Adel El Titi	State. Inst. for Plant Protection Reinsburgstrasse 107 7197 Stuttgart 1 Fax no. 49-711622268	I/EAFS 1 exp. farm	Lautenbach	DE 1
	2. Dr. Michael Wildenhayn	Forschungs und Studienzentrum Landwirtschaft und Umwelt Von Siebold-Str. 8 D-37075 Göttingen Fax no. 49-551394601	I/EAFS 2 exp. farms	Reinshof Marienstein	DE 2a DE 2b
GREECE **(GR)**	1. Dr. Kiriaki Kalburtji	University of Thessaloniki Faculty of Agriculture Lab. Ecology and Environmental Protection 54006 Thessaloniki Fax no. 30-31471795	EAFS 3 exp. sites	-	in prep.
IRELAND **(IRL)**	1. Dr. Finnain S. Mac-Naeidhe	Johnstown Castle Research Centre - Wexford Fax no. 353-5342004	EAFS 1 exp. farm	Johnstown	IRL 1
	2. Dr. James Burke	Oak Park Research Centre Carlow Fax no. 353-50342423	1 IAFS 1 exp. farm	-	in prep.

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ITALY **(I)**	1. Prof. dr Concetta Vazzana	University of Florence Faculty of Agric. and Forestry Piazzale delle Cascine 18 50144 Florence Fax no. 39-55332472	I/EAFS 1 exp. farm	Montepaldi	I 1
	2. Prof. dr Giuseppe Zerbi (absent)	University of Udine Dept. of Plant Prod. and Agrotechnology Via delle Science, 208, 33100 Udine Fax no. 39-432558603	IAFS 1 pilot farm	-	in prep.
THE NETHERLANDS **(NL)**	1. Ir. Frank Wijnands	Exp. Station of Arable Farming P.O. Box 430 8200 AK Lelystad Fax no. 31-320030479	I/EAFS 1 exp. farm	Nagele	NL 1
	2. Dr. Pieter Vereijken	Research Institute for Agrobiology and Soil Fertility (AB-DLO) P.O. Box 14 6700 AA Wageningen Fax no. 31-837075952	EAFS 10 pilot farms	Flevoland	NL 2
PORTUGAL **(PT)**	1. Dr. Mario Carvalho	University of Evora Department of Agronomy 7000 Evora Fax no. 35-1-66711163	IAFS 1 exp. farm	-	in prep.
SPAIN **(ES)**	1. Dr. José Carlos Avila Cano	ETSIAM/ISEC Apartado de Correos 3048 14080 Cordoba Fax no. 34-57218563	EAFS 1 pilot farm	-	in prep.
	2. Dr. Carlos Cantero -Martinez	IRTA C. Alcalde Rovira Roure 177 25006 LLeida Fax no. 34-73238301	IAFS 1 exp. farm	-	in prep.
	3. Dr. Ricardo Colmenares	Centro Invest. "F.G. Bernaldez". C/ San Sebastián, 71 28791 Soto del Real (Madrid) Fax no. 34-18478130	EAFS 3 pilot farms	-	in prep.
UNITED KINGDOM **(UK)**	1. Dr. Vic Jordan	Long Ashton Research Station Long Ashton - Bristol BS18 9AF Fax no. 44-275 394007	IAFS 1 exp. farm	LIFE	UK 1
	2. Dr. Sue Ogilvy	ADAS-High Mowthorpe EHF Duggleby, Malton Y 0178 BP North Yorkshire Fax no. 44-944 738434	IAFS 6 exp. farms	LINK	UK 2

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Countries outside EU

FINLAND **(FIN)**	1. Dr. Tapani Pulkki	University of Helsinki Dep. of Plant Production PL 27 Viikki 00014 Helsinki Fax no. 358-0 708 5463	IAFS 1 exp. farm	Suitia	FIN 1
NORWAY **(N)**	1. Dr. Arve Skutlaberg	Agricultural University of Norway P.O. Box 5041 1432 Ås Fax no. 47- 64 94 7921	EAFS 3 pilot farms	-	in prep.
POLAND **(PL)**	1. Dr. Edward Majewski	FAPA Nieklanska 35 03-924 Warszawa Fax no. 48-26179593	IAFS 2 pilot farms	-	in prep.
POLAND **(PL)**	2. Dr. Marian Krol	Institute of Soil Science and Plant Cult. 24-100 Pulawy Fax no. 48-831 4547	I/EAFS 11 pilot farms	-	in prep.
SWEDEN **(S)**	1. Dr. Carl Anders Helander	Hushållningssällskapet Skaraborg P.O. Box 124 532 23 Skara Fax no. 46-51118631	I/EAFS 1 exp. farm	Logården	S 1
	2. Dr. Christer Nilsson	University of Agricultural Science P.O. Box 44 23053 Alnarp Fax no. 46-40462166	IAFS 1 exp. farm	Alnarp	S 2
SWITZERLAND **(CH)**	1. Dr. Padruot Fried	Swiss Fed. Res. Station of Agronomy 8046 Zürich-Reckenholz Fax no. 41-13777201	I/EAFS 1 exp. farm	Burgrain	CH 1
	2. Dr. Fritz Häni	Swiss College of Agriculture 052 Berne-Zollikofen Fax no. 41-31 9102299	IAFS 3 pilot farms	Third Way	CH 2