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3. Testing and Improving Prototypes

Progress Reports of the 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 third progress report of EU concerted action AIR-CT 920755 presents the state of the art in European research on prototyping Integrated and Ecological Arable Farming Systems (I/EAFS). The basic objective is to establish a common frame of reference for prototyping these systems by elaborating and standardising the methods of prototyping, which will be laid down and disseminated in four progress reports and a manual (1993 - 1997).

The methods of prototyping I/EAFS comprise 5 consecutive steps:

(1) *drawing up a hierarchy of general and specific objectives (Part 1 of prototype's identity card);*

(2) *transforming the major objectives (10) into multi-objective parameters to quantify them, and establishing the multi-objective farming methods needed to achieve those quantified objectives (Part 2);*

(3) *designing a theoretical prototype by linking parameters to farming methods and designing these methods until they are ready for initial testing (Parts 3 and 4);*

(4) *laying out for testing and improving the prototype in general, and the farming methods in particular, until the objectives as quantified in the set of parameters have been achieved (Parts 5 and 6);*

(5) *disseminating the prototype by pilot groups (<15 farmers), regional networks (15-30 farmers) and finally by national networks (regional networks interlinked), with a gradual shift in supervision from researchers to extensionists.*

This third progress report focuses on Step 4. Seven teams, each with a project on an experimental farm, have been selected to present in this step the state of the art for in total 11 prototypes (7 IAFS and 4 EAFS). Firstly, they present their theoretical prototype (Part 3) and their Multifunctional Crop Rotation (Part 4) as a baseline (Agro-ecological layout as Part 5 has already been presented in Progress Report 1). Secondly, they present their progress in Step 4 from 1993 to 1995 for selected parameters of the EU-shortlist. Thirdly, they present the actual state of the art in Step 4 for all parameters and methods of their theoretical prototype as Part 6 of their identity card.

The Parts 3, 4 and 6 of the identity cards clearly show the similarities and differences of the 11 prototypes, as well as their strengths and weaknesses, to the benefit of all participating projects, whether ongoing or in preparation.

The report ends with critical, but constructive conclusions and recommendations that calls for further progress on developing methods for prototyping more sustainable arable farming systems in Europe, for both the short (IAFS) and long term (EAFS).

1 Introduction to the concerted action

In agreement with the programme of the concerted action (annex 1), the second progress report dealt with design and testing of prototypes, particularly on pilot farms.

In this progress report, the scope has been widened to include improving prototypes. The method of improving is elaborated and the state of the art in testing and improving prototypes is presented from the 7 experimental farms in the EU network that have at least 3 years of experience in this.

The shift of focus from projects on groups of pilot farms back to projects on single experimental farms has been made to be able to present a sufficient number of projects for which at least 3 years of testing results are available. Data for this period is needed to be able to judge if a team is improving successfully, which implies that the shortfall between achieved and desired results is gradually being made good. Next year there will also be a sufficient number of pilot projects to be able to present their state of the art in testing and improving prototypes.

1.1 The second year reviewed

The first two steps on the methodical way of prototyping Integrated (for the short term) and Ecological (for the long term) Arable Farming Systems (I/EAFS) were considered in the first progress report. Those steps were:

(1) *drawing up a hierarchy of general and specific objectives (prototype's identity card Part 1);*
(2) *transforming the major (10) objectives into multi-objective parameters to quantify them and establishing the multi-objective farming methods needed to achieve those quantified objectives (prototype's identity card Part 2).*

The next two steps were considered in the second progress report. They were:

(3) *designing a theoretical prototype by linking parameters to farming methods and designing the methods in this context until they are ready for initial testing;*
(4) *laying out for testing and improving the prototype in general, and the farming methods in particular, until the objectives as quantified in the set of parameters have been achieved.*

The aim of the second report was to elaborate Step 3 and the testing part of Step 4, and to present the state of the art up to Step 3 of 9 selected projects on pilot farms.
Pilot projects were preferred to projects on experimental farms because prototyping on an experimental farm may easily lead to agro-ecological, agronomic and economic distortions, due to un-representative scale and management, and lack of replicates to cover the regional ranges of soil, climate, farm structure and farm management. Of course that does not mean one cannot try to minimise these disadvantages and develop useful prototypes on an experimental farm. Nevertheless, Steps 3 and 4 must be repeated with a group of pilot farms to assess the feasibility and competitiveness of the new system, a prerequisite for the final step of dissemination.

Therefore, it will also save time and money to cover the entire methodical way of designing, testing and improving with a group of pilot farms. From the second progress report it can be concluded that most of the teams succeeded fairly well in presenting their state of the art in terms of the methodical way up to Step 3. It included the design of a theoretical prototype as Part 3 and a Multifunctional Crop Rotation as Part 4 of their prototype's identity card. However this does not imply that all these pilot projects will be managed from now on in ways consistent with methodical prototyping. Because most pilot projects do not follow it from the beginning, ongoing testing programmes should be revised by excluding parameters that do not occur in the theoretical prototype and by making ready for use parameters that do already occur in the theoretical prototype but are not yet used in testing.

Similarly, the presentation of a Multifunctional Crop Rotation for one of the pilot farms of any pilot project does not imply that all farms within any pilot project already have such a rotation. On the contrary, most rotations of arable farmers in the EU are too short and cereal-dominated. Therefore, to maintain soil fertility and crop vitality as a base for quality production most teams must still make great efforts to introduce on their pilot farms a well-balanced 'team' of crops that require a minimum of inputs that pollute and are based on fossil energy (nutrients, pesticides, machinery and fuel).

A final issue dealt with in the second year was the need for an agro-ecological layout. Such a layout is based on the concept that I/EAFS should be an agro-ecological whole consisting of a 'team' of steadily interacting and rotating crops, including their accompanying (beneficial or harmful) flora and fauna.

Only by considering the farming system as an agro-ecological whole:

- can the prototype achieve sufficient agro-ecological identity in a turbulent and distorting environment dominated by monocultures and short rotations that come with a chronic imbalance between beneficial and harmful flora and fauna and chronic use of pesticides to compensate for this.
- can the prototype achieve results desired in multi-objective parameters that directly depend on agro-ecological identity, such as Ecological Infrastructure requiring sufficient spatial continuity (for flora, fauna and recreation), and Exposure of Environment to Pesticides and Quality Production, both requiring sufficient support from beneficial flora and fauna.
- can the prototype achieve desired results in multi-objective parameters, which indirectly depend on an agro-ecological whole, insofar as it supports a management that is effective and efficient in timing and input of labour and energy. In principle, all parameters, including Net Surplus and Energy Efficiency, are concerned.

From the concept of a farm as an agro-ecological whole, a set of 7 agro-ecological criteria has been drawn up to characterise the layouts of the 9 selected pilot projects (Part 5 of their prototype's identity card) and subsequently to evaluate them (Chapter 7). The state of the art in laying out prototypes is that most layouts fall seriously short of meeting the 7 agro-ecological criteria. In 1994, only some agro-ecologically valid layouts were present in DE 3, IRL 1 and NL 2 (see Annex II for definition of project codes). After minor revision, some could also be present in B 1, F 1, NL 1 and PL 1. However most pilot projects need major revision to achieve agro-ecologically valid layouts of all prototype variants, because many of the pilot farms have one or more fields that are not adjacent to the others. Therefore their prototype variants cannot be laid out as an agro-ecological whole, which is a prerequisite for an agro-ecological identity.

Because of the general tendency of farmers to scatter their fields and the tendency of researchers to split their plots, teams with ongoing projects, or projects in preparation, are strongly advised to layout their prototypes as an agro-ecological whole. Depending on the value attached to the criterion of field adjacency, there are various options for revising the layout of prototype variants. The most consistent solution is to select only those pilot farms whose fields are all adjacent (permanent grassland included). Another consistent solution is to layout the prototype only on a part of the farm with adjacent fields, thus excluding non-adjacent fields. As a compromise, 1 or 2 non-adjacent fields could be included if they can be connected to the other fields by the ecological infrastructure (for example, by hedge-rows or ditches buffered by grass strips).

1.2 Scope of the third year

The scope of this third year was to elaborate the methodology of the improving part of Step 4 and to present the state of the art in testing and improving (Step 4) of the projects that have at least 3 years of data.

Currently the criterion of at least 3 years of data from Step 4 cannot yet be fulfilled by most pilot projects. Therefore this progress report presents the state of the art of only 7 selected projects on experimental farms.

Most pilot projects do not yet have a testing programme consistent with the methodical way of prototyping (Section 1.1). The same is true for most of the projects on experimental farms, because they, too, were already testing and improving prototypes before this concerted action began. In the first progress report projects selected presented their hierarchy of objectives as Part 1 and parameters and farming methods as Part 2 of their prototype's identity card. In this report they should first present their theoretical prototype as Part 3, an indispensable base for Step 4.

Before designing a theoretical prototype, they should check and update the results of the preceding steps by carefully answering the following questions:

- does your hierarchy of objectives (Part 1) really cover the shortcomings of conventional arable farming (IAFS) or organic farming (EAFS) in your region (no too low ratings for 'new' objectives, such as nature, and no too high ratings for 'old' objectives, such as basic income/profit) to ensure that you really are innovating and not just slightly ahead of the main group of farmers?
- have you in Part 2 (second column) really transformed the objectives into the appropriate set of multi-objective parameters (not too few, but certainly not too many, parameters!) and have you in Part 2 (second column) quantified each objective appropriately (not more, but certainly not less, ambitious than needed); and have you in Part 2 (third column) established an appropriate set of farming methods (not too many single-objective or too few multi-objective methods)?

In general testing prototypes is a matter of operating the set of parameters by comparing the results achieved with the results desired, as quantified in the Part 2 of the prototype's identity card. Improving prototypes is a matter of operating the set of farming methods, by relating the possible shortfall between achieved and desired results to the methods that are linked to the parameters in question, and by improving them in a targeted way.

Consequently, testing before a desired result is quantified is useless when following a methodical way of prototyping. Furthermore, laying out the prototype from year to year without gradually making good the shortfall between achieved and desired results means lack of improvement. Therefore, in this third year it was a major challenge for any of the 7 selected teams to present a successful state of the art in testing and improving.

1.3 Layout of this report

This third progress report is laid out as follows.

After presenting 7 selected projects and their teams on an experimental farm (Section 1.4), Parts 3 and 4 (theoretical prototype and multifunctional crop rotation) of their identity cards are discussed in Chapter 2.
Improving a prototype is explained and a format is proposed for improving farming methods according to a set of 4 criteria (Chapter 3). Based on this format, the 7 selected projects present the state of the art in testing and improving of their prototypes (Step 4) with various parameters of the EU shortlist, including:

- P and K Available Reserves (P/KAR) and Annual Balances ((P/KAB) (Chapter 4);
- N Available Reserves (NAR), Soil Cover Index (SCI) and Organic Matter Annual Balance (OMAB) (Chapter 5);
- Pesticide Index (PI), Environment Exposure to Pesticides (EEP) and Quality Production Index (QPI) (Chapter 6);
- Ecological Infrastructure Index (EII) and Plant Species Diversity (PSD) (Chapter 7);
- the state of the art in 1995 as Part 6 of their identity cards (Chapter 8).

The team organising the third workshop (UK 1) presents the state of the art in testing and improving its IAFS prototype (Chapter 9).
This third progress report ends with conclusions and recommendations (Chapter 10), and a list of selected new references.

Table 1. List of selected European projects in I/EAFS prototyping on experimental farms, ongoing in 1995

Criteria concerted action (see Section 1.4)		**DE 2** Niedersachsen	**DK 1** Foulum	**I 1** Montepaldi	**NL 1** Nagele	**UK 1** LIFE	**UK 2** LINK	**S 1** Logården
Duration (years)								
IAFS	≥ **4**	4	10	8	10	11	5	8
EAFS	≥ **6**	-	10	8	10	-	-	8
IAFS-Variants		2	2	1	2	2	1	2
Ha/variant	≥ **4**	11.8	8.0	5.2	20	7	17.5	28.0
Ha/field	≥ **1**	3.0	1.5	1.3	2.5	2	3.5	4.0
EAFS-Variants			2	1	1			1
Ha/variant	≥ **6**		10.0	5.2	22			22.0
Ha/field	≥ **1**		1.5	1.3	3.7			3.1
Objectives ranked								
Prototyping	= **1**	1	1	1	1	1	1	1
Scientist years								
In prototyping	≥ **1**	1	3	1	0.6	3	3.5	2.3
Project full-timers	≥ **1**	1	1	2	0	4	0	0
Research leader								
% time involved	≥ **50**	80	50	60	50	80	50	70
Main activity of leader								
Designing farming systems	= **1**	1	1	1	1	1	1	1

1.4 Selection of projects in prototyping I/EAFS

Research leaders and their projects have been selected for the workshop and progress report of this third year of concerted action on almost the same sets of general and specific criteria as were used in the second year.

General criteria

(1) *Up to 25 participants may attend the workshop, up to 3 from large countries and up to 2 from small countries.*

(2) *Participants must be the creative leaders of research teams on I/EAFS projects.*

(3) *Ongoing projects are preferred to projects in preparation, but the latter may be admitted if at an advanced stage of planning.*

(4) *In this third year, research leaders of both pilot projects and projects on experimental farms may participate in the workshop, but the pilot projects should postpone ther presentation of the state of the art in testing and improving to the fourth progress report so that there will be a sufficient number of them with at least 3 years of data available.*

Based on these 4 general criteria, 23 research leaders from ongoing projects or projects in preparation were invited to the workshop held 2-7 July 1995 in Bristol (Annex 2).
Of the 18 ongoing projects, 11 are projects on pilot farms and 7 are projects on an experimental farm. A pilot farm is a commercial farm with one prototype system being studied.
An experimental farm is a non-commercial farm, usually with more than one system being studied, therefore most of the systems and fields are much smaller than for commercial farms.

Specific criteria

(1) *Project duration ≥ 4-6 years*
An IAFS or EAFS requires at least one period of a full rotation, i.e. 4 or 6 years to be developed as a prototype (see Progress Report 2, Section 1.2).

(2) a. *Projects on pilot farms*
- *Size of pilot group ≥ 10 farms*
  Prototyping requires a pilot group of at least 10 farms to cover the regional ranges in soil, climate, farm structure and farm management.
- *Agro-ecological layout of the pilot farms*
  I/EAFS require an agro-ecological layout based on various criteria (see Progress Report 1, Section 7.4) to obtain sufficient agro-ecological identity and validity.

b. *Projects on experimental farms*
- *Size of prototype systems ≥ 4-6 hectares and field sizes ≥ 1 hectares*
  An integrated or ecological system requires at least a 4- or 6-year crop rotation, and for a representative layout and management a field should be at least 1 hectare.
- *Agro-ecological layout of the experimental farm*
  I/EAFS require an agro-ecological layout based on various criteria (see Progress Report 1, Section 7.4) to obtain sufficient agro-ecological identity and validity.

(3) *Prototyping = project objective number 1*
Only projects aimed primarily at prototyping are expected to make an appropriate contribution to the concerted action. Comparison and demonstration have their use, of course, but should be subordinate to prototyping.

(4) *Scientist years in prototyping ≥ 1*
Prototyping projects on I/EAFS require at least an input from scientists equivalent to one functional time unit per year. This is the experience of teams of the first wave.

(5) *Project full-timers ≥ 1*
Prototyping, whether on pilot farms or an experimental farm, requires the total commitment of at least 1 scientist.

(6) *Research leader ≥ 50 % involved*
The leadership of a team on I/EAFS prototyping, whether on pilot farms or an experimental farm, requires involvement for at least 2.5 days/week.

(7) *Main activity of research leader = design*
The leadership of a team on I/EAFS prototyping requires primarily creative input.

Although these 7 specific criteria are far from ambitious from a professional point of view, of the 7 selected projects on experimental farms in 1995, only DE 2, DK 1 and UK 1 could fulfil them all (Table 1). This points to a general deficiency in research capacity. Therefore all teams are still encouraged to try to achieve a scientific core of 2 full-timers: a senior researcher (creative leader) and a junior researcher (to be groomed as a potential leader).

2 Parts 3 and 4 of the identity cards of the 7 selected projects

In line with the set of parameters and methods in Part 2 of their prototype's identity card, the teams of the 7 selected European projects on an experimental farm present their theoretical prototype, Part 3 of their identity card, in Section 2.1 and their multifunctional crop rotation, Part 4 of their identity card, in Section 2.3.
The state of the art for Parts 3 and 4 is briefly discussed in Sections 2.2 and 2.4.

2.1 Theoretical prototype (Part 3)

The theoretical prototype shows the major and minor methods to be followed to achieve the desired result for each parameter.Conversely, it also shows which parameters are supported by a method, thus indicating the overall impact of a method. Consequently, the theoretical prototype defines the context and the order of designing the methods, as the teams briefly explain in their Parts 3.

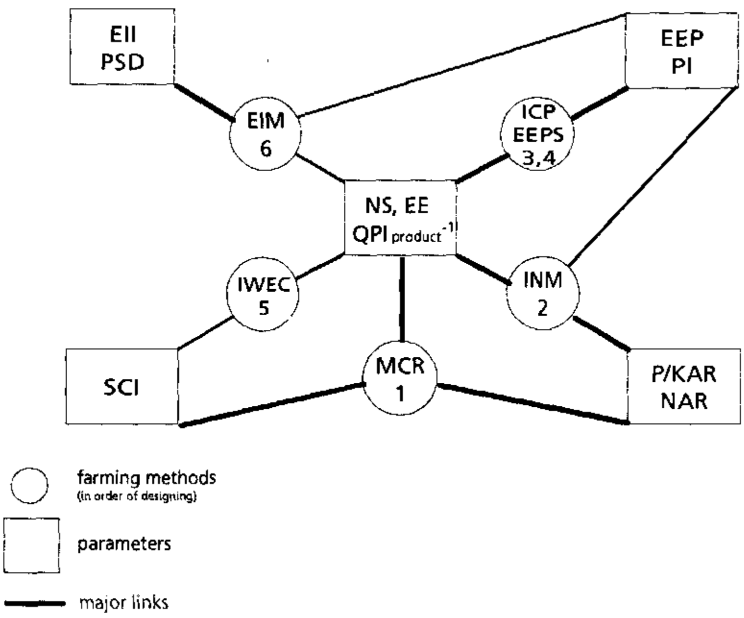


Figure 1.1 Theoretical IAFS prototype of Reinshof (DE 2)

In Reinshof, the 10 major objectives as quantified in 11 parameters are being achieved by 6 multi-objective methods, designed and made ready for use in the following order:

(1) Multifunctional Crop Rotation (MCR) is one of the major methods to achieve results desired in Net Surplus (NS), Quality Production Index (QPI) and Energy Efficiency (EE). It is also one of the two major methods to achieve results desired in Available Reserves of N, P and K (NAR, PAR, KAR), and the major method to achieve results desired in Soil Cover Index (SCI).

(2) Integrated Nutrient Management (INM) is the second of the two major methods to achieve results desired in N, P and K Available Reserves. It is one of the major methods to achieve results desired in Net Surplus, Quality Production Index and Energy Efficiency. It is also a supporting method to reduce Pesticide Index (PI) and Environmental Exposure to Pesticides (EEP).

(3,4) Integrated Crop Protection (ICP) and Environment Exposure-based Pesticide Selection (EEPS) are the two major methods to achieve results desired in Pesticide Index and Environmental Exposure to Pesticides. They are also major methods to achieve results desired in Net Surplus, Quality Production Index and Energy Efficiency.

(5) Integrated Weed and Erosion Control (IWEC) is a supporting method for achieving results desired in Soil Cover Index, Net Surplus, Quality Production Index and Energy Efficiency.

(6) Ecological Infrastructure Management (EIM) is the major method to achieve results desired in Ecological Infrastructure Index (EII) and Plant Species Diversity (PSD). It is a supporting method for achieving results desired in Pesticide Index and in Environmental Exposure to Pesticides.

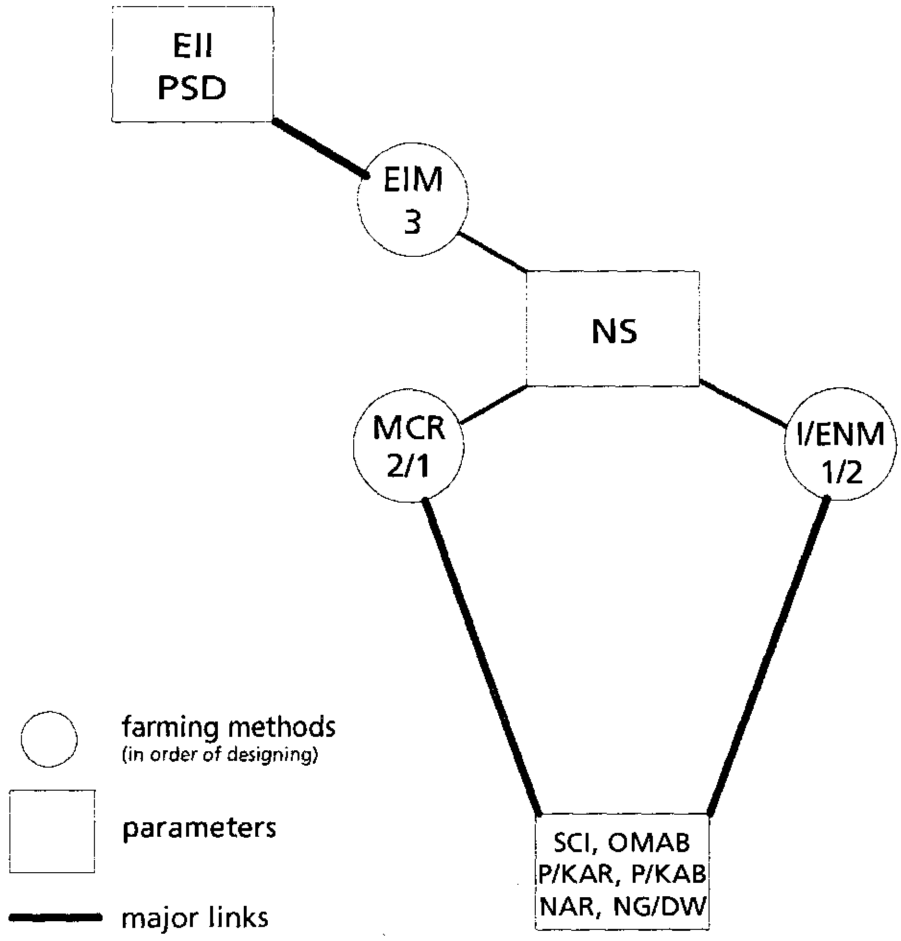


Figure 1.2 Theoretical I/EAFS prototypes of Foulum (DK 1)

In Foulum, the 10 major objectives as quantified in 12 parameters are being achieved by 3 multi-objective methods, designed and made ready for use in the following order:

(1,2) Multifunctional Crop Rotation (MCR, to be designed first in EAFS) and Integrated or Ecological Nutrient Management (I/ENM) (INM to be designed first in IAFS) are the major methods to achieve results desired in Net Surplus (NS), Soil Cover Index (SCI), Organic Matter Annual Balance (OMAB), PK Available Reserves (P/KAR), PK Annual Balances (P/KAB), N Available Reserves (NAR) and N Ground or Drainage Water (NG/DW).

(3) Ecological Infrastructure Management (EIM) is the major method for achieving results desired in Ecological Infrastructure Index(EII) and Plant Species Diversity (PSD). It is also a method supporting Net Surplus.

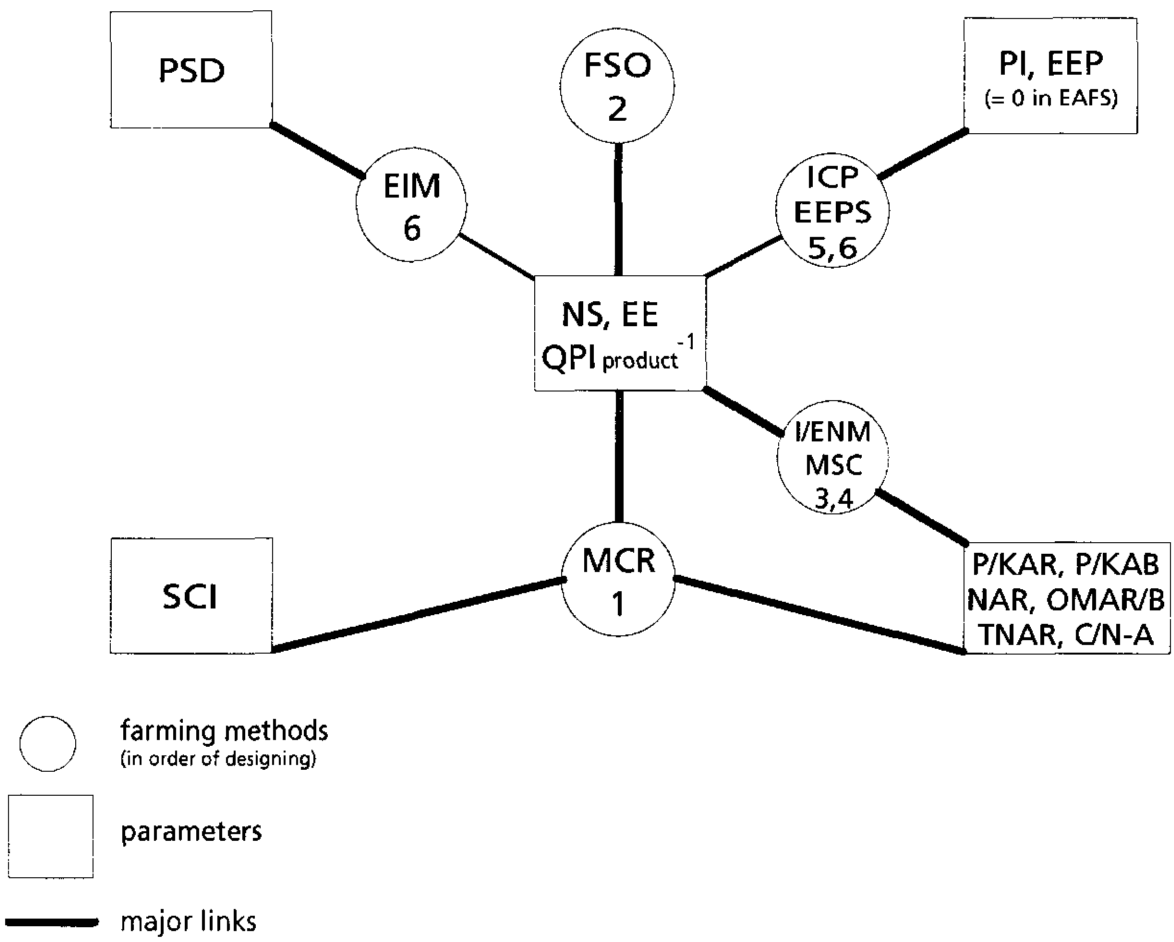


Figure 1.3 Theoretical I/EAFS prototypes of Montepaldi (I 1)

In Montepaldi, the 10 major objectives as quantified in 17 parameters are being achieved by 7 multi-objective methods, designed and made ready for use in the following order:

(1) Multifunctional Crop Rotation (MCR) is one of the four major methods to achieve Energy Efficiency (EE), one of the three major methods to achieve Organic Matter Annual Balance (OMAB), Organic Matter Annual Reserves (OMAR), Nitrogen Available Reserves (NAR), P/K Annual Balance (P/KAB), P/K Available Reserves, and two local parameters called Total Nitrogen Available Reserves (TNAR) and Annual Carbon/Nitrogen (C/N-A); one of the two major methods to achieve Net Surplus (NS) and Quality Production Index (QPI): and the major method to achieve Soil Cover Index (SCI).

(2) Farm Structure Optimisation (FSO) is one of the four major methods to achieve Energy Efficiency, and one of two major methods to achieve Net Surplus and Quality Production Index.

(3,4) Integrated or Ecological Nutrient Management (I/ENM) and Minimum Soil Cultivation (MSC) are jointly two of the four major methods to achieve Energy Efficiency; two of the three major methods to achieve Organic Matter Annual Balance, Organic Matter Annual Reserves, Nitrogen Available Reserves, P/K Annual Balance and P/K Available Reserves, Total Nitrogen Annual Reserves and Annual Carbon/Nitrogen; and two of the five supporting methods to achieve Quality Production Index.

(5,6) Integrated Crop Protection ICP) and Environment Exposure-based Pesticide Selection are the major methods to achieve results desired of IAFS in Pesticide Index (PI); two of the five supporting methods to achieve Quality Production Index; and one of the two supporting methods to achieve Energy Efficiency.

(7) Ecological Infrastructure Management (EIM) is the major method to achieve Ecological Infrastructure Index (EII) and Plant Species Diversity (PSD); one of the four supporting methods to achieve Quality Production Index; and one of the two supporting methods to achieve Energy Efficiency.

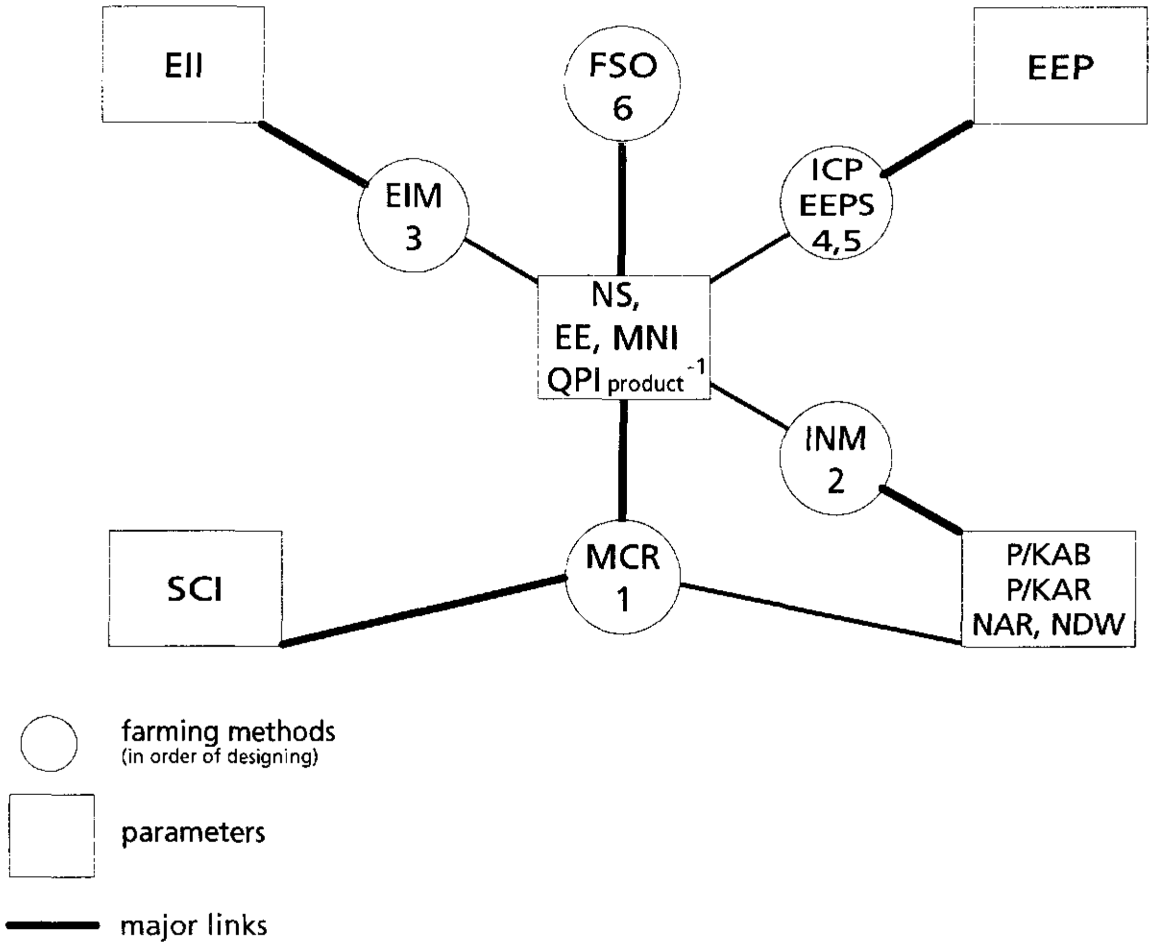


Figure 1.4.1 Theoretical IAFS prototype of Nagele (NL 1)

In Nagele, the 10 major objectives as quantified in 13 parameters are being achieved by 6 multi-objective methods, designed and made ready for use in the following order:

(1) Multifunctional Crop Rotation (MCR) is the major method to achieve results desired in Quality Production Indices (QPI product^{-1}), Net Surplus (NS), Energy Efficiency (EE), Mineral Nitrogen Input (MNI, local parameter additional to EE) and Soil Cover Index (SCI). It is also a method supporting P and K Annual Balances (P/KAB), P and K Available Reserves (P/KAR), N Available Reserves (NAR) and N Drainage Water (NDW).

(2) Integrated Nutrient Management (INM) is the major method to achieve results desired in PK Annual Balances and Available Reserves, N Available Reserves and N Drainage Water. It is also a method supporting Quality Production Indices, Net Surplus, Energy Efficiency and Mineral Nitrogen Input.

(3) Ecological Infrastructure Management (EIM) is the major method to achieve results desired in Ecological Infrastructure Index (EII). It is also a method supporting Quality Production Indices and Net Surplus.

(4,5) Integrated Crop Protection (ICP) and Environment Exposure-based Pesticide Selection (EEPS) are the two major methods to achieve results desired in Environment Exposure to Pesticides (EEP). They are also supporting Quality Production Indices, Net Surplus and Energy Efficiency.

(6) Farm Structure Optimisation (FSO) is the finalising method to achieve results desired in Net Surplus and Energy Efficiency, if the amounts of land, labour or capital goods of the current layout fail to do so with the agronomically and ecologically optimised prototype IAFS.

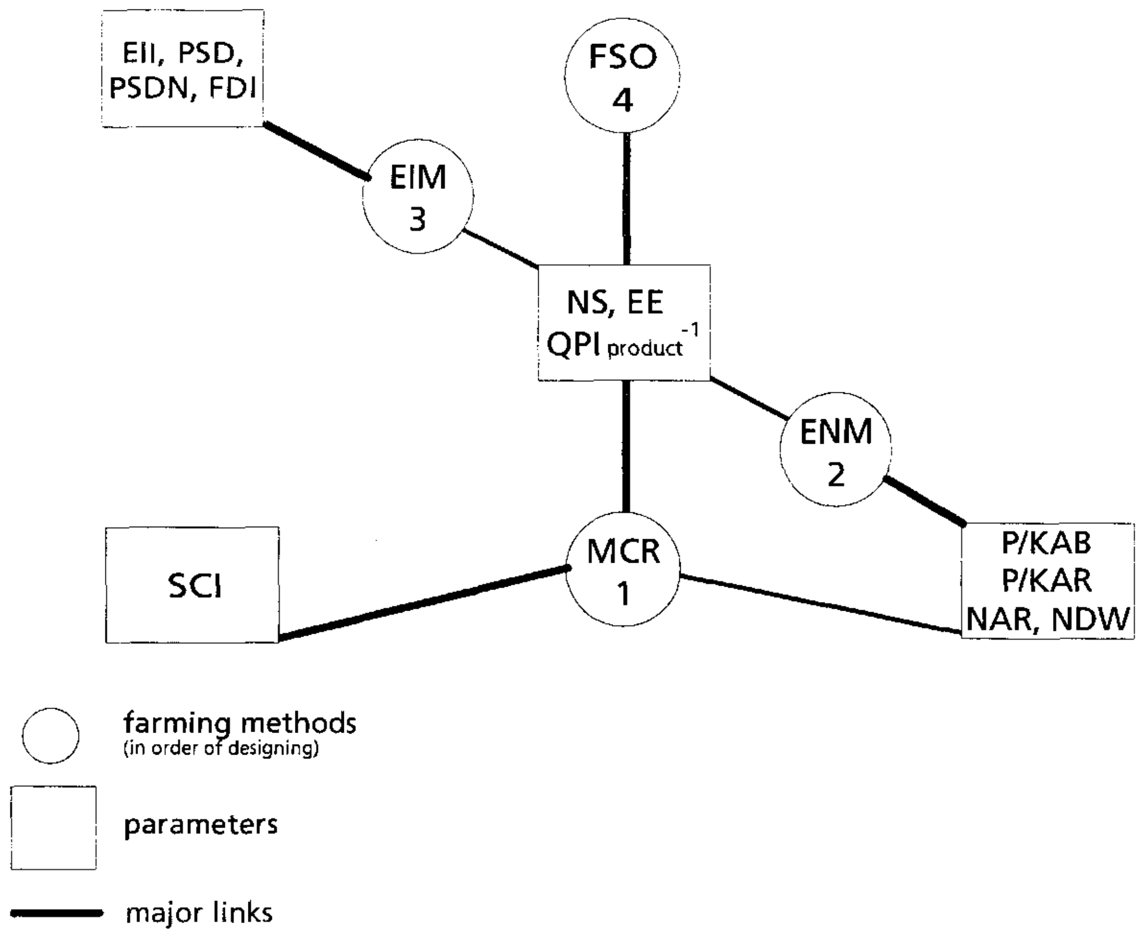


Figure 1.4.2 Theoretical EAFS prototype of Nagele (NL 1)

In Nagele, the 10 major objectives as quantified in 14 parameters are being achieved by 5 multi-objective methods, and made ready for use in the following order:

(1) Multifunctional Crop Rotation (MCR) is the major method to achieve results desired in Quality Production Indices (QPI $product^{-1}$) without using pesticides (EEP=0); Net Surplus (NS), Energy Efficiency (EE) and Soil Cover Index (SCI). It is also a method supporting P and K Annual Balance (P/KAB), P and K Available Reserves (P/KAR), N Available Reserves (NAR) and N Drainage Water (NDW).

(2) Ecological Nutrient Management (ENM) is the major method to achieve results desired in P and K Annual Balances, P and K Available Reserves, N Available Reserves and N Drainage Water. It is also a method supporting Quality Production Indices (without using pesticides), Net Surplus and Energy Efficiency.

(3) Ecological Infrastructure Management (EIM) is the major method to achieve results desired in Ecological Infrastructure Index (EII), Plant Species Diversity (PSD) and local parameters of flora: Plant Species Distribution (PSDN) and Flower Density (FDI). It is also a method supporting Quality Production Indices and Net Surplus.

(4) Farm Structure Optimisation is the finalising method to achieve the result desired in Net Surplus, if the current amounts of land, labour or capital goods of the current layout fail to do so with the agronomically and ecologically optimised prototype EAFS.

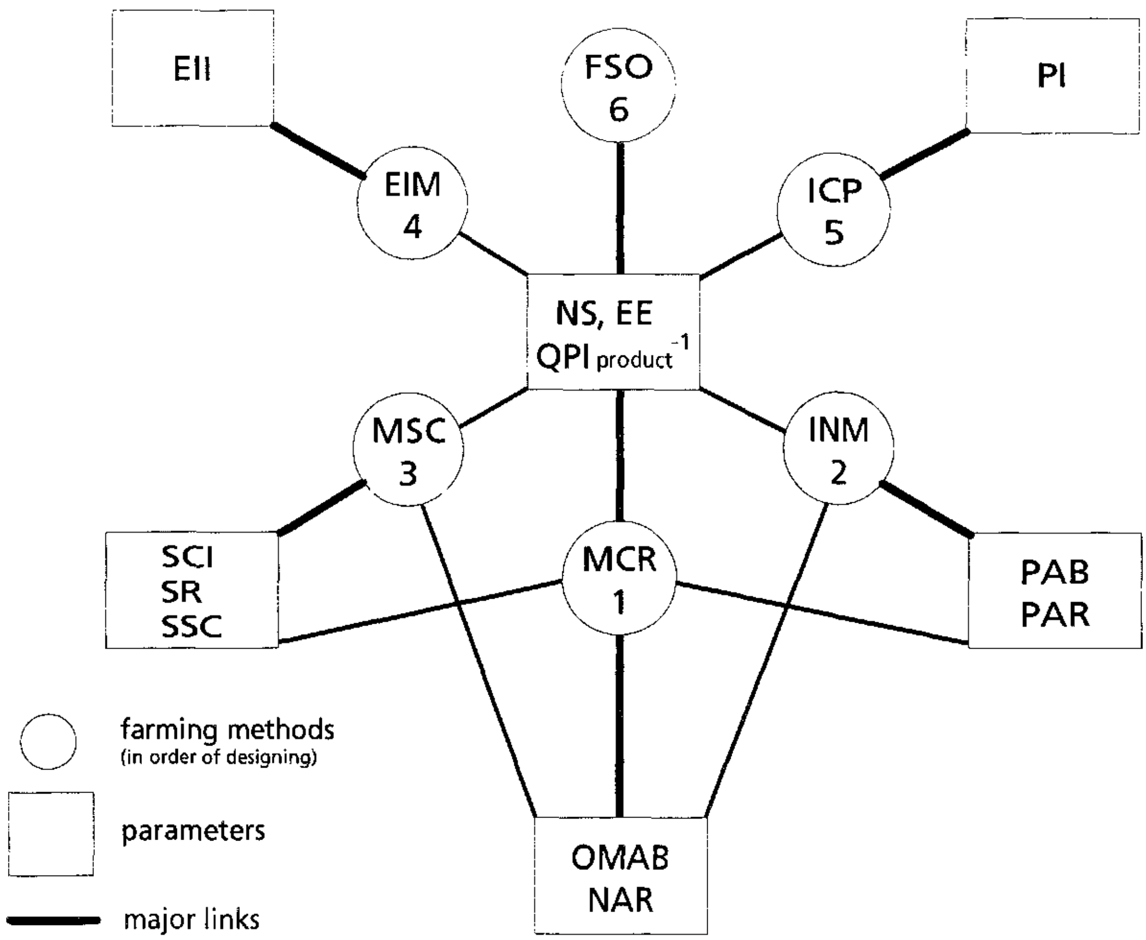


Figure 1. 5.1. Theoretical IAFS prototype of Logården (S 1)

In Logården, the 10 major objectives as quantified in 12 parameters are being achieved by 6 multi-objective methods, designed and made ready for use in the following order:

(1) Multifunctional Crop Rotation (MCR) is the major method to achieve results desired in Quality Production Indices (QPI product-1), Net Surplus (NS) and Energy Efficiency (EE). It is also a method supporting P Annual Balance (PAB), P Available Reserves (PAR), N Available Reserves (NAR), Organic Matter Annual Balance (OMAB), N Available Reserves, Soil Cover Index (SCI), Soil Respiration (SR) and Soil Structure and Compaction (SSC). The latter two are local parameters.

(2) Integrated Nutrient Management (INM) is the major method to achieve results desired in P Annual Balance, P Available Reserves and Organic Matter Annual Balance. It is also a method supporting Quality Production Indices, Net Surplus and Energy Efficiency.

(3) Minimum Soil Cultivation (MSC) is the major method to achieve results desired in Soil Cover Index, Soil Respiration and Soil Structure and Compaction. It is also a method supporting Quality Production Indices, Net Surplus, Energy Efficiency and Organic Matter Annual Balance.

(4) Ecological Infrastructure Management (EIM) is the major method to achieve results desired in Ecological Infrastructure Index (EII). It is also a method supporting Quality Production Indices, Net Surplus and Energy Efficiency.

(5) Integrated Crop Protection (ICP) is the major method to achieve results desired in Pesticide Index (PI). It is also a method supporting Quality Production Indices, Net Surplus and Energy Efficiency.

(6) Farm Structure Optimisation (FSO) is the finalising method to achieve results desired in Net Surplus and Energy Efficiency, if the current amounts of land, labour or capital goods of the experimental farm fail to do so with the agronomically and ecologically optimised prototype IAFS.

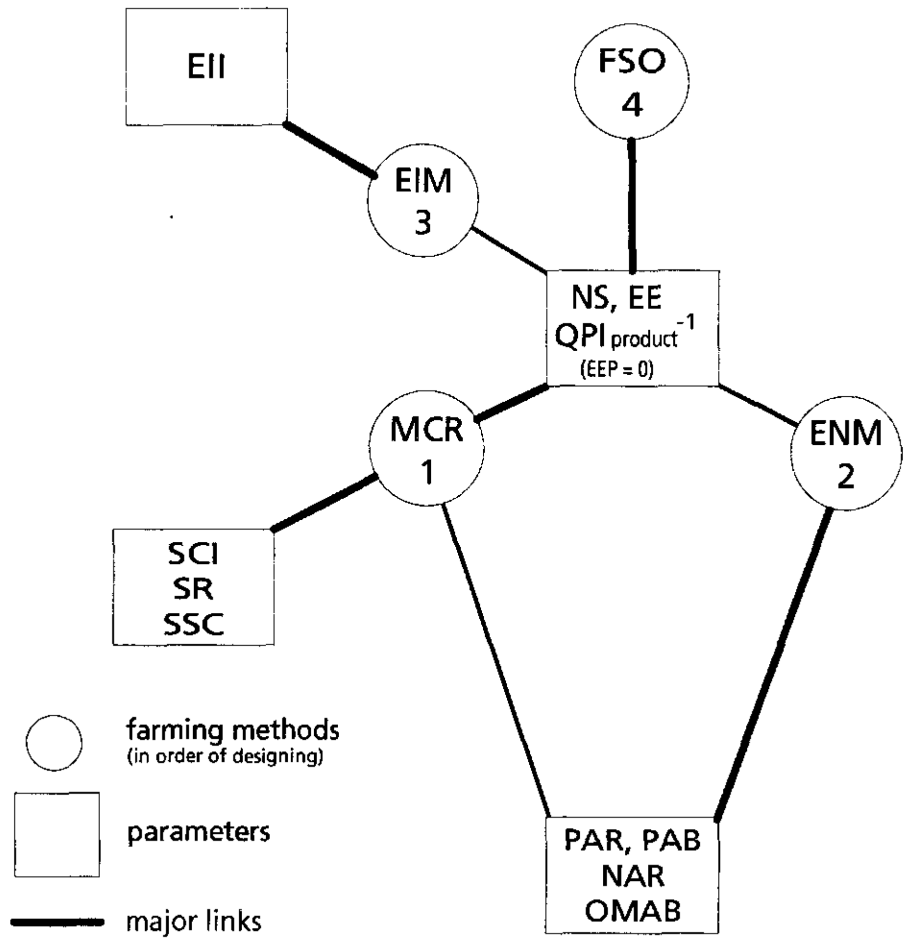


Figure 1.5.2 Theoretical EAFS prototype of Logården (S 1)

In Logården, the 10 major objectives as quantified in 11 parameters are being achieved by 4 multi-objective methods, designed and made ready for use in the following order:

(1) Multifunctional Crop Rotation (MCR) is the major method to achieve results desired in Quality Production Indices (QPI product^{-1}) without using pesticides (EEP=0), Net Surplus (NS), Energy Efficiency (EE), Soil Cover Index (SCI), Soil Respiration (SR), and Soil Structure and Compaction (SSC). It is also a method supporting P Annual Balance (PAB), P Available Reserves (PAR), N Available Reserves (NAR) and Organic Matter Annual Balance (OMAB).

(2) Ecological Nutrient Management (ENM) is the major method to achieve results desired in P Annual Balance, P Available Reserves, N Available Reserves and Organic Matter Annual Balance. It is also a method supporting Quality Production Indices, Net Surplus and Energy Efficiency.

(3) Ecological Infrastructure Management (EIM) is the major method to achieve results desired in Ecological Infrastructure Index (EII). It is also a method supporting Quality Production Indices, Net Surplus and Energy Efficiency.

(4) Farm Structure Optimisation (FSO) is the finalising method to achieve results desired in Net Surplus and Energy Efficiency, if the current amount of land, labour or capital goods of the experimental farm fail to do so with the agronomically and ecologically optimised prototype EAFS.

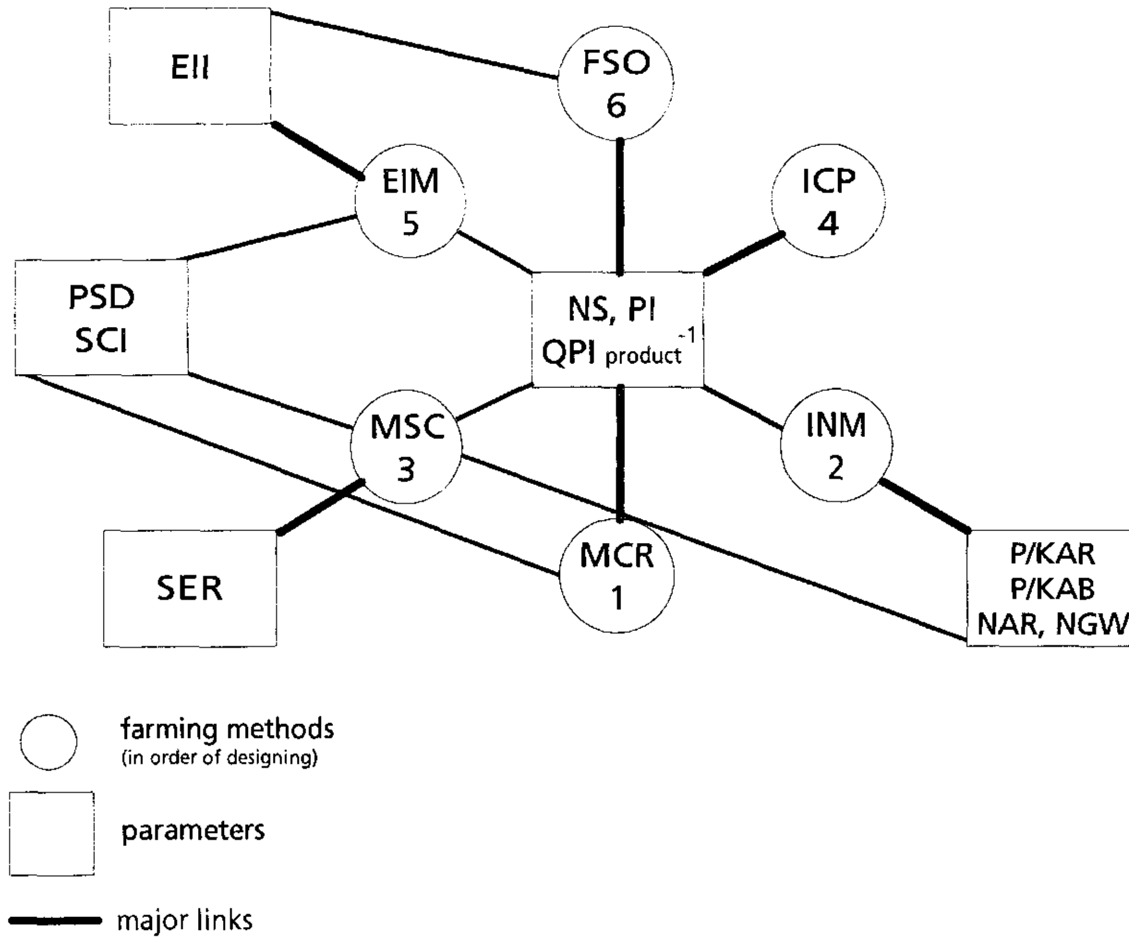


Figure 1.6 Theoretical IAFS prototype of LIFE (UK 1)

In LIFE, the 10 major objectives as quantified in 13 parameters are being achieved by 6 multi-objective methods, designed and made ready for use in the following order:

(1) Multifunctional Crop Rotation (MCR) is the first of the three major methods to achieve results desired in Quality Production Indices (QPI) and Net Surplus (NS), but cannot be exploited to full potential because it market-driven. It is also a supporting method for Soil Cover Index (SCI), Plant Species Diversity (PSD) and Pesticide Index (PI).

(2) Integrated Nutrient Management (INM) is the second of the three major methods to achieve results desired in Net Surplus and Quality Production Index. It is also a supporting method for Pesticide Index (PI), NPK Available Reserves (NAR, PAR, KAR) and N Groundwater (NGW).

(3) Minimum Soil Cultivation (MSC) is the major method to achieve results desired in Soil Erosion Rate (SER, a local parameter). It is also a supporting method for NPK Available Reserves, Pesticide Index, Soil Cover Index and N Groundwater.

(4) Integrated Crop Protection (ICP) is the major method to achieve results desired in Pesticide Index. It is also a supporting method for Net Surplus and Quality Production Index.

(5) Ecological Infrastructure Management (EIM) is the major method to achieve results desired in Ecological Infrastructure Index (EII). It is also a supporting method for Net Surplus, Plant Species Diversity, Soil Cover Index and Pesticide Index.

(6) Farm Structure Optimisation (FSO) is the third of the three methods to achieve the result desired in Net Surplus. It is also a supporting method for Ecological Infrastructure Index.

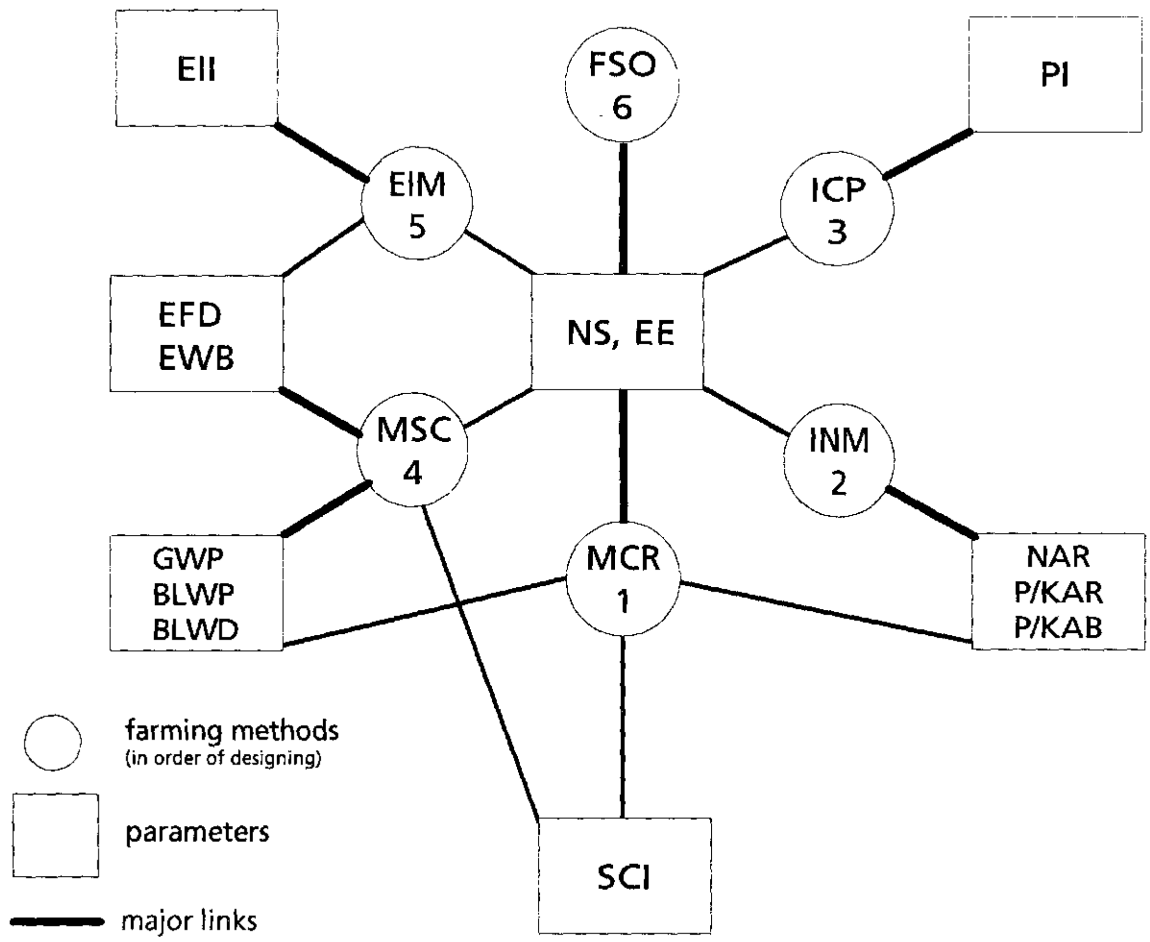


Figure 1.7 Theoretical IAFS prototype of LINK (UK 2)

In LINK, the 10 major objectives as quantified in 15 parameters are being achieved by 6 multi-objective methods, designed and made ready for use in the following order:

(1) Multifunctional Crop Rotation (MCR) is the major method to achieve results desired in Net Surplus (NS),Energy Efficiency (EE) and Soil Cover Index (SCI). It is also a method supporting P and K Annual Balances (P/KAB); N, P and K Available Reserves (N/P/KAR); Grass Weed Populations and Broad-leaved Weed Populations (GWP, BLWP); and Broad-leaved Weed Diversity (BLWD). The last three are local parameters.

(2) Integrated Nutrient Management (INM) is the major method to achieve results desired in N/P/K Available Reserves and P/K Annual Balances. It is also a method supporting Net Surplus and Energy Efficiency.

(3) Integrated Crop Protection (ICP) is the major method to achieve results desired in Pesticide Index (PI). It is also a method supporting Net Surplus and Energy Efficiency.

(4) Minimum Soil Cultivation (MSC) is the major method to achieve results desired in Grass and Broad-leaved Weed Populations, Broad-leaved Weed Diversity, Epigeeic Fauna Diversity (EFD) and Earthworm Biomass (EWB). The last five are local parameters. It is also a method supporting Soil Cover Index, Net Surplus and Energy Efficiency.

(5) Ecological Infrastructure Management (EIM) is the major method to achieve results desired in Ecological Infrastructure Index (EII). It is also a method supporting Epigaeic Fauna Diversity, Earthworm Biomass, Net Surplus and Energy Efficiency.

(6) Farm Structure Optimisation (FSO) is a major finalising method to achieve results desired in Net Surplus and Energy Efficiency.

2.2 State of the art in theoretical prototyping

Designing a theoretical prototype and the farming methods in this context is an indispensable Step 3 in a methodical way of prototyping I/EAFS. Designing a theoretical prototype implies the careful linking of the methods to the parameters established in Step 2. As a result, the theoretical prototype shows which are the major and minor methods used to achieve the desired result in any parameter. Moreover, the theoretical prototype shows the overall impact of any method, and thus reveals the context for and order in which the methods should be designed.
Only if a consistent theoretical prototype has been designed and the methods have been sufficiently elaborated for initial use can you proceed to Step 4, testing and improving the prototype in practice until the objectives as transformed and quantified in the set of multi-objective parameters have achieved. However most of the 11 theoretical prototypes presented were drawn up while the team was already testing! As a result, the testing programme needs to be thoroughly revised and made consistent with the first 3 steps! This implies that testing with parameters that do not occur in the theoretical prototypes should be abandoned.Alternatively, parameters that occur in the theoretical prototype and have not yet used in testing should be made ready for use by assessing which results are desired and how they can be quantified in practice. If you are not able to quantify the desired results for certain parameters, then, you must conclude that such parameters are not appropriate for prototyping and that they should be removed from the theoretical prototype.

Major revision of the ongoing testing programme may be embarrassing and even painful for your team, but it is always better than proceeding along a path of comparative research and ending up with a report about an inconsistent, incomplete prototype.

Table 2. Up-to-date shortlist of multi-objective parameters and farming methods * in I/EAFS prototyping shared by at least 5 of the 12 IAFS; and 9 EAFS prototypes presented in Progress Reports 2 and 3.

Parameters		Farming methods	
Name	**Prototypes**	**Name**	**Prototypes**
NS (Net Surplus)	19	**MCR** (Multifunctional Crop Rotation)	19
NAR (N Available Reserves)	18	**INM, ENM** (Integr./Ecol. Nutrient Management, cover crops, recycling of organic waste and biol. N fixation included)	19
EII (Ecological Infrastructure Index)	17		
PAB, KAB (PK Annual Balances)	17	**EIM** (Ecological Infrastructure Management)	19
SCI (Soil Cover Index)	16	**FSO** (Farm Structure Optimisation)	14
PAR, KAR (PK Available Reserves)	13	**ICP** (Integrated Crop Protection)	11
QPI (Quality Production Index)	13	**MSC** (Minimum Soil Cultivation)	7
PSD (Plant Species Diversity)	12		
NGW, NDW (N Groundwater/Drainage Water)	12	**EEPS** (Environment Exposure-based Pesticides Selection)	3
OMAB (Organic Matter Annual Balance)	11		
EE (Energy Efficiency)	9		
EEP ** (Environment Exposure to Pesticides)	8		
PI ** (Pesticide Index)	8		

* See Progress Report 1, Tables 3-4 for definitions
** Unlike EEP, PI is only useful if reference CAFS is available.

2.3 Multifunctional Crop Rotation (Part 4)

The teams of the 7 selected European projects on an experimental farm present a representative variant of their Multifunctional Crop Rotation (MCR) as Part 4, in line with the formats for designing an MCR (Progress Report 2, Subsection 3.2.1). In format A, they first present the selection of the most profitable crops eligible for the MCR in the region in question, listing their major characteristics in terms of biological, physical and chemical soil fertility. Subsequently, in format B they present the MCR that optimally complies with the multifunctional set of demands (Progress Report 2, Subsection 3.2.1).
The MCRs are briefly evaluated in Section 2.4 in terms of the multifunctional set of demands.

Table 3.1 Multifunctional Crop Rotation of IAFS prototype in Reinshof (DE 2)

A. Selection of crops for the region (crops in order of profitability).

crop no.	biological species	group[1]	physical (ratings) cover[2]	rooting[3]	compaction[4]	structure[3+4]	chemical (N ratings) uptake[5]	transfer[6]
1	sugar beet	chen.	-2	1	-4	-3	3	1
2	oil seed rape	cruc.	0	2	-1	1	5	1
3	winter wheat	cer.	0	3	-1	2	5	1
4	winter rye	cer.	0	3	-1	2	4	1
5	winter barley	cer.	0	3	-1	2	4	1
6	oats	cer.	0	3	-1	2	3	1
7	set-aside	(mixture)	0	2	0	2	1	1
mean of crop selection			-0.3	2.4	-1.3	1.1	3.6	1.0

B. Multifunctional Crop Rotation for the region.

block no.	crop no.	biological species	group[1]	physical (ratings) cover[2]	structure[3+4]	chemical (N ratings) uptake[5]	transfer[6]	need[7]
I	2	oilseed rape	cruc.	0	1	5	2	4
II	6	oats	cer.	0	2	3	1	1
III	3	winter wheat	cer.	0	2	5	1	4
IV	7	set-aside	volunteers/weeds	0	2	1	1	0
mean of crop rotation		share species^{-1} ≤ 0.25	share group^{-1} ≤ 0.5	0	1.8	3.5	1.25	2.25

1) Genetically and phytopathologically related groups, such as cereals (cer.), legumes (leg.), crucifers (cruc.) and chenopodes (chen.), composites (comp.) and umbellifers (umbel.), liliaceae (lil.). All subsequent blocks of perennial crops are counted as one block.
2) No cover in autumn and winter = -4; no cover in autumn or winter = -2; all others = 0 (green manure crops included).
3) Cereals, grasses and lucerne = 3; root, bulb and tuber crops = 1; all others = 2 (green manure crops included).
4) Compaction by mowing in summer = -1 and in autumn = -2; lifting in summer = -2 and in autumn = -4.
5) N uptake by crop from soil reserves: legumes = 0. All other crops: 25-50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3; 150-200 kg ha^{-1} = 4; etc. (N uptake = N product + N crop residue).
6) N transfer is the expected net contribution of N to subsequent crop, based on N residues in the soil after harvest, N mineralisation from crop residues and N losses by leaching and denitrification. In this rating the effect of green manure crops should be included. N transfer < 50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3.
7) N_{need} (block *x*) = N_{uptake} (block *x*) minus $N_{transfer}$ (block *x*-1). N need is net N input to be provided by manure or N fertiliser.

Table 3.2.1 Multifunctional Crop Rotations of IAFS prototypes of Foulum (DK 1)

A. Selection of crops for mixed farms in the region (crops in descending order of profitability).

crop no.	biological: species	biological: group[1]	physical (ratings): cover[2]	physical (ratings): rooting[3]	physical (ratings): compaction[4]	physical (ratings): structure[3+4]	chemical (N ratings): uptake[5]	chemical (N ratings): transfer[6]
1	fodderbeet	chen.	-2	1	-4	-3		1
2	winter wheat	cer.	-2	3	-1	2		1
3	barley/pea/grass	cer./leg./grass	0	3	-1	2		1
4	barley	cer.	0	3	-1	2		1
5	grass	grass	0	3	-1	2		1
6	spring rape	cruc.	0	3	-1	2		1
7								
8								
9								
10								
mean of crop selection			-0.7	2.7	-1.5	1.2		1

B. Multifunctional Crop Rotations for the region, cattle variant

block no.	crop no.	biological: species	biological: group[1]	physical (ratings): cover[2]	physical (ratings): structure[3+4]	chemical (N ratings): uptake[5]	chemical (N ratings): transfer[6]	chemical (N ratings): need[7]
I	1	fodderbeet	chen.	-2	-3		1	
II	3	barley/pea/grass	cer./leg./grass	-2	2		1	
III	4	grass	grass	0	2		1	
IV	2	winter wheat	cer.	-2	2		1	
mean of crop rotation		share species^{-1} ≤ 0.33	share group^{-1} ≤ 0.33	-1.5	0.8		1	

pig variant

block no.	crop no.	biological: species	biological: group[1]	physical (ratings): cover[2]	physical (ratings): structure[3+4]	chemical (N ratings): uptake[5]	chemical (N ratings): transfer[6]	chemical (N ratings): need[7]
I	2	winter wheat	cer.	-2	2		1	
II	4	barley	cer.	0	2		1	
III	4	barley	cer.	0	2		1	
IV	6	spring rape	cruc.	0	2		1	
mean of crop rotation		share species^{-1} ≤ 0.5	share group^{-1} ≤ 0.75	-0.5	2		1	

1) Genetically and phytopathologically related groups, such as cereals (cer.), legumes (leg.), crucifers (cruc.) and chenopodes (chen.), composites (comp.) and umbellifers (umbel.), liliaceae (lil.). All subsequent blocks of perennial crops are counted as one block.
2) No cover in autumn and winter = -4; no cover in autumn or winter = -2; all others = 0 (green manure crops included).
3) Cereals, grasses and lucerne = 3; root, bulb and tuber crops = 1; all others = 2 (green manure crops included).
4) Compaction by mowing in summer = -1 and in autumn = -2; lifting in summer = -2 and in autumn = -4.
5) N uptake by crop from soil reserves: legumes = 0. All other crops: 25-50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3; 150-200 kg ha^{-1} = 4; etc. (N uptake = N product + N crop residue).
6) N transfer is the expected net contribution of N to subsequent crop, based on N residues in the soil after harvest, N mineralisation from crop residues and N losses by leaching and denitrification. In this rating the effect of green manure crops should be included. N transfer < 50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3.
7) N_{need} (block *x*) = N_{uptake} (block *x*) minus $N_{transfer}$ (block *x*-1). N need is net N input to be provided by manure or N fertiliser.

Table 3.2.2 Multifunctional Crop Rotation of EAFS prototype of Foulum (DK 1)

A. Selection of crops for mixed farms with cattle in the region (crops in descending order of profitability).

crop no.	biological species	group[1]	physical (ratings) cover[2]	rooting[3]	compaction[4]	structure[3+4]	chemical (N ratings) uptake[5]	transfer[6]
1	grassclover	grass/leg.	0	3	-1	2		2
2	fodderbeet	chen.	-2	1	-4	-3		1
3	winter wheat	cer.	-2	3	-1	2		1
4	barley/pea/grass	cer./leg./cer.	0	3	-1	2		1
5	barley	cer.	-2	3	-1	2		1
mean of crop selection			-1.2	2.6	-1.6	1		1.2

B. Multifunctional Crop Rotation for the region.

block no.	crop no.	biological species	group[1]	physical (ratings) cover[2]	structure[3+4]	chemical (N ratings) uptake[5]	transfer[6]	need[7]
I	1	grassclover	grass/leg.	0	2		2	
II	1	grassclover	grass/leg.	0	2		2	
III	4	barley/pea/grass	cer./leg./grass	-2	2		1	
IV	3	winter wheat	cer.	-2	2		1	
V	3	fodderbeet	chen.	-2	-3		1	
VI	5	barley	cer.	0	2		1	
mean of crop rotation		share species^{-1} ≤ 0.22	share group^{-1} ≤ 0.40	-1	1.2		1.3	

1) Genetically and phytopathologically related groups, such as cereals (cer.), legumes (leg.), crucifers (cruc.) and chenopodes (chen.), composites (comp.) and umbellifers (umbel.), liliaceae (lil.). All subsequent blocks of perennial crops are counted as one block.
2) No cover in autumn and winter = -4; no cover in autumn or winter = -2; all others = 0 (green manure crops included).
3) Cereals, grasses and lucerne = 3; root, bulb and tuber crops = 1; all others = 2 (green manure crops included).
4) Compaction by mowing in summer = -1 and in autumn = -2; lifting in summer = -2 and in autumn = -4.
5) N uptake by crop from soil reserves: legumes = 0. All other crops: 25-50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3; 150-200 kg ha^{-1} = 4; etc. (N uptake = N product + N crop residue).
6) N transfer is the expected net contribution of N to subsequent crop, based on N residues in the soil after harvest, N mineralisation from crop residues and N losses by leaching and denitrification. In this rating the effect of green manure crops should be included. N transfer < 50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3.
7) N_{need} (block *x*) = N_{uptake} (block *x*) minus $N_{transfer}$ (block *x*-1). N need is net N input to be provided by manure or N fertiliser.

Table 3.4.2 Multifunctional Crop Rotation of EAFS prototype in Nagele (NL 1)

A. Selection of crops for the region (crops in descending order of profitability).

crop	biological		physical (ratings)				chemical (N ratings)	
no.	species	group[1]	cover[2]	rooting[3]	compaction[4]	structure[3+4]	uptake[5]	transfer[6]
1	carrot	umbel.	-2	1	-4	-3	4	1
2	seed potato	solan.	-2	1	-2	-1	3	2
3	onion	lil.	-4	1	-2	-1	3	1
4	celeriac	umbel.	-2	1	-4	-3	3	1
5	sugar beet	chen.	-2	1	-4	-3	5	1
6	pea, bean	leg.	-2	2	-1	1	0	2
7	wheat	cer.	-2	3	-1	2	3	2
8	oats	oats	-2	3	-1	2	3	2
9	barley	cer.	-2	3	-1	2	3	2
10	grassclover	leg.	0	3	-1	2	3	2
mean of crop selection			-2.0	1.9	-2.1	-0.2	3.0	1.6

B. Multifunctional Crop Rotation for the region.

block	crop	biological		physical (ratings)		chemical (N ratings)		
no.	no.	species	group[1]	cover[2]	structure[3+4]	uptake[5]	transfer[6]	need[7]
I	1	carrot	umbel.	-2	-3	4	1	2
II	8	oats	oats	-2	2	3	2	2
III	2	seed potato	solan.	-2	-1	3	2	1
IV	7	spring wheat	cer.	-2	2	3	2	1
V	3/4	onion/celeriac	lil./umbel.	-4/-2	-1/-3	3/3	1/1	1/1
VI	9	spring barley	cer.	-2	-1	3	2	2
mean of crop rotation		share species^{-1} ≤ 0.167	share group^{-1} ≤ 0.33	-2.2	-0.5	3.2	1.7	1.5

1) Genetically and phytopathologically related groups, such as cereals (cer.), legumes (leg.), crucifers (cruc.) and chenopodes (chen.), composites (comp.) and umbellifers (umbel.), liliaceae (lil.). All subsequent blocks of perennial crops are counted as one block.

2) No cover in autumn and winter = -4; no cover in autumn or winter = -2; all others = 0 (green manure crops included).

3) Cereals, grasses and lucerne = 3; root, bulb and tuber crops = 1; all others = 2 (green manure crops included).

4) Compaction by mowing in summer = -1 and in autumn = -2; lifting in summer = -2 and in autumn = -4.

5) N uptake by crop from soil reserves: legumes = 0. All other crops: 25-50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3; 150-200 kg ha^{-1} = 4; etc. (N uptake = N product + N crop residue).

6) N transfer is the expected net contribution of N to subsequent crop, based on N residues in the soil after harvest, N mineralisation from crop residues and N losses by leaching and denitrification. In this rating the effect of green manure crops should be included. N transfer < 50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3.

7) N_{need} (block *x*) = N_{uptake} (block *x*) minus $N_{transfer}$ (block *x*-1). N need is net N input to be provided by manure or N fertiliser.

Table 3.5.1 Multifunctional Crop Rotation of IAFS prototype of Logården (S 1)

A. Selection of crops for the region (crops in descending order of profitability).

crop no.	biological: species	group[1]	physical (ratings): cover[2]	rooting[3]	compaction[4;8]	structure[3+4+8]	chemical (N ratings): uptake[5]	transfer[6]
1	winter wheat	cer.	0	3	-1 +0	2	4	1
2	winter rape	cruc.	0	2	-1 +0	1	4	1
3	pea	leg.	-2	2	-2 -2	-2	0	2
4	spring rape	cruc.	-2	2	-2 -2	-2	3	1
5	barley	cer.	-2	3	-2 -2	-1	3	1
6	oats	cer.	0	3	-2 -2	-1	3	1
7	triticale	cer.	0	3	-1 +0	2	4	1
8	set-aside	grass/leg.	0	3	-1 +2	4	1	2
9	rye	cer.	0	3	-1 +0	2	3	1
10	spring wheat	cer.	-2	2	-2 -2	-1	4	1
mean of crop selection			-0.8	2.6	-1.5 -0.8	0.4	2.9	1.3

B. Multifunctional Crop Rotation for the region.

block no.	crop no.	biological: species	group[1]	physical (ratings): cover[2]	structure[3+4+8]	chemical (N ratings): uptake[5]	transfer[6]	need[7]
I	1	winter wheat	cer.	0	2	4	1	2
II	8	set-aside	grass/leg.	0	4	1	2	0
III	8	set-aside	grass/leg.	0	4	1	3	-1
IV	2	winter rape	cruc.	0	1	4	1	1
V	1	winter wheat	cer.	0	2	4	1	3
VI	6	oats	cer.	0	-1	3	1	2
VII	7	triticale	cer.	0	2	4	1	3
VIII	3	pea	leg.	-2	-2	0	2	-1
mean of crop rotation		share species^{-1} ≤ 0.25	share group^{-1} ≤ 0.5	-0.25	1.5	2.6	1.4	1.1

1) Genetically and phytopathologically related groups, such as cereals (cer.), legumes (leg.), crucifers (cruc.) and chenopodes (chen.), composites (comp.) and umbellifers (umbel.), liliaceae (lil.). All subsequent blocks of perennial crops are counted as one block.
2) No cover in autumn and winter = -4; no cover in autumn or winter = -2; all others = 0 (green manure crops included).
3) Cereals, grasses and lucerne = 3; root, bulb and tuber crops = 1; all others = 2 (green manure crops included).
4) Compaction by mowing in summer = -1 and in autumn = -2; lifting in summer = -2 and in autumn = -4.
5) N uptake by crop from soil reserves: legumes = 0. All other crops: 25-50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3; 150-200 kg ha^{-1} = 4; etc. (N uptake = N product + N crop residue).
6) N transfer is the expected net contribution of N to subsequent crop, based on N residues in the soil after harvest, N mineralisation from crop residues and N losses by leaching and denitrification. In this rating the effect of green manure crops should be included. N transfer < 50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3.
7) N_{need} (block *x*) = N_{uptake} (block *x*) minus $N_{transfer}$ (block *x*-1). N need is net N input to be provided by manure or N fertiliser.
8) Compacting by sowing in spring = -2 and in autumn = 0; not sowing = +2.

Table 3.5.2 Multifunctional Crop Rotation of EAFS prototype in Logården (S 1)

A. Selection of crops for the region (crops in descending order of profitability).

crop	biological		physical (ratings)				chemical (N ratings)	
no.	species	group[1]	cover[2]	rooting[3]	compaction[4;8]	structure[3+4+8]	uptake[5]	transfer[6]
1	winter wheat	cer.	0	3	-1 0	2	3	1
2	set-aside	grass/leg.	0	3	-1 +2	4	1	2
3	rye	cer.	0	3	-1 0	2	2	1
4	spring wheat	cer.	-2	3	-2 -2	-1	3	1
5	oats	cer.	-2	3	-2 -2	-1	2	1
6	barley	cer.	-2	3	-2 -2	-1	2	1
7	pea	leg.	-2	2	-2 -2	-2	0	2
8	bean	leg.	-2	2	-2 -2	-2	o	2
9	winter rape	cruc.	0	2	-1 0	1	3	1
10	vetch	leg.	-2	2	-2 -2	-2	0	2
mean of crop selection			-1.2	2.6	-1.6 -1.0	0	1.8	1.4

B. Multifunctional Crop Rotation for the region.

block	crop	biological		physical (ratings)		chemical (N ratings)		
no.	no.	species	group[1]	cover[2]	structure[3+4+8]	uptake[5]	transfer[6]	need[7]
I	1	winter wheat	cer.	0	2	3	1	1
II	2	set-aside	grass/leg.	0	4	1	2	0
III	3	rye	cer.	0	2	2	1	0
IV	8	bean	leg.	-2	-2	0	2	-1
V	5	oats	cer.	-2	-1	2	1	0
VI	2	set-aside	grass/leg.	0	4	1	2	0
VII	9	winter rape	cruc.	0	1	3	1	1
VIII	7	pea	leg.	-2	-2	0	2	-1
mean of crop rotation		share species^{-1} ≤ 0.125	share group^{-1} ≤ 0.375	0.75	1	1.5	1.5	0

1) Genetically and phytopathologically related groups, such as cereals (cer.), legumes (leg.), crucifers (cruc.) and chenopodes (chen.), composites (comp.) and umbellifers (umbel.), liliaceae (lil.). All subsequent blocks of perennial crops are counted as one block.

2) No cover in autumn and winter = -4; no cover in autumn or winter = -2; all others = 0 (green manure crops included).

3) Cereals, grasses and lucerne = 3; root, bulb and tuber crops = 1; all others = 2 (green manure crops included).

4) Compaction by mowing in summer = -1 and in autumn = -2; lifting in summer = -2 and in autumn = -4.

5) N uptake by crop from soil reserves: legumes = 0. All other crops: 25-50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3; 150-200 kg ha^{-1} = 4; etc. (N uptake = N product + N crop residue).

6) N transfer is the expected net contribution of N to subsequent crop, based on N residues in the soil after harvest, N mineralisation from crop residues and N losses by leaching and denitrification. In this rating the effect of green manure crops should be included. N transfer < 50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3.

7) N_{need} (block x) = N_{uptake} (block x) minus $N_{transfer}$ (block x-1). N need is net N input to be provided by manure or N fertiliser.

8) Compacting by sowing in spring = -2 and in autumn = 0; not sowing = +2.

Table 3.6 Multifunctional Crop Rotation of IAFS prototype of LIFE (UK 1)

A. Selection of crops for the region (crops in descending order of profitability).

crop no.	biological species	group[1]	physical (ratings) cover[2]	rooting[3]	compaction[4]	structure[3+4]	chemical (N ratings) uptake[5]	transfer[6]
1	wheat	cer.	0	3	-1	2	3	1
2	barley	cer.	0	3	-1	2	2	1
3	oilseed rape	cruc.	0	2	-1	1	2	2
4	winter oats	cer.	0	3	-1	2	1	1
5	bean	leg.	0	2	-1	1	2	2
6	set-aside	-	0	3	-1	2	1	1
7								
8								
9								
10								
mean of crop selection			-0	2.7	-1	1.7	1.8	1.3

B. Multifunctional Crop Rotation for the region.

block no.	crop no.	biological species	group[1]	physical (ratings) cover[2]	structure[3+4]	chemical (N ratings) uptake[5]	transfer[6]	need[7]
I	1	winter wheat	cer.	0	2	3	1	1
II	3	rape	cruc.	0	1	2	2	1
III	1	winter wheat	cer.	0	2	3	1	1
IV	4	winter oats	cer.	0	2	1	1	0
V	6	set-aside	-	0	2	1	1	0
VI	1	winter wheat	cer.	0	2	3	1	2
VII	5	s. bean	leg.	0	1	2	2	-1
mean of crop rotation		share species^{-1} ≤ 0.43	share group^{-1} ≤ 0.57	0	1.7	2.2	1.3	0.9

1) Genetically and phytopathologically related groups, such as cereals (cer.), legumes (leg.), crucifers (cruc.) and chenopodes (chen.), composites (comp.) and umbellifers (umbel.), liliaceae (lil.). All subsequent blocks of perennial crops are counted as one block.
2) No cover in autumn <u>and</u> winter = -4; no cover in autumn <u>or</u> winter = -2; all others = 0 (green manure crops included).
3) Cereals, grasses and lucerne = 3; root, bulb and tuber crops = 1; all others = 2 (green manure crops included).
4) Compaction by mowing in summer = -1 and in autumn = -2; lifting in summer = -2 and in autumn = -4.
5) N uptake by crop from soil reserves: legumes = 0. All other crops: 25-50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3; 150-200 kg ha^{-1} = 4; etc. (N uptake = N product + N crop residue).
6) N transfer is the expected net contribution of N to subsequent crop, based on N residues in the soil after harvest, N mineralisation from crop residues and N losses by leaching and denitrification. In this rating the effect of green manure crops should be included. N transfer < 50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3.
7) N_{need} (block *x*) = N_{uptake} (block *x*) minus $N_{transfer}$ (block *x*-1). N need is net N input to be provided by manure or N fertiliser.

Table 3.7 Multifunctional Crop Rotation of IAFS prototype of LINK (UK 2)

A. Selection of crops for the region (crops in descending order of profitability).

crop no.	biological species	group[1]	physical (ratings) cover[2]	rooting[3]	compaction[4]	structure[3+4]	chemical (N ratings) uptake[5]	transfer[6]
1	potato	sol.	-4	1	-4	-3	4	2
2	winter wheat	cer.	0	3	-1	2	4	2
3	w. barley/oats	cer.	0	3	-1	2	3	1
4	s. barley	cer.	-4	3	-1	2	3	1
5	w. oilseed rape	cruc.	0	2	-1	1	4	2
6	pea	leg.	-4	2	-1	1	0	2
7	spring bean	leg.	-4	2	-2	0	0	1
8	s. oilseed rape	cruc.	-4	2	-2	0	3	2
9	linseed	lin.	-4	2	-2	0	1	1
10	set-aside	cereals/mix.	0	3	-1	2	1	1
mean of crop selection			-2.4	2.3	-1.6	0.7	2.4	1.5

B. Multifunctional Crop Rotation for the region.

block no.	crop no.	biological species	group[1]	physical (ratings) cover[2]	structure[3+4]	chemical (N ratings) uptake[5]	transfer[6]	need[7]
I	1	potato	sol.	-2	-3	4	1	2
II	2	winter wheat	cer.	0	2	4	2	3
III	10	set-aside	mix.	0	2	1	1	-1
IV	6	pea	leg.	-2	1	0	1	-1
V	2	winter wheat	cer.	0	2	4	2	3
mean of crop rotation		share species^{-1} ≤ 0.4	share group^{-1} ≤ 0.4	-0.8	1	2.6	1.4	1.2

1) Genetically and phytopathologically related groups, such as cereals (cer.), legumes (leg.), crucifers (cruc.) and chenopodes (chen.), composites (comp.) and umbellifers (umbel.), liliaceae (lil.). All subsequent blocks of perennial crops are counted as one block.

2) No cover in autumn and winter = -4; no cover in autumn or winter = -2; all others = 0 (green manure crops included).

3) Cereals, grasses and lucerne = 3; root, bulb and tuber crops = 1; all others = 2 (green manure crops included).

4) Compaction by mowing in summer = -1 and in autumn = -2; lifting in summer = -2 and in autumn = -4.

5) N uptake by crop from soil reserves: legumes = 0. All other crops: 25-50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3; 150-200 kg ha^{-1} = 4; etc. (N uptake = N product + N crop residue).

6) N transfer is the expected net contribution of N to subsequent crop, based on N residues in the soil after harvest, N mineralisation from crop residues and N losses by leaching and denitrification. In this rating the effect of green manure crops should be included. N transfer < 50 kg ha^{-1} = 1; 50-100 kg ha^{-1} = 2; 100-150 kg ha^{-1} = 3.

7) N_{need} (block *x*) = N_{uptake} (block *x*) minus $N_{transfer}$ (block *x*-1). N need is net N input to be provided by manure or N fertiliser.

2.4 State of the art in designing MCRs

In all 11 theoretical prototypes presented in Section 2.1, Multifunctional Crop Rotation (MCR) plays a central role as a major method used to achieve desired results in the multi-objective parameters of soil fertility and environment (SCI, OMAB, EEP, P/KAR etc.), as well as in the Quality Production Indices (QPIs product^{-1}) and the major parameters of economic and energy efficiency (NS and EE). Consequently, MCR should be designed primarily to provide a well-balanced 'team' of crops that require a minimum of inputs that are polluting or based on fossil energy (nutrients, pesticides, machinery, fuel) to maintain soil fertility and crop vitality for quality production.

Being the central method, and also the first to be designed, MCR is an appropriate Part 4 of your identity card, after your theoretical prototype (Part 3). Because of their central role, the MCRs of the 7 selected projects need a more detailed evaluation, based on the set of multifunctional demands (Progress Report 2, Subsection 3.2.1). Table 4 suggests that only DE 2 has succeeded in designing an MCR that fulfils all demands. Most teams have not yet succeeded in designing an MCR with sufficient soil cover (SCI!), as a major preventive measure against erosion by wind or water and leaching or runoff of nutrients. Nor have most teams succeeded in sufficiently diversifying their MCR by limiting the share species^{-1}, as a major preventive measure against weeds and soilborne pests and diseases (Progress Report 1, Chapter 7). In particular, the teams DK 1 and I 1 (EAFS) and UK 1 and UK 2 (IAFS), have built in high risks because their MCRs also have too high
a share group^{-1} of phytopathologically related crop species. Except for NL 1 (IAFS), all teams have succeeded in designing an MCR with a balance between crops degrading soil structure (by compaction at harvest) and crops restoring soil structure (by intensive rooting). Finally, all teams have succeeded in designing an MCR with a minimum need for N input, largely compensating for N offtake (by products) by fixing N biologically and transferring N efficiently from residues of crops.

Generally it can be concluded that most Crop Rotations need to be improved before they can properly be called Multifunctional and can act as the sound base of an I/EAFS prototype that is able to achieve an ambitious set of objectives.

Table 4 Evaluation of Multifunctional Crop Rotations of selected projects in 1995 *

Multifunctional demands (explained in Report 2, Subsection, 3.2.1)		**DE 2** Reinshof	**DK 1** Foulum	**I 1** Montepaldi	**NL 1** Nagele	**S 1** Logården	**UK 1** LIFE	**UK 2** LINK
Share species^{-1}								
IAFS	≤ **0.25**	≤ 0.25	≤ 0.33	≤ 0.40	≤ 0.25	≤ 0.25	≤ 0.43	≤ 0.4
EAFS	≤ **0.167**	-	≤ 0.22	≤ 0.25	≤ 0.167	≤ 0.13	-	-
Share group^{-1}								
IAFS	≤ **0.50**	≤ 0.50	≤ 0.33	≤ 0.40	≤ 0.25	≤ 0.50	≤ 0.57	≤ 0.40
EAFS	≤ **0.33**	-	≤ 0.40	≤ 0.50	≤ 0.33	≤ 0.40	-	-
Soil cover								
IAFS	≥ **-1**	0	-1.5	-1	-1.5	-0.25	0	-1.3
EAFS	**= 0**	-	-1	-1	-2.2	-0.75	-	-
Soil structure								
IAFS	≥ **-1**	1.8	0.8	1.1	-1.3	1.5	1.7	1
EAFS	≥ **0**	-	1.2	1.25	-0.5	1.	-	
N need								
IAFS	≤ **3**	2.25	?	1.0	2.8	1.2	0.9	1.2
EAFS	≤ **2**	-	?	0.25	1.5	0	-	-

* Tables 3.1 – 3.7

Format 4B Improving I/EAFS prototypes by carrying out 4 tasks [1]

(1) Establishing parameters with shortfalls				(2) Establishing the main cause of any shortfall			(3) Establishing the first criterion not yet fulfilled by any method listed under (2)				(4) Establishing improvements of any method listed under (2), to fulfil the criterion under (3)
para-meters	desired results	achieved results	relative shortfalls	slow response	major methods	minor methods	ready for use	man-age-ability	accept-ability	effect-iveness	

1 Tasks 1 – 4 are explained in Sections 3.1 – 3.4

3 Improving I/EAFS prototypes

Improving a prototype is a matter of relating the shortfalls between achieved and desired test results to the farming methods and improving them in a targeted way. Such shortfalls may have one or more of the following 4 causes: the method(s) in question is not ready for use; or not manageable by the farmer; or not acceptable to the farmer; or it is not effective. In positive terms, Step 4 (A. testing and B. improving) has been finalised if the prototype, in general, and the methods, in particular, fulfil 4 consecutive criteria: ready for use, manageable, acceptable and effective.

Consequently, a methodical way to improve the prototype (Step 4B) entails 4 tasks:

(1) Establishing which parameters have shortfalls between achieved and desired testing results;

(2) Establishing from the theoretical prototype which methods are involved;

(3) Establishing which criteria have not yet been fulfilled by these methods:
- *ready for use,*
- *manageable by the farmers,*
- *acceptable to the farmers,*
- *effective;*

(4) Establishing targeted improvements of the methods to meet these consecutive criteria.

After the improving Part B of Step 4, you repeat Part A by laying out and testing the improved prototype for another year. Subsequently, you improve the prototype again, based on the remaining shortfalls, and lay it out again, and so on. Consequently Step 4 is a matter of testing and improving the prototype for several years until all shortfalls between achieved and desired results in the set of parameters have been made good. The final outcome of Step 4 is that the prototype is all-round, i.e. all objectives as quantified in the set of parameters have been achieved by a set of methods that are manageable, acceptable and effective!

To facilitate a coherent and transparent carrying out of the Tasks 1 – 4 of Step 4B, a format is proposed (format 4B). The tasks are elaborated and the format is explained in Sections 3.1 – 3.4.

3.1 Establishing parameters with shortfalls between achieved and desired results

Task 1 entails:
- listing in the first column of the format all parameters from your (updated) theoretical prototype (Part 3 of your prototype's identity card);
- listing in the second column the desired results for any parameter (quantified objectives of your Part 2);
- listing in the third column the result achieved at the latest testing for any parameter;
- calculating and listing in the fourth column, the relative shortfall of the achieved to the desired result for any parameter.

The shortfall between achieved and desired results should be calculated in relative terms to be able to present the state of the art in testing and improving (Step 4) by a simple and clear circle diagram (Part 6 of your prototype's identity card (Chapter 8)). The relative shortfall = 0, at minimum, if the achieved result is equal to or better than the desired result of a parameter. The relative shortfall = 1, at maximum, if the absolute difference between achieved and desired result, divided by desired result, ≥ 1. In other words, the relative shortfall = 1 if either achieved result ≥ 2 *x* desired result, when the desired result concerns a maximum norm (for example NAR ≤ 70 kg/ha); or if achieved result = 0, when the desired result concerns a minimum norm (for example PSD ≥ 50 species).
So the range of the relative shortfall is 0 ≤ relative shortfall ≤ 1 (assuming desired result > 0).

3.2 Establishing the main cause of any shortfall

Task 2 entails establishing if the main cause for any shortfall is:

- either the major method indicated in the theoretical prototype (which is likely in initial years of testing);
- or a minor method indicated in the theoretical prototype (which may occur in later years of testing);
- or a slow response of the parameter in question (which may occur in initial years of testing and is likely in later years of testing in inert parameters such as PAR, KAR and PSD).

For any shortfall, the main cause should be specified in the format by a mark in the fifth column, for slow response, or by an acronym of a method in the sixth or seventh column, for major or minor method.

3.3 Establishing the first criterion not yet fulfilled by a farming method

Task 3 entails establishing for any major or minor method identified as the main cause of a shortfall between achieved and desired results which is the first criterion that has not been fulfilled:

- either not ready for use;
- or not manageable by the farmers;
- or not acceptable for the farmers;
- or not effective.

For any method as a main cause of a shortfall, the first criterion not yet fulfilled should be specified in the format by a mark in one of the four columns, as indicated.
Task 3 is rather complicated. Therefore it is elaborated in Subsections 3.3.1 - 3.3.4.

3.3.1 When is a farming method not ready for use?

One main reason why a method may not appear ready for use is the unexpected occurrence of factors that interfere to such an extent that the method needs to be revised to take these factors and their effects into account. As a result, methods will gradually evolve from those that are simple and subjective to those that are comprehensive and objective.
Examples:

- management factors, such as choice of crops and varieties, machines, fertilisers, pesticides;
- agro-ecological factors, such as pests, diseases, weeds, and physical and chemical soil status.

3.3.2 When is a farming method not manageable?

Even if ready for use, a method may still not appear to be manageable to the farmers.
Examples:

- planning or operations too complicated;
- too laborious to fit into the labour film;
- too specific to be carried out with the usual machinery.

3.3.3 When is a farming method not acceptable?

Even if ready for use and manageable, a method may still not appear to be acceptable to the farmers.
Examples:

- costs too high and/ or too few benefits, at least in the short term;
- too little confidence in utility and/or effectiveness.

3.3.4 When is a method not effective?

Even if ready for use, manageable and acceptable, a method may still not appear to be effective for achieving the desired result for a certain parameter. This conclusion may be premature, as in case of parameters with a slow response. Apart from this, the main reason why a method may, indeed, not be effective is that the theoretical prototype is too simple or distorted for the method and parameter in question.

Examples:

- the method needs the support of another method;
- the method has only a minor influence, so another method should be established as the major method.

Because most parameters are under the control of more than one method, and because many parameters have a slow response, effectiveness is the most difficult and also the most time-consuming of all the 4 criteria to establish. Generally, testing and improving a prototype will take at least 4 years for I/EAFS and 6 years for EAFS (corresponding with one run of the prototype as a complete crop rotation on each field) before reliable responses of abiotic parameters (soil, groundwater) and biotic parameters (crops, flora and fauna) are obtained. The effectiveness of the methods and the overall prototype can only be established on the basis of these reliable responses of the multi-objective parameters.

Theoretically the number of years needed for Step 4 would be the sum of the years needed to fulfil the first 3 criteria and the years, needed to fulfil the 4th criterion. In practice, however, biotic and abiotic parameters begin to respond from the very first year the prototype is laid out, provided the prototype is well designed and does not change dramatically in subsequent years. As a result, the adaptation of these parameters mostly occurs simultaneously with testing and improving by farmers and researchers, so Step 4 could be completed in a minimum of 4-6 years. This does not imply, however, that all parameters will have achieved a steady state by then. For example, it may take decades before possible excessive reserves of soil P diminish or depleted organic matter reserves are replenished to desired ranges. Nevertheless, if the shortfalls between achieved and desired results incontrovertably decrease from year to year, you may speak about reliable responses proving the effectiveness of the prototype.

3.4 Establishing improvements of methods to fulfil the consecutive criteria

Task 4 of the improving Part B of Step 4 entails establishing for any method those improvements that are needed for it to fulfil the first criterion not yet fulfilled in the latest testing year. Depending on the first criterion not yet fulfilled, one of the Subsections 3.3.1 – 3.3.4 should be studied to establish targeted improvements. These improvements should be specified in short lines or keywords in the last column of the format.

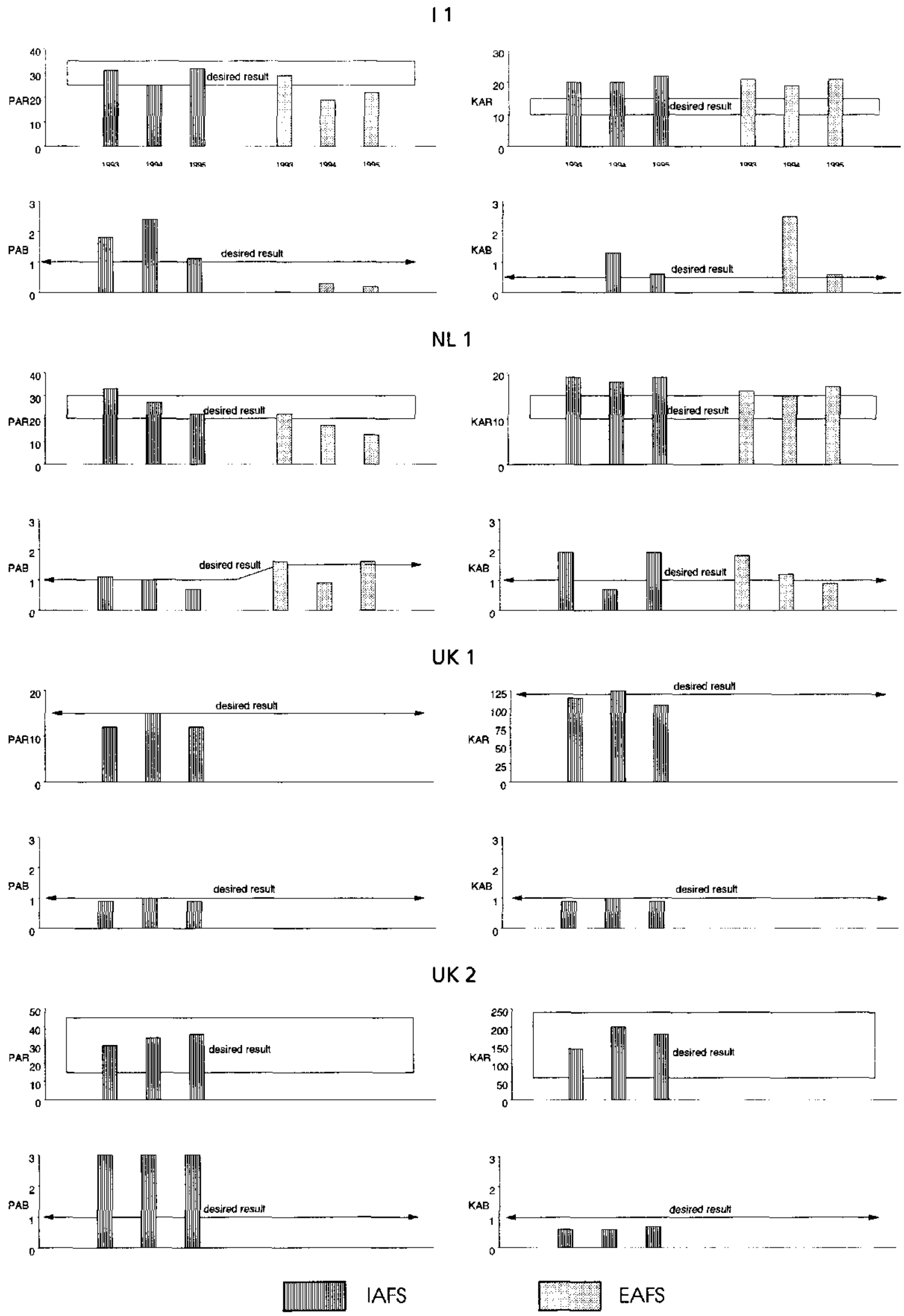


Figure 2 Testing and improving P and K Available Reserves (P/KAR, kg/ha), and Annual Balances (P/KAB) of I/EAFS prototypes on 4 experimental farms, 1993 - 1995.

4 Testing and improving with P/KAR and P/KAB

Brief definitions and ranges
Phosphorus and Kalium Available Reserves (P/KAR) is the agronomically desired and environmentally acceptable range of PK soil reserves (x_p < PAR< y_p, x_k < KAR < y_k). Phosphorus and Kalium Annual Balances (P/KAB) is PK inputs / product PK outputs (over all fields). The balances are the help parameters to manage slowly responding reserves. Consequently, desired P/KAB > 1, = 1 or < 1, if P/KAR is below, in or beyond the desired range.

(1) *Testing with P/KAR and P/KAB:*
- establishing desired ranges of PAR and KAR for your IAFS or EAFS;
- establishing mean actual PAR and KAR of fields to be fertilised this year;
- establishing desired ranges of PAB and KAB for your IAFS or EAFS (PAB > 1, = 1 or < 1, if actual PAR <, = or > desired PAR) (similarly for KAB);
- establishing actual PAB and KAB after fertilisation and harvest of crops.

(2) *Improving with P/KAR and P/KAB:*
- establishing parameters for which there is a shortfall between achieved and desired testing results;
- establishing from the theoretical prototype which methods are involved (mostly INM or ENM);
- establishing which criteria have not yet been fulfilled by these methods (ready for use, manageable by the farmers, acceptable to the farmers, effective);
- establishing targeted improvements of the methods to meet these consecutive criteria.

Figure 2 presents the testing results with P/KAR and P/KAB of the 4 I/EAFS projects on experimental farms that have data from at least 3 consecutive years (1993 - 1995). I 1, NL 1 and UK 2 have indeed established desired ranges for P/KAR to reflect the compromise to be achieved between the agronomically needed and ecologically acceptable levels of P/KAR. However, a wide range, such as with KAR of UK 2, contains the risk of covering levels that are agronomically too low or ecologically too high. As yet, UK 1 has no range in P/KAR.

The great challenge is, of course, to get and keep P/KAR in their desired ranges by tuning PK inputs from organic or inorganic fertilisers to PK outputs in harvest products, i.e. to manage P/KAR by a well established P/KAB. The performances of the 4 teams will now be briefly discussed in the light of this challenge.

I 1 seems to manage PAR in IAFS by a well established PAB. However, the too-low PAR in EAFS is aggravated by an extremely low PAB, instead of being corrected by a PAB > 1. KAR exceed the desired range in both IAFS and EAFS. Only in 1995 was the desired low KAB in both systems achieved. In subsequent years it should be kept low to lower KAR to the desired range.

NL 1 is facing a gradual decrease of PAR in both systems, even for a PAB of about 1. Apparently there is some P fixation by the marine soil there, rich in lime because of the many seashells. Consequently, a PAB slightly higher than 1 is advisable, least for the time being. Both systems have KAR somewhat higher than the desired range, which is quite common in young marine soils. The policy for KAB in EAFS seems consistently aimed at reducing KAR. As yet, in IAFS the policy is unclear.

UK 1 has a strict policy of maintaining P/KAB = 1, apparently because P/KAR is at about the desired level. Time will tell if this approach is effective.

UK 2 has wide ranges of P/KAR. Therefore it is not surprising P/KAR remain within their ranges, even if PAB is set very high and KAB is set very low! As P/KAR are in the desired range, a consistent policy would be P/KAB = 1! Or, should desired ranges of P/KAR be established more precisely?

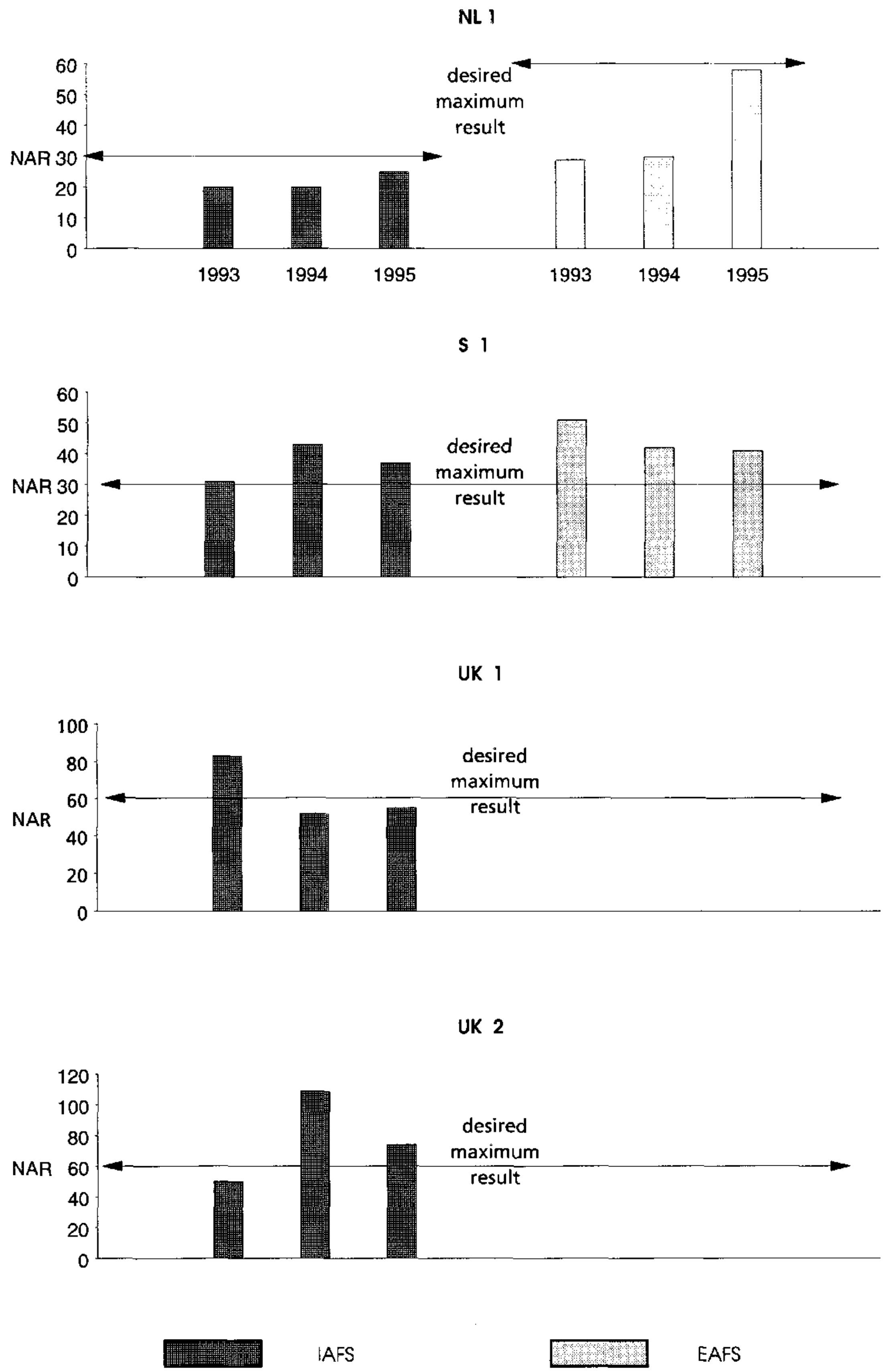


Figure 3 Testing and improving N Available Reserves (NAR, Kg/ha) of I/EAFS prototypes on 4 experimental farms, 1993 - 1995

5 Testing and improving with NAR, SCI and OMAB

5.1 N Available Reserves (NAR)

Brief definition and range:
Nitrogen Available Reserves (NAR) is the environmentally acceptable range of N_{min} soil reserves (0-100 cm) at start of leaching period. NAR < 45 kg ha^{-1} on sand and NAR < 70 kg ha^{-1} on clay correspond approximately to the EU norm for drinking and shallow ground water, which is < 50 mg nitrate l^{-1}.

(1) *Testing with NAR:*
- establishing desired range of NAR to meet desired NDW or NGW for your IAFS or EAFS (EU norm or EU guideline, which is < 25 mg nitrate l^{-1});
- establishing achieved NAR of each field.

(2) *Improving with NAR:*
- establishing which fields/crops have a NAR exceeding the desired range;
- establishing from the theoretical prototype which methods are involved (mostly INM or ENM);
- establishing which criteria have not yet been fulfilled by these methods (ready for use, manageable by the farmers, acceptable to the farmers, effective);
- establishing targeted improvements of the methods to meet these consecutive criteria.

Figure 3 presents the results of testing with NAR of the 4 I/EAFS projects on experimental farms that have data from at least 3 consecutive years (1993 - 1995). NL 1 (IAFS) and S 1 (I/EAFS) have adopted an ambitious desired result of NAR ≤ 30 kg ha^{-1} N-nitrate, corresponding with the EU guideline for drinking and shallow ground water. NL 1 (EAFS), UK 1 and UK 2 each have a less ambitious desired result of NAR ≤ 60 kg ha^{-1} N-nitrate, corresponding with the EU norm.

NL 1 achieves the desired results for all 3 years in both systems. However, NAR in EAFS almost doubles in 1995. There may be various causes for this, such as:
- overdosage or too late an incorporation of animal or green manure;
- too little recovery by main crops or green manure crops;
- too high a share of leguminous crops in the rotation.

The NAR achieved by single crops may indicate which of these are the major causes. Subsequently, ENM can be improved in design (ready for use) or management (manageability), to avoid NAR exceeding the desired result in the future.

S 1 cannot achieve the desired results in I/EAFS, though the difference is quite small. Again, in this project the performances of single crops may indicate how design and/or management of I/ENM can be improved.

UK 1 achieved the desired result in 1994 and 1995, but the team is not satisfied with INM. They want to improve it, because the protein content of the wheat is below the norm set for top baking quality. As a result their price has been cut by some 30 %. They are facing a dilemma that is significant for all teams in EU regions with intensive cereal production. On the one hand, you want to lower the N input to render crops less vulnerable to disease and pests and make them less dependent on pesticides. On the other hand, you want to have sufficient N available for the crop to be of high quality. The solution is to strive for a delicate balance, by raising the crop with just enough N available for a healthy vegetative period and by providing for just enough additional N during the generative period to maintain health and to boost the protein content to the desired level. A quick scan of N available in the soil and in the crop seems indispensable for this sort of fine tuning. If straw is incorporated after harvest, soil life has the needed energy source to recover the N left by the crop and to keep NAR well below the norm.

UK 2 has not achieved the desired result yet. Compared to UK 1 it has a less cereal-dominated rotation including a crop such as potato, with a high N need and a limited N recovery, which results in a high NAR. Nevertheless, a systematic check of design and management of INM should lead to various options of improvement.

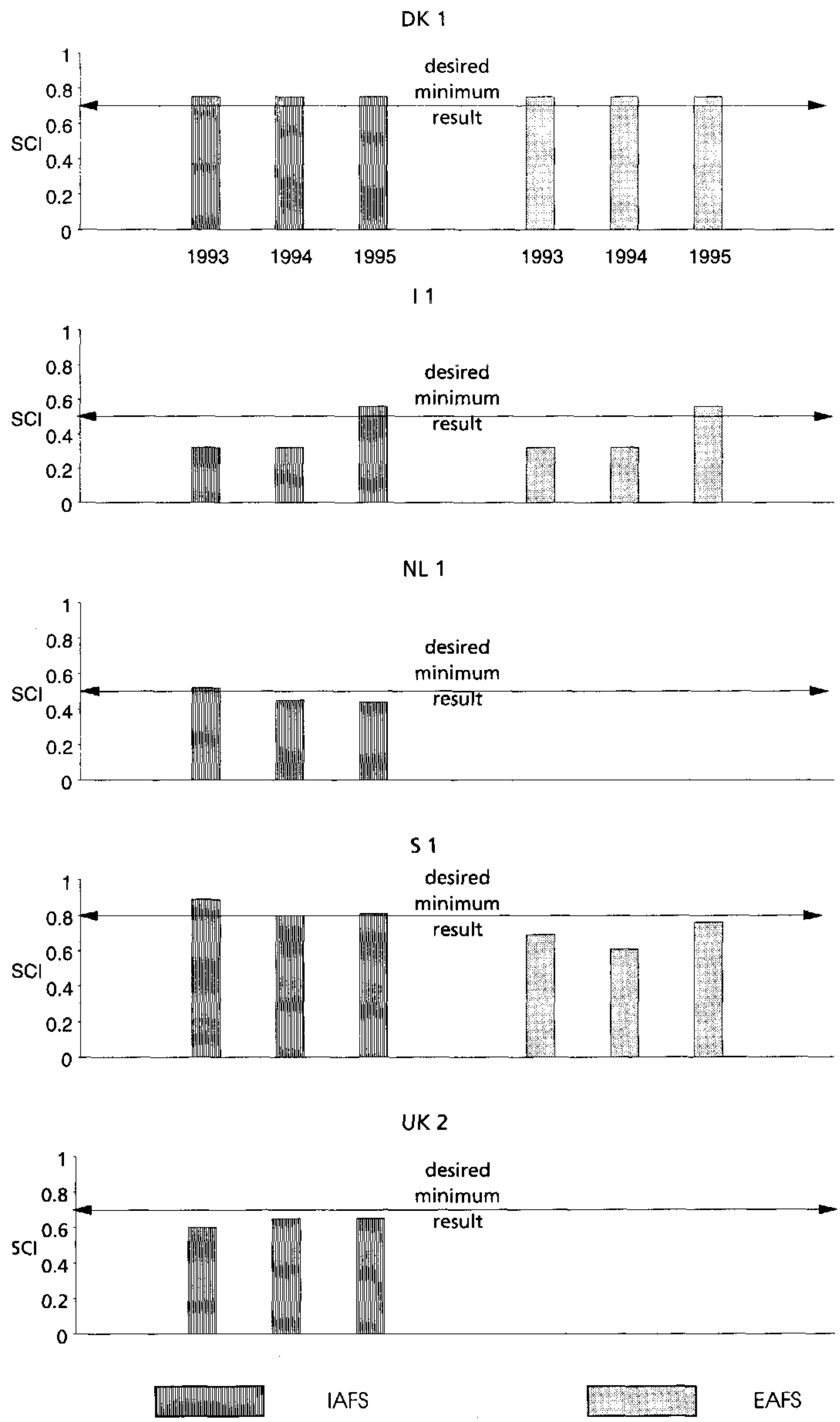


Figure 4 Testing and improving Soil Cover Indices (SCI, for the whole year) of I/EAFS prototypes on 5 experimental farms, 1993 - 1995

5.2 Soil Cover Index (SCI)

Brief definition:
SCI expresses the extent to which the soil of a field or a farm is covered by crops or crop residues, during a crucial period or throughout the year. It is assessed at monthly intervals:

$$\text{SCI month}^{-1} = \frac{\text{SCI (at start)} + \text{SCI (at end)}}{2} \qquad \text{SCI period}^{-1} = \frac{\text{sum SCIs month}^{-1}}{\text{number of months}}$$

Range of SCI:
SCI = 1 at maximum, if soil is fully covered by a crop or crop residues.
SCI = 0 at minimum, if soil is entirely fallow throughout the crucial period of the year.

(1) *Establishing desired ranges of SCI month^{-1} or period^{-1}:*
- in view of the need for soil cover on the entire farm, or on individual, steeply sloping or sandy fields, to control erosion and nutrient losses by runoff or leaching;
- in view of the need for soil cover on the entire farm, or on individual fields, to benefit fauna and landscape.

(2) *Testing with SCI month^{-1} or period^{-1}:*
- establishing actual SCI month^{-1}, field by field ($0 \leq \text{SCI} \leq 1$);
- calculating SCI period^{-1} by field or by farm. The latter is a weighted average of all fields (including Ecological Infrastucture and land permanently set aside) on the farm, taking into account the area of the fields (ha).

(3) *Improving with SCI month*$^{-1}$ or period^{-1}:
- establishing whether there is a shortfall between achieved and desired SCI;
- establishing from the theoretical prototype which farming methods are involved (mostly MCR and MSC);
- establishing which criteria have not yet been fulfilled by these methods (ready for use, manageable by farmers, acceptable to farmers, effective);
- establishing targeted improvements of the methods to meet the above criteria.

Figure 4 presents the testing results with SCI of the 5 I/EAFS projects on experimental farms that have data available from at least 3 consecutive years (1993 - 1995). The 5 teams (DK 1, I 1, NL 1, S 1 and UK 2) have established desired results for mean SCI year^{-1} that vary between SCI > 0.5 and SCI > 0.8. Probably these desired results are based on a best guess. However, to ascertain the underlying methods (MCR, MSC) are both effective in control of erosion and nutrient runoff, and in providing cover for fauna and landscape, the desired result in SCI should correspond with the desired result for the most demanding underlying parameter!

In the follow-up of this concerted action, it would be worthwhile to quantify the desired result in SCI for the separate underlying parameters and, subsequently, to assess the overall desired result in SCI. This would help targeted improvements based on shortfalls between achieved and desired results to be made.

From Figure 4 it can be concluded that all 5 teams have achieved the desired result, more or less. But the question is, whether all desired results of underlying parameters are now covered, so that MCR and MSC are generally effective in terms of erosion control, control of nutrient runoff and leaching, provision of food and shelter for fauna and provision of an attractive landscape for recreationists?

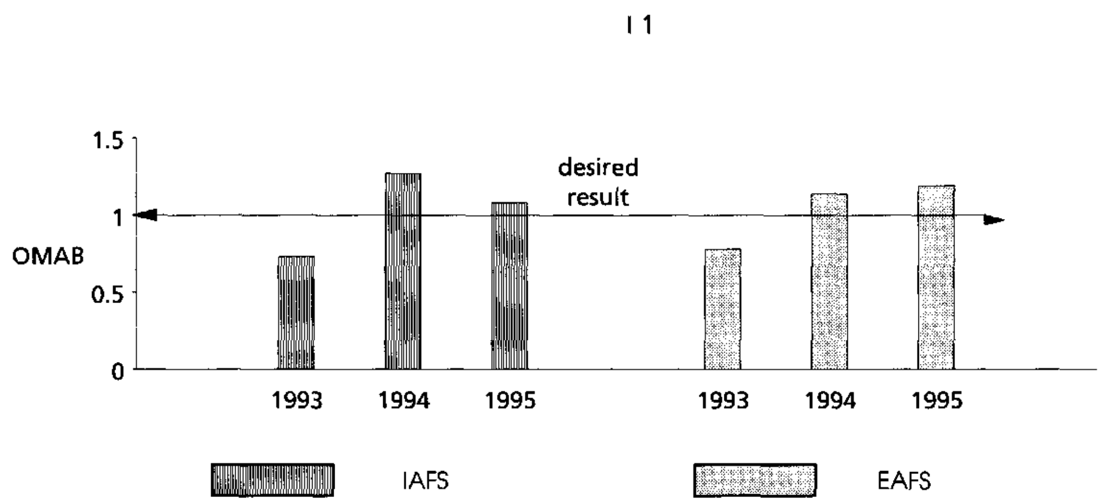


Figure 5 Testing and improving Organic Matter Annual Balances (OMAB) of I/EAFS prototypes on Montepaldi (I 1), 1993 - 1995

5.3 Organic Matter Annual Balance (OMAB)

Brief definition:
OMAB is annual input/output of effective organic matter. Inputs are crop residues (green manures included) and organic waste, such as manure (kg ha^{-1}) · humification coefficients. Output is estimated loss of soil organic matter by respiration and possibly erosion.
Desired ranges of OMAB:

By analogy with PK Balances and PK Available Reserves, a desired range of OMAB can only be established after a desired range of organic matter content (or, by analogy, Organic Matter Available Reserves = OMAR) has been established.

(1) Testing with OMAB:
- establishing desired ranges of OMAR for your I/EAFS, by system (or farm) or by field;
- establishing mean actual OMAR of the fields of each system;
- establishing desired ranges of OMAB (>1 or=1 if actual OMAR < or ≥ desired range).

(2) Improving with OMAB:
- establishing which fields/crops achieve an OMAB falling short of the desired range;
- establishing from the theoretical prototype which methods are involved (mostly I/ENM, MSC and MCR);
- establishing which criteria have not yet been fulfilled by these methods (ready for use, manageable by the farmers, acceptable to the farmers, effective);
- establishing targeted improvements of the methods to meet above criteria.

Figure 5 presents the testing results with OMAB of I 1, the only I/EAFS project having data available from at least 3 consecutive years (1993 - 1995). For both prototypes, OMAB = 1 has been established as the desired result. Apparently, the actual OMAR is in the desired range. In both systems the desired OMAB was achieved in 1994 and 1995.

Besides I 1, DK 1 and S 1 have OMAB in their theoretical prototypes. The fact that only one of 3 teams is able to present data may indicate falling interest in OMAB. This would be a mistake in the case of heavy soils vulnerable for compaction and water logging, or light soils vulnerable for erosion and drought. As well physical soil fertility (balance between solid matter, air and water), OMAB accounts for chemical soil fertility (N mineralisation) and biological soil fertility (feed for soil life, buffering against pests and diseases, and restoring soil structure). Though less directly and specifically, SCI also covers these objectives. Therefore each team should consider the value OMAB may add to SCI in their regional circumstances.

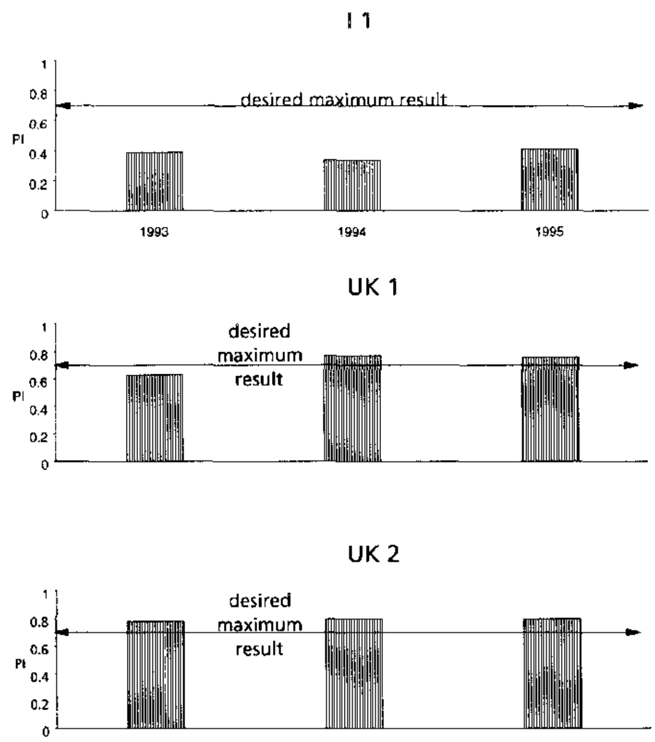


Figure 6A Testing and improving Pesticides Indices (PI) of IAFS prototypes on 3 experimental farms, 1993 - 1995

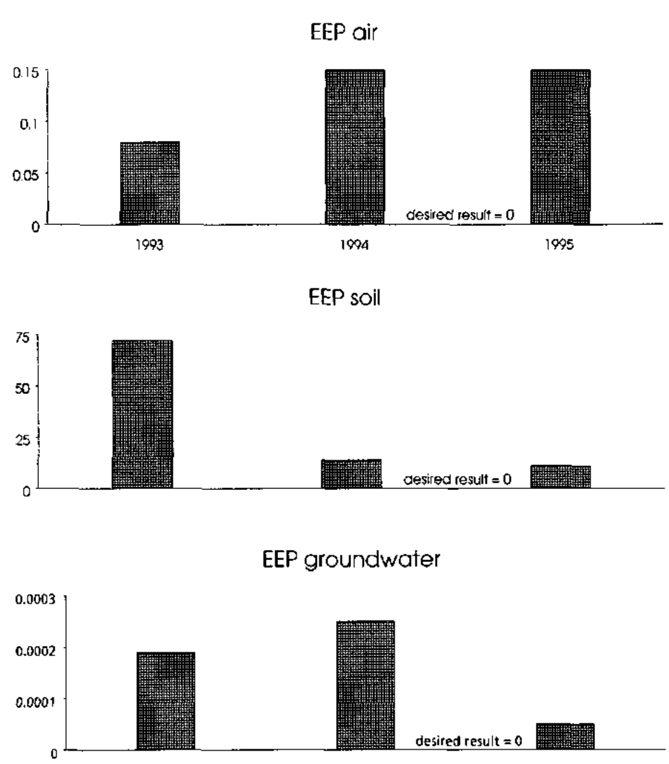


Figure 6B Testing and improving Environment Exposure to Pesticides (EEP) of IAFS prototype in Nagele (NL 1), 1993 - 1995, specified for air (kg Pa/ha), soil (kg days/ha) and groundwater (kg days/ha)(mobility).

6 Testing and improving with PI, EEP and QPI

6.1 Pesticide Index (PI)

Brief definition and range:
PI is pesticide inputs in the IAFS in kg active ingredients (a.i.)$ha^{-1}yr^{-1}$ /the same as for a conventional reference system ($0 \leq PI \leq 1$).

(1) *Establishing a desired range of PI:*
- taking into account national or regional policy papers, or local considerations;
- by farming system or by crop.

(2) *Testing with PI:*
- establishing total inputs in kg a.i. $ha^{-1}yr^{-1}$ by IAFS-system and by crop;
- establishing PI by system and by crop, based on records of a conventional reference system or on regional or national records.

(3) *Improving with PI:*
- establishing fields/crops for which PI falls short of the desired range;
- establishing from the theoretical prototype which methods are involved (mostly ICP and MCR);
- establishing which criteria have not yet been fulfilled by these methods (ready for use etc.);
- establishing targeted improvements of the methods to meet consecutive criteria.

Figure 6A presents the testing results with PI of the 3 IAFS projects on experimental farms that have data from at least 3 consecutive years (1993 - 1995). Though they are prototyping in quite different regions, all 3 teams are aiming to achieve the same PI < 0.7. Having achieved a PI < 0.4 in the last 3 years, I 1 could have set a more ambitious desired PI. The teams of UK 1 and UK 2 have shown little progress towards achieving the rather modest desired PI. Both could benefit from accepting the challenge of trying to meet a more ambitious desired result.

6.2 Environment Exposure to Pesticides (EEP)

Brief definition:
EEP is specified as EEPair, EEPsoil and EEPgroundwater by pesticide, crop or farm.
EEPair = active ingredients (kg ha^{-1}) · vapour pressure (Pa at 20-25 °C);
EEPsoil = active ingredients (kg ha^{-1}) · 50 % degradation time (days);
EEPgroundwater = EEPsoil (kg days ha^{-1}) · mobility (mobility = K_{om}^{-1} and K_{om} = partition coefficient of the pesticide over dry matter and water fractions of the soil-organic matter fraction of the soil).

(1) *Testing with EEPs air, soil and groundwater:*
- establishing achieved EEPs by pesticide (ha^{-1}), by crop (sum of pesticides ha^{-1} $crop^{-1}$) and by farming system (weighted average of pesticides ha^{-1} $crop^{-1}$);
- establishing desired EEPs at the farming system level;
- ranking EEPs at the farm level by pesticide · area treated (ha).

(2) *Improving with EEPs air, soil and groundwater:*
- establishing shortfalls between achieved and desired EEPs at the farming system level;
- establishing how these shortfalls can be made good by replacing the highest ranking pesticide treatments with non-chemical protective measures or less ranking pesticide treatments based on the same or other pesticides, and including band spraying, spot-wise treatment or low-dose treatment;
- establishing whether the needed improvements in ICP, and possibly MCR, INM or another method, are manageable by and acceptable to the farmers.

Figure 6B presents the testing results for EEP of NL 1, the only project having data available from at least 3 consecutive years (1993 - 1995). In line with the preventive character of EEP, the NL 1 team has established desired EEPs of air, soil and groundwater = 0! In this way, they have maximised the challenge of achieving sustainable crop protection. The results of the last 3 years show great progress in EEPs soil and groundwater, but stagnation in EEP air. Whether intended or not, the exposure of the local environment to pesticides is more reduced than that of the wider environment.

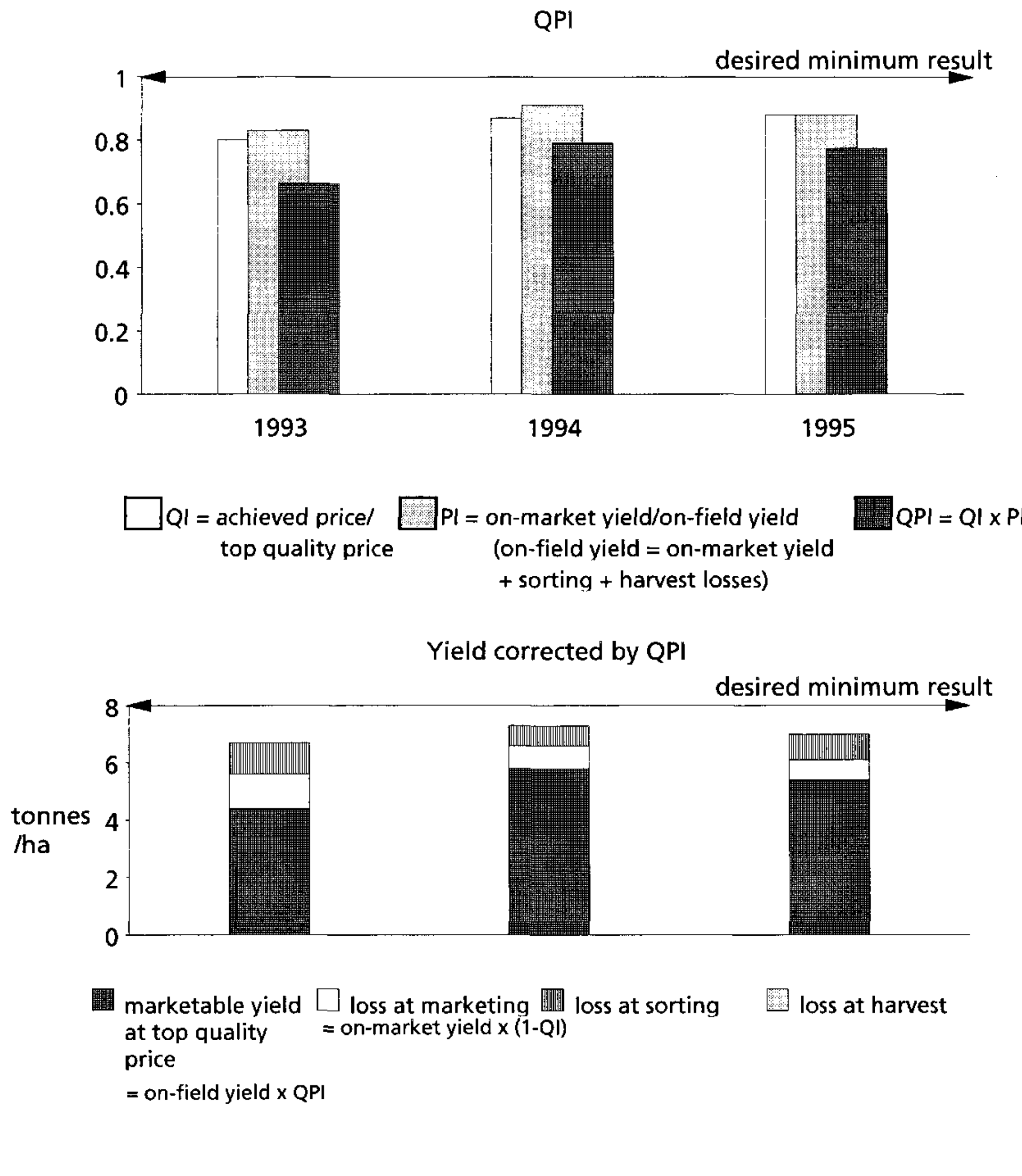


Figure 7 Testing and improving Quality Production Index (QPI) and QPI-corrected yield of winter wheat for bread-making of IAFS prototype of LIFE (UK 1), 1993 - 1995

6.3 Quality Production Indices (QPIs)

Brief definition:
QPI is a comprehensive parameter of quality and quantity of production of single crops = Quality Index · Production Index = (achieved price kg $^{-1}$/top-quality price kg^{-1}) · (marketed kg ha^{-1}/ field produced kg ha^{-1}).

Range of QPI:

QPI = 1 at maximum, if a crop product has been marketed for a top quality price (QI = 1) without any losses before, during or after harvest (PI = 1). This may only occur if the crop is vital, with optimal growth and minimal stress physically (soil structure, water and air supply), chemically (nutrients supply) and biologically (weeds, pests and diseases).
QPI = 0 at minimum, if a crop product has completely gone to waste before or after the harvest because of lodging, weeds, pests or disease, regardless of conditions of weather, soil or preservation (PI = 0), or whether the product has not been marketed because of unacceptable low quality or there is a surplus on the market (QI = 0).

(1) Testing with QPIs of single crops

(1.1) Quantifying losses in quality (prices kg $^{-1}$):

- dividing achieved price by the top-quality price achievable at the moment of marketing a product (Quality Index);
- assigning possible price losses to assessed causes (any cause ≥ 5 % of top-quality price).

(1.2) Quantifying losses in production (kg ha^{-1}):

- assessing losses before (ripening stage), during or after harvest;
- calculating on-field yield (kg ha^{-1}) = pre-harvest losses + post-harvest losses + on-market yield (kg ha^{-1});
- dividing on-market yield (kg ha^{-1}) by on-field yield kg ha^{-1} (Production Index).
- assigning possible production losses to assessed or probable causes (any cause ≥ 5 % of on-field yield);

(1.3) Quantifying QPIs and QPI corrected yields:

- calculating crop-wise QPI = Quality Index · Production Index
- calculating crop-wise QPI corrected yield = marketable yield at top-quality price = on-field yield · QPI.

(2) Improving with QPIs of single crops:

- assessing crop-wise a desired QI, PI and QPI estimating the chances of overcoming the causes of current losses;
- establishing which crops have shortfalls between achieved and desired results in QPI;
- assessing from the theoretical prototype which methods are involved (MCR, ICP, I/ENM etc.) with the major causes of losses;
- establishing which criteria have not yet been fulfilled by these methods (ready for use, manageable by the farmers, acceptable to the farmers, effective);
- establishing targeted improvements of the methods to meet the successive criteria.

Figure 7 presents the testing results with QPI of wheat of UK 1, the only project having data on this major European crop available from at least 3 consecutive years (1993 - 1995). There is a persistent and large shortfall between desired and achieved results, mainly caused by insufficient N available in the generative stage of the crop, leading to harvest and sorting losses (small kernels) and also marketing losses (low protein content). Ways to overcome this have already been discussed in Section 5.1. The question remains whether it is realistic to assess QPI = 1 and QPI corrected yield = 8 t ha^{-1} as desired minimum results.
If the answer is that these results are necessary to achieve the desired result in Net Surplus, it should be realised that the desired Net Surplus can also be achieved by Farm Structure Optimisation, including a sufficient size of the farm and possibly a layout and management to meet requirements for environment-conditioned payment or a trade mark.

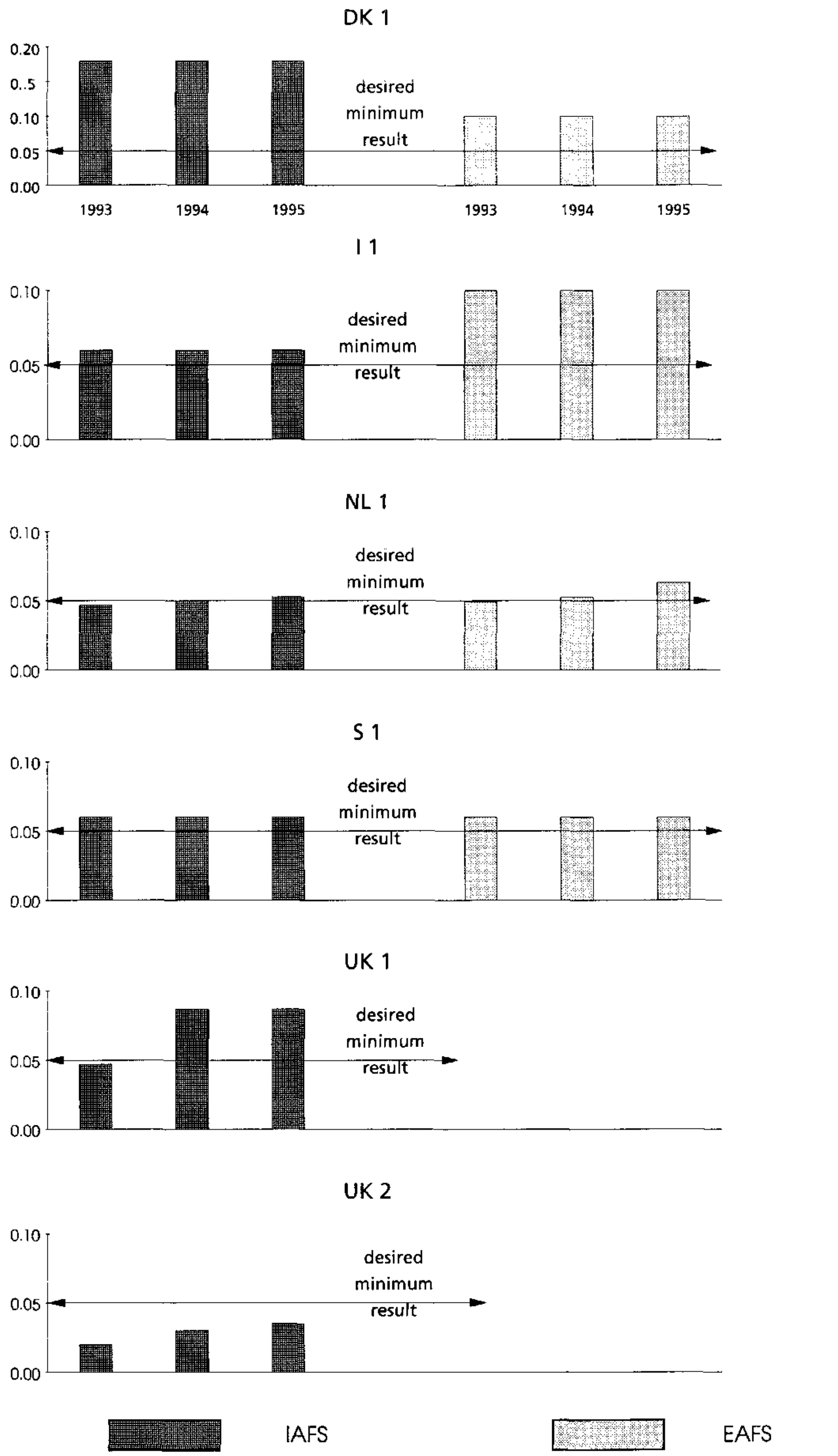


Figure 8 Testing and improving Ecological Infrastructure Indices (EII) of I/EAFS prototypes on 6 experimental farms, 1993 -1995

7 Testing and improving with EII and PSD

7.1 Ecological Infrastructure Index (EII) and related Plant Species Diversity (PSD)

Brief definition and range:
EII refers to the part of the farm laid out and managed as a network of linear and non-linear habitats and corridors for wild flora and fauna, including buffer strips($0 \le EII \le 1$).

(1) *Testing with EII:*
- establishing the desired range of EII, based on the desired layout, management and size of the EI, and expressed as EI including bufferstrips (ha) / production area of the farm (ha);
- establishing achieved EII.

(2) *Improving with EII:*
- establishing which EI elements are involved in a possible shortfall of achieved results;
- establishing which criteria have not yet been fulfilled by the responsible method EIM (ready for use, manageable by the farmers, acceptable to the farmers, effective);
- establishing targeted improvements of EIM to meet these consecutive criteria.

Figure 8 presents the testing results with EII of all I/EAFS projects on all experimental farms except DE 2. The results are discussed briefly below.

DK 1 has laid out EIs for IAFS and EAFS that are multiples of the desired EIs. Economically, such exaggeration is undesirable. Or are the grass strips only needed for separating experiments also accounted for? If they are not needed to buffer a habitat or corridor for flora and fauna, they should not be accounted for.

I 1 has laid out an EI for EAFS that is double the desired result. Again, a case of exaggeration, incorrect quantification, or of a too-low desired result?

NL 1 and S 1 have achieved the desired results. As the EAFS of NL 1 is also one of the 10 pilot farms of NL 2 (my team, ed.), I can add that its EI is made up of ditch slopes (40 %) and buffer strips (60 %), each with appropriate management for flora, fauna and recreational users.

UK 1 has doubled the EI of its IAFS since 1994. Again, a case of economically undesirable exaggeration, incorrect quantification or a too-low desired result?

UK 2 has a considerable shortfall between achieved and desired result, which is only slowly being alleviated. In Part 6 of its prototype identity card (Chapter 8), it is stated that EIM is still not ready for use.

The striking unanimity about the desired EII (≥ 0.05) and the remarkably higher EII than desired in various projects raises concern about the quality of designing EIM in our network. Most teams are small and consist of agronomists with little expertise in the ecology of plants, animals and landscape. The teams in question are advised to arrange access to the required expertise for design, layout and management of EIM that are appropriate for the region, in general, and the location, in particular.

7.2 Plant Species Diversity (PSD)

Brief definition:
PSD is the number of target plant species in the EI. A target plant species is one that is both attractive for recreational use by people and for animals to feed on or shelter in.

(1) *Testing with PSD:*
- establishing a desired PSD, considering the desired function of the EI as a habitat and corridor for flora and fauna, and as part of a recreational network.

(2) *Improving with PSD:*
- establishing which EI elements are involved in a possible shortfall of achieved results;
- establishing which criteria have not yet been fulfilled by the responsible method EIM (ready for use, manageable by the farmers, acceptable to the farmers, effective);
- establishing targeted improvements of EIM to meet these consecutive criteria.

Figure 9 presents the testing results with PSD of the two I/EAFS projects that have data from at least 3 consecutive years (1993 - 1995).

I 1 has since 1993 had a considerable shortfall between achieved and desired results. First, is the desired result well established, considering the desired functioning of the EI as a habitat and corridor for flora and fauna and, possibly, as part of a recreational network? Second, are efforts really being made to improve EIM in line with the format?

NL 1 is clearly making progress in PSD of its EAFS. As this EAFS is also one of the 10 pilot farms of NL 2 (my team, ed.), I can add that progress has been achieved by sowing more than 80 target species across the existing vegetation of the ditch slopes as main elements of the EI. Between 1991 and 1995, these species have been carefully selected and collected as possible elements of a regional flora that fits local soil types and habitats. By appropriate management of the EI elements (ditch slopes and buffer strips) gradually habitats are being created that are required for the introduced species to settle successfully in the existing herbal vegetation. At the start of the project in 1991, only 10 target species were present. In 1995 20 of the 80 target species sown appeared to have settled. Another 20 should settle in the coming years to achieve the desired result. This has been set at 50 target species, taking into account on the one hand the potential of more than 100 species and on the other the need for a minimum number of species to achieve continual flowering between April and October, to benefit fauna and recreational users.

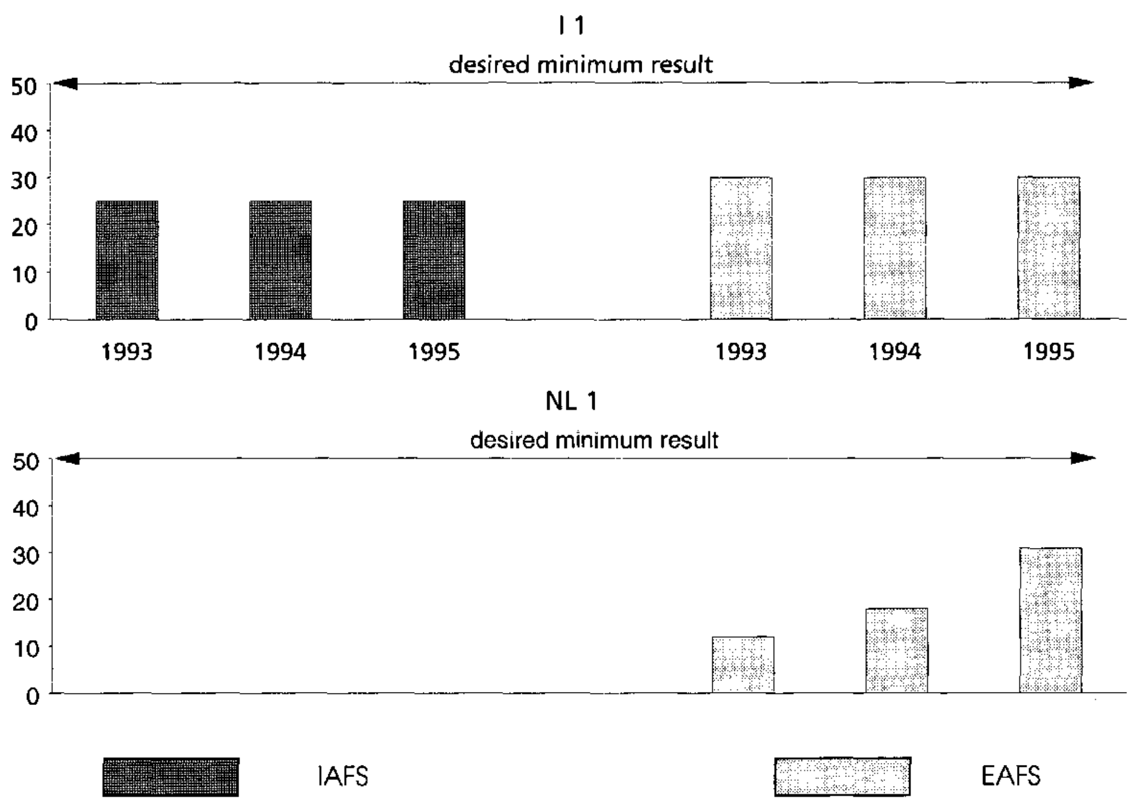


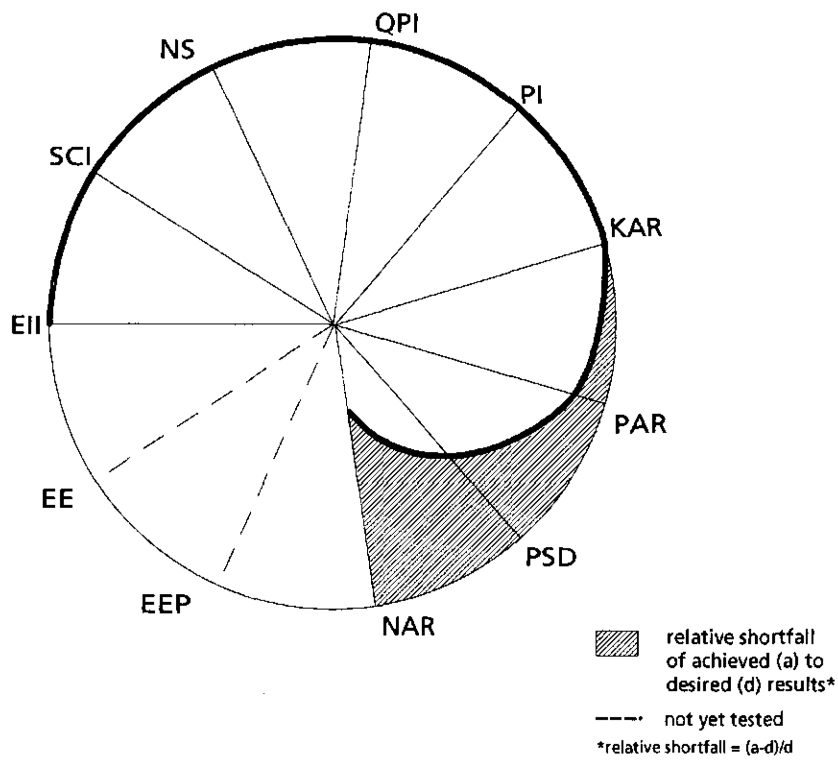
Figure 9 Testing and improving Plant Species Diversity (PSD) of I/EAFS prototypes on 2 experimental farms, 1993 - 1995

8 Part 6 of the identity cards of the prototypes in the 7 selected projects

In line with the format for improving I/EAFS prototypes (Chapter 3), the teams of the 7 selected European projects on an experimental farm present their state of the art for Part 6 of their identity cards in Section 8.1 (Layout is Part 5, see Progress Report 1, Chapter 8). The general state of the art in testing and improving (Step 4) is briefly evaluated in Section 8.2.

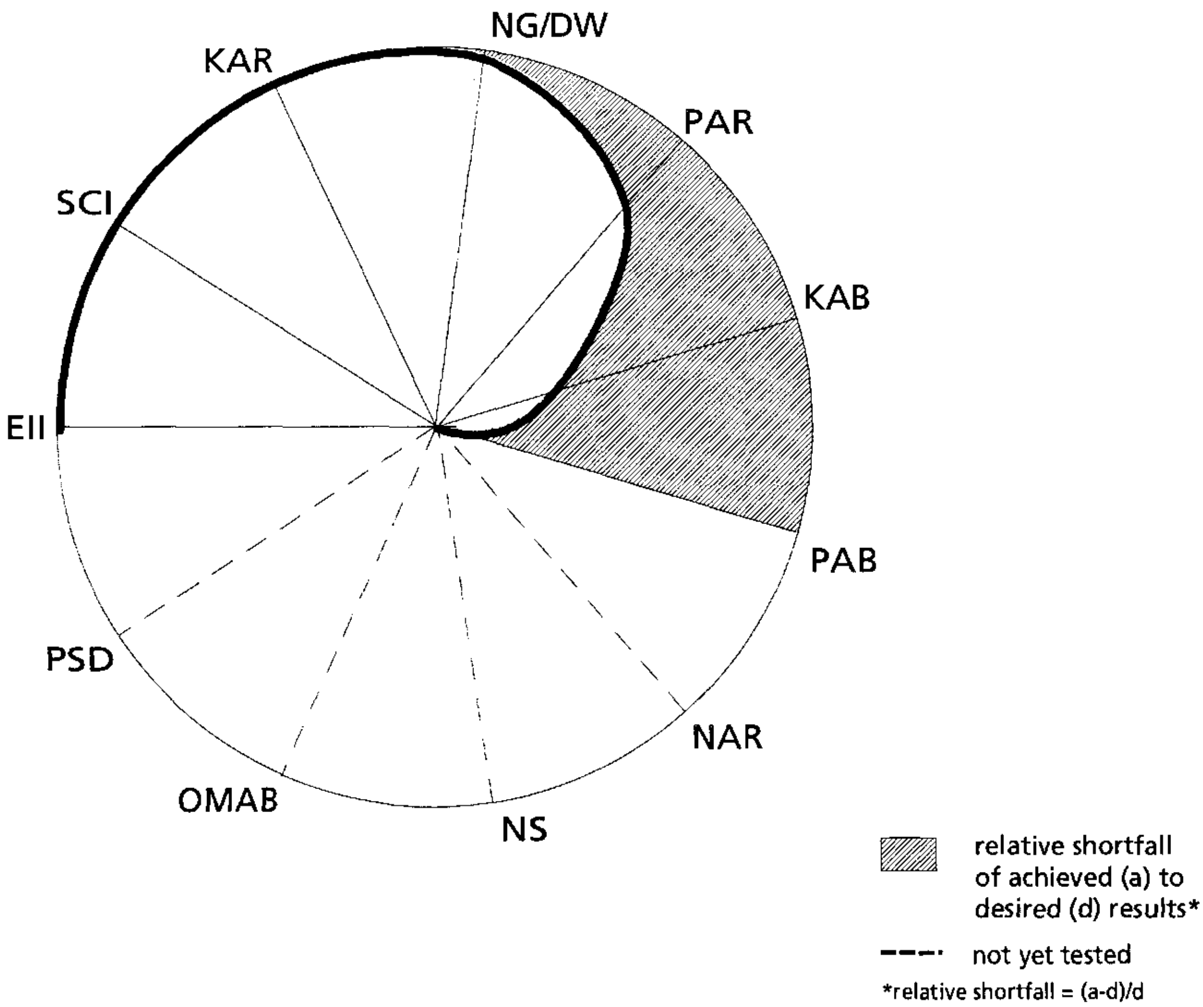
8.1 State of the art (Part 6)

Part 6 summarises the state of the art by circle diagram and a simple table. The circle diagram shows the parameters ranked clock-wise by increasing relative shortfall between achieved and desired results. In this way, it shows on which parameters, and to what extent, the prototype is all round or still has to be improved. The table specifies for any parameter the desired and achieved results, the main cause of a possible shortfall and, if that cause is a farming method, the criterion on which it needs to be improved first.



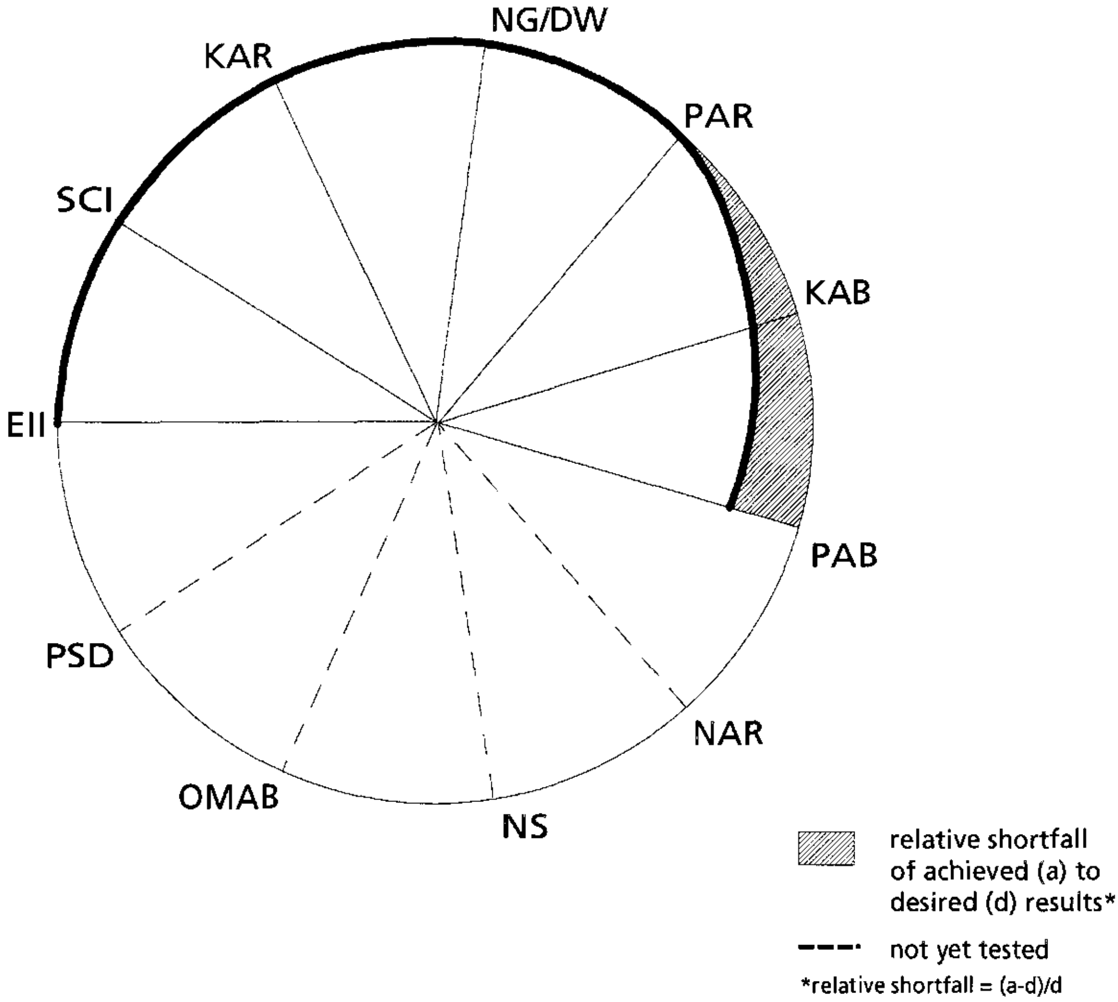
Parameters (see Parts 2 and 3)	Desired results (quantified objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read. Accept. Manag. Effect. (see in Chapter 3)
EII	> 0.05	0.08		
SCI	> 0.6 (year)	0.6		
NS	> 0 DEM/ha	0		
QPI	> 0.9	0.93		
PI	< 0.25	0.23		
KAR	6 - 10	9		
PAR	11 - 18	20	slow response	
PSD	> 50 species	32	slow response	
NAR	< 45 kg/ha (0-?cm)	77	INM	INM
EEP	?			
EE	?			

Figure 10.1 State of the art in 1995 for IAFS of Reinshof (DE 2)



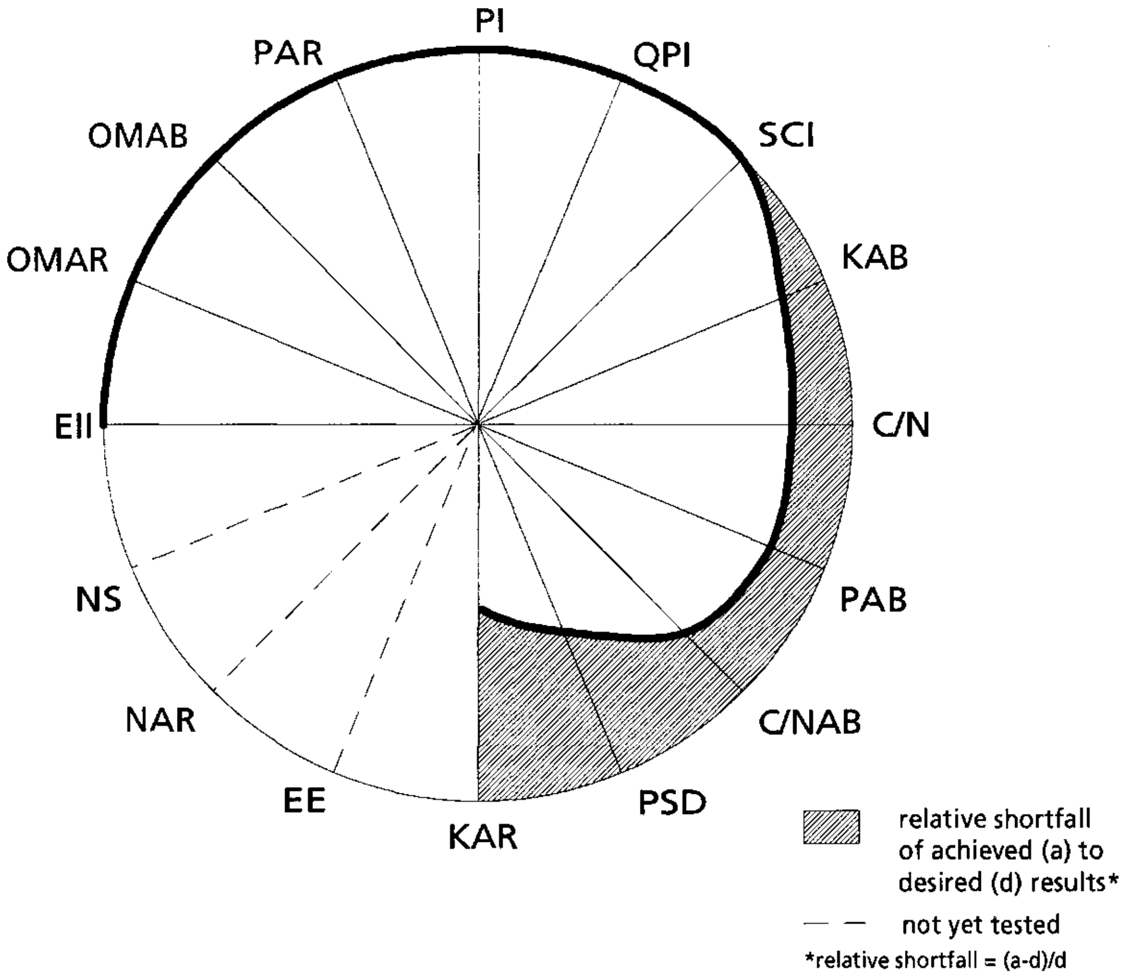
Parameters (see Parts 2 and 3)	Desired results (quantified objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read. Accept. Manag. Effect. (see in Chapter 3)
EII	> 0.05	0.21		
SCI	0.65 (year)	0.75		
KAR	7<K-acetate<11	9.3		
NG/DW	< 11.2 mg/l	< 11.2 mg/l		
PAR	2<P-olsen<4	4.8	ENM	ENM
KAB	1	1.64	ENM	ENM
PAB	1	2.18	ENM	ENM
NAR	45 kg/ha (0-100cm)	?		
NS	> 0 DKK/ha	?		
OMAB	?	?		
PSD	?	?		

Figure 10.2.1 State of the art in 1995 for IAFS of Foulum (DK 1)



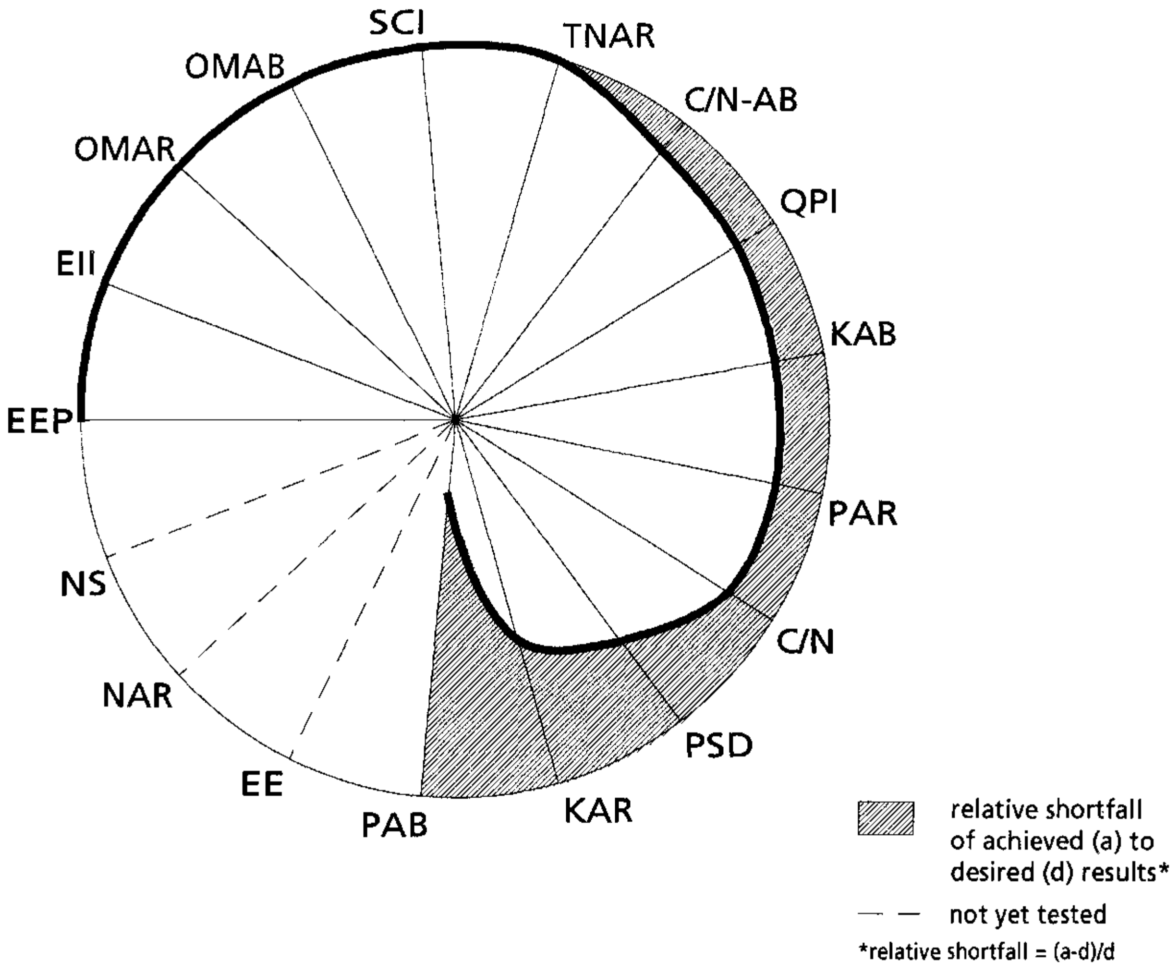
Parameters (see Parts 2 and 3)	Desired results (quantified objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read. Accept. Manag. Effect. (see in Chapter 3)
EII	> 0.05	0.10		
SCI	0.65 (year)	0.75		
KAR	7<K-acetate<11	7.5		
NG/DW	< 11.2 mg/l	< 11.2 mg/l		
PAR	2<P-olsen<4	3.2		
KAB	1	0.91	ENM	ENM
PAB	1	1.16	ENM	ENM
NAR	45 kg/ha (0-100cm)	?		
NS	> 0 DKK/ha	?		
OMAB	?	?		
PSD	?	?		

Figure 10.2.2 State of the art in 1995 for EAFS of Foulum (DK 1)



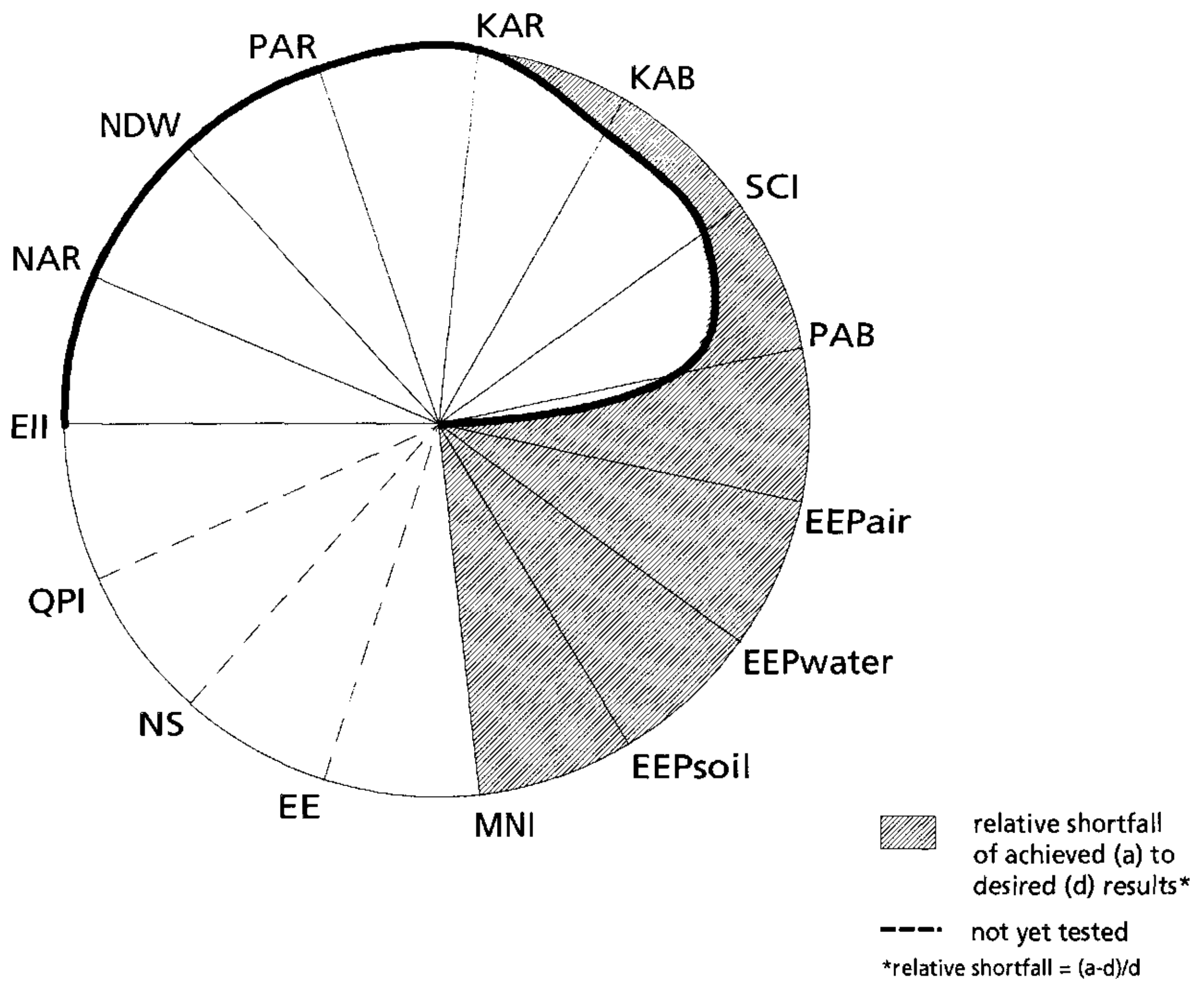
Parameters (see Parts 2 and 3)	Desired results (quantified objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read. Accept. Manag. Effect. (see in Chapter 3)
EII	> 0.05	0.06		
OMAR	1.5-2.5%	1.72		
OMAB	> 1	1.1		
PAR	25-35	32		
PI	< 0.7	0.41		
QPI	0.9 (barley)	0.9		
SCI	> 0.6 (year)	0.6		
KAB	0.5	0.56	INM	INM
C/N	> 10	8.6	slow response	
PAB	1.0	1.15	INM	INM
C/NAB	> 1.2	1	MCR, INM	MCR INM
PSD	> 40	25	slow response	
KAR	10-15	22.4	slow response	
EE	?			
NAR	? (0-100 cm)			
NS	?			

Figure 10.3.1 State of the art in 1995 for IAFS of Montipaldi (I 1)



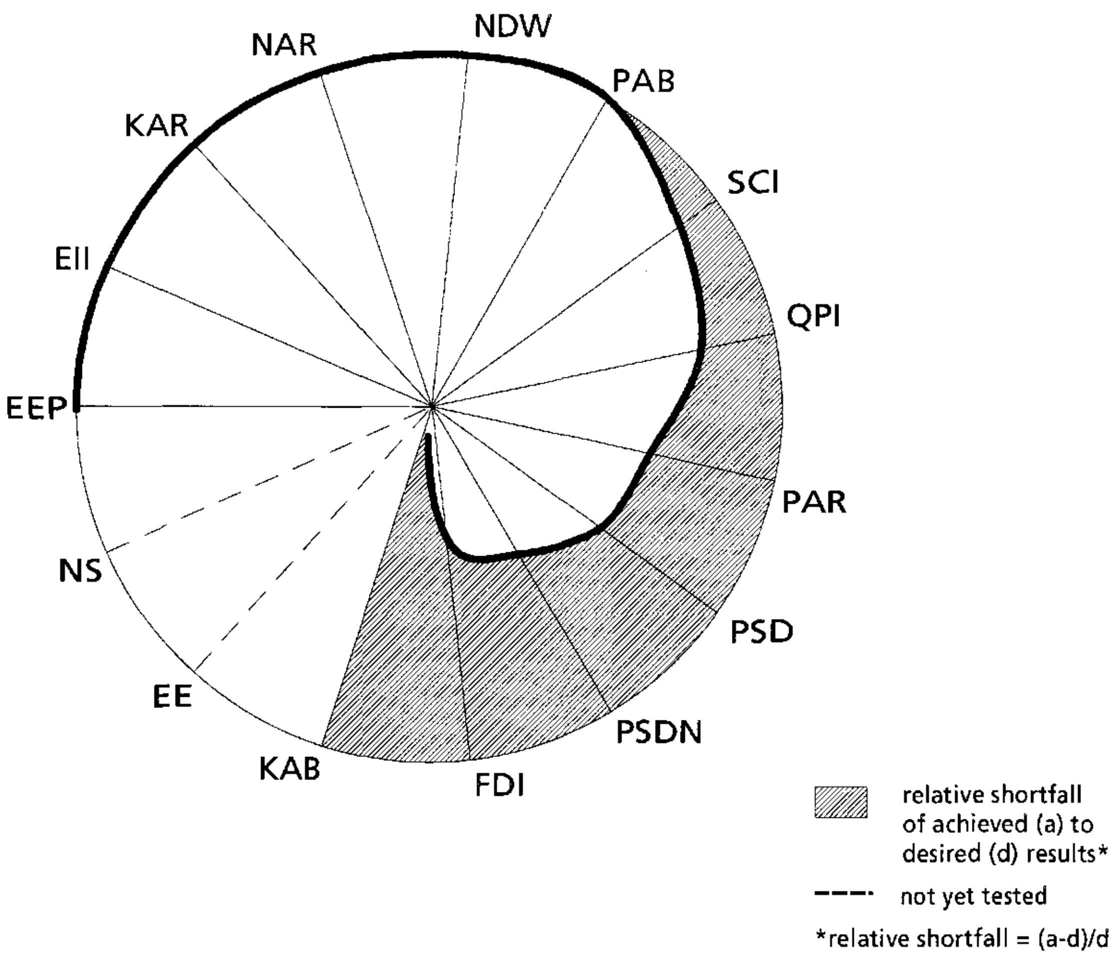
Parameters (see Parts 2 and 3)	Desired results (quantified objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read.	Accept.	Manag.	Effect. (see in Chapter 3)
EEP	0	0					
EII	> 0.05	0.1					
OMAR	1.5-2.5%	1.8					
OMAB	> 1	1.2					
SCI	> 0.5 (year)	0.56					
TNAR	1.0-1.5%	1.2					
C/N-AB	1.2	1.1	MCR, ENM	MCR		ENM	
QPI	>0.9 (barley)	0.8	FSO				FSO
KAB	0.5	0.56	ENM			ENM	
PAR	25-35	22	ENM				ENM
C/N	10	8.7	slow response				
PSD	40 species	30	slow response				
KAR	15	21	slow response				
PAB	1	0.2	ENM			ENM	
EE	?						
NAR	? (0-100 cm)						
NS	?						

Figure 10.3.2 State of the art in 1995 for EAFS of Montipaldi (I 1)



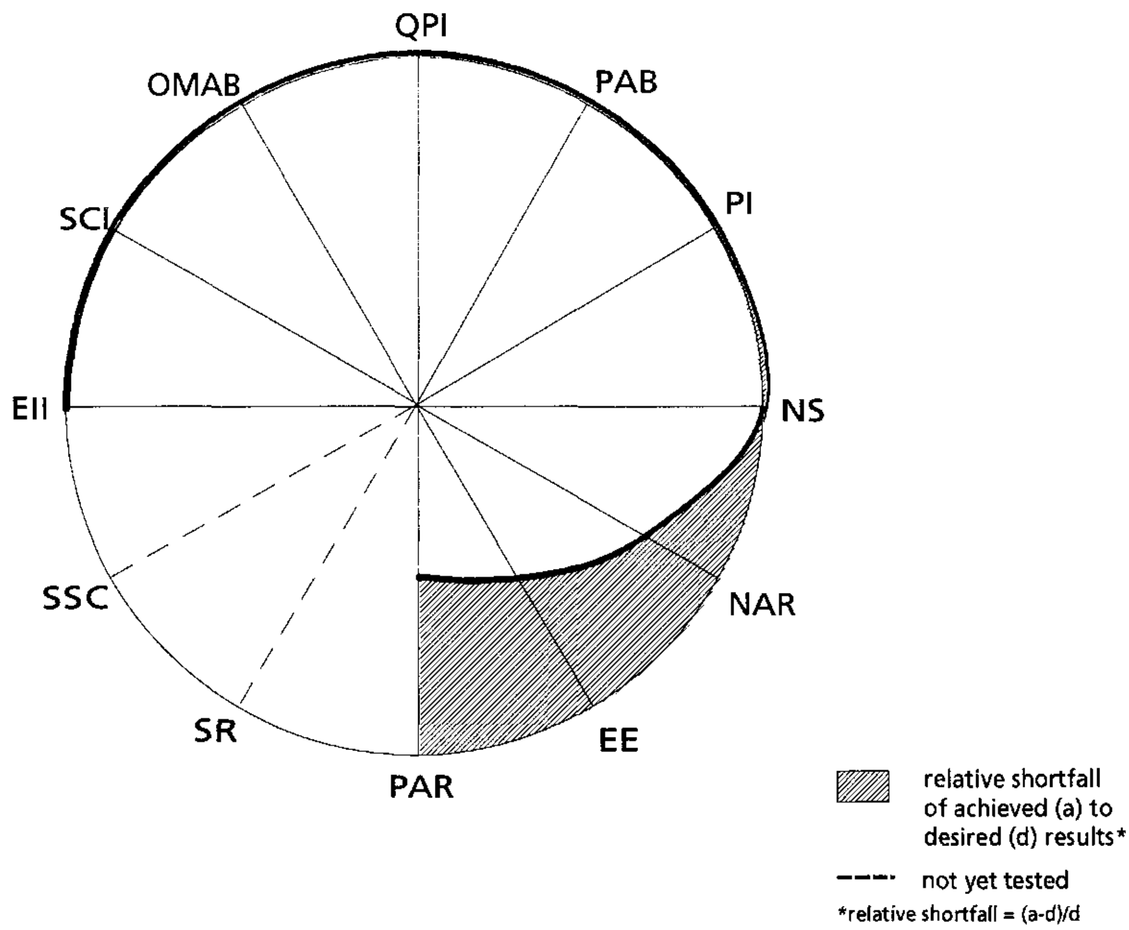
Parameters (see Parts 2 and 3)	Desired results (quantified objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: (see in Chapter 3) Read.	Accept.	Manag.	Effect.
EII	> 0.05	0.05					
NAR	< 35 kg/ha (0-100 cm)	25					
NDW	< 5.6 mg/l	5.2					
PAR	20<Pw-count<30	22					
KAR	14<K-count<20	19					
KAB	1.0	0.93	INM			INM	
SCI	> 0.5 (year)	0.44	MCR	MCR			
PAB	1.0	0.68	INM			INM	
EEPair	0 kg Pa/ha	1.1	ICP	ICP			
EEPwater	0 kg days/ha/Kom	0.4	ICP	ICP			
EEPsoil	0 kg days/ha	46	ICP	ICP			
MNI	< 50 kg/ha	125	INM			INM	
EE	?	?					
NS	> 0 NLG/ha	?					
QPI	?	?					

Figure 10.4.1 State of the art in 1995 for IAFS of Nagele (NL 1)



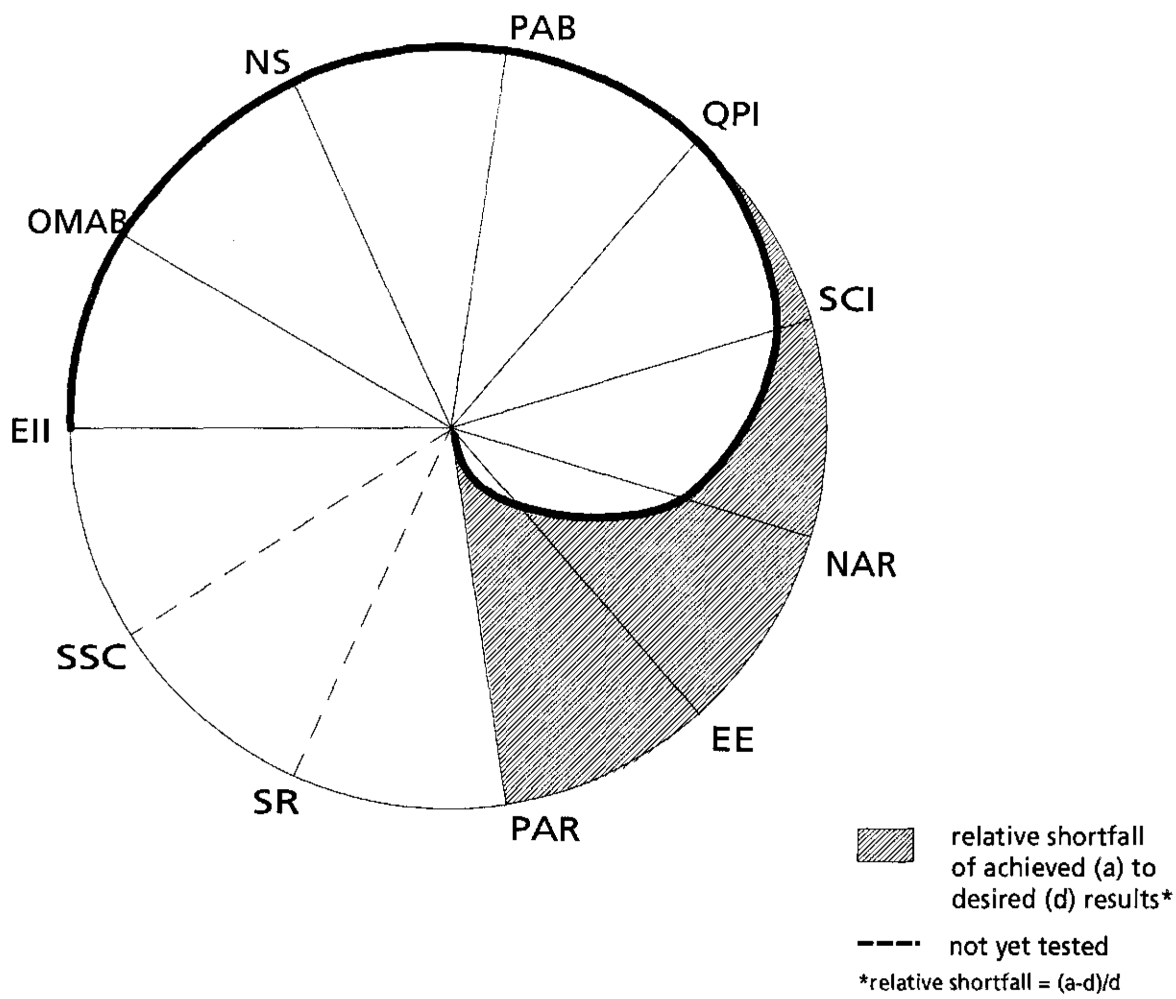
Parameters (see Parts 2 and 3)	Desired results (quantified objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read. (see in Chapter 3)	Accept.	Manag.	Effect.
EEP	0 (air, soil, water)	0					
EII	> 0.05	0.05					
KAR	14<K-count<20	17					
NAR	< 70 kg/ha (0-100 cm)	60					
NDW	< 11.2 mg/l	10					
PAB	> 1	1.6					
SCI	> 0.5 (year)	0.44	MCR	MCR			
QPI	> 0.9 (potato, carrot)	0.73	MCR				MCR
PAR	20<Pw-count<30	13	slow response				
PSD	> 50 species/EI	30	slow response				
PSDN	> 20 species/EI section (100 m)	10	slow response				
FDI	> 10 flowers/m/month EI	4	slow response				
KAB	1	1.9	ENM			ENM	
EE	?	?					
NS	> 0 NLG/ha	?					

Figure 10.4.2 State of the art in 1995 for EAFS of Nagele (NL 1)



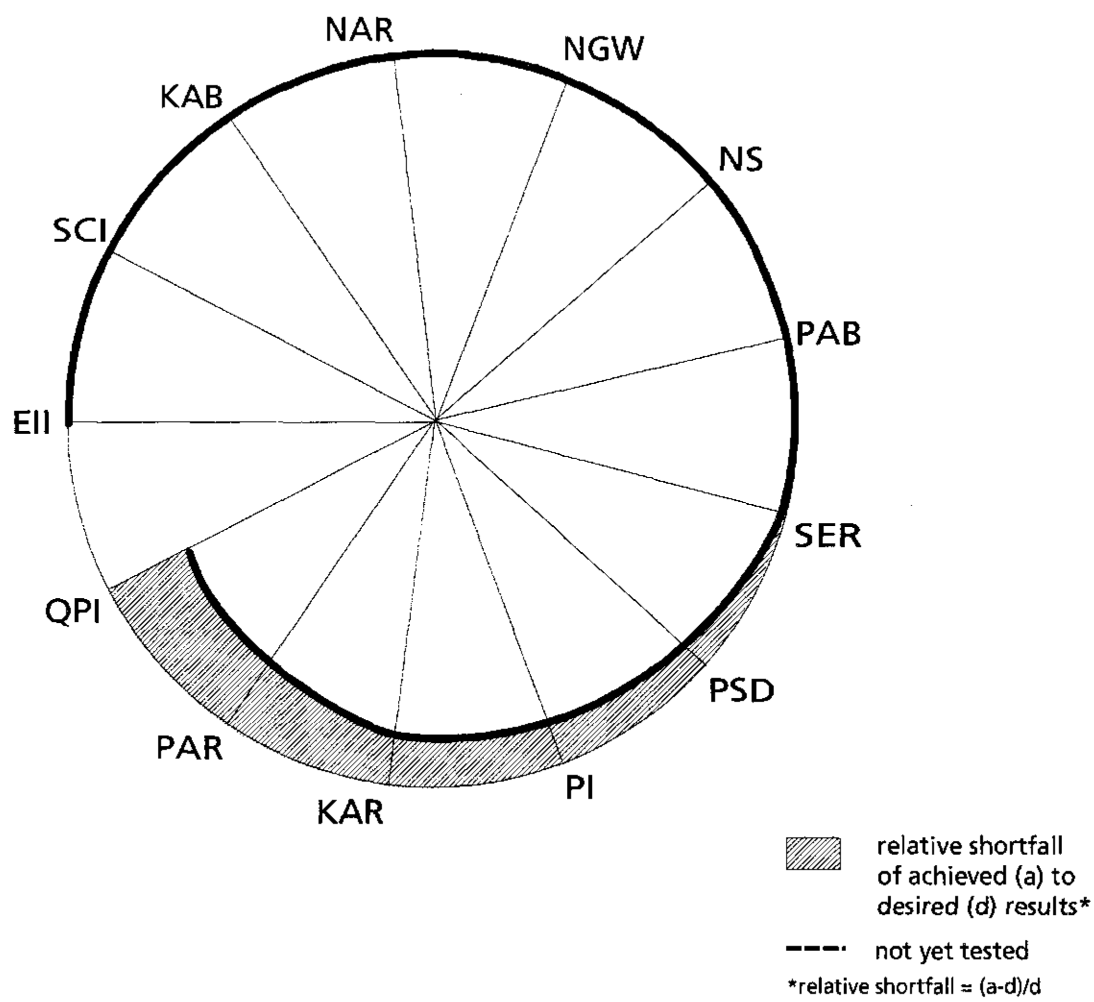
Parameters (see Parts 2 and 3)	Desired results (quantivied objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read. Accept. Manag. Effect. (see in Chapter 3)
EII	> 0.05	0.06		
SCI	> 0.8 (year)	0.8		
OMAB	> 1	> 1		
QPI	1 (wheat)	1		
PAB	< 1	< 1		
PI	< 0.5	0.3		
NS	> 0 SEK/ha	0		
NAR	< 30 kg/ha (0-100cm)	37	INM, MSC, MCR	INM,MSC,MCR
EE	> 6	3.6		
PAR	4 - 12	18	slow response	
SR	?	?		
SSC	?	?		

Figure 10.5.1 State of the art in 1995 for IAFS of Logården (S 1)



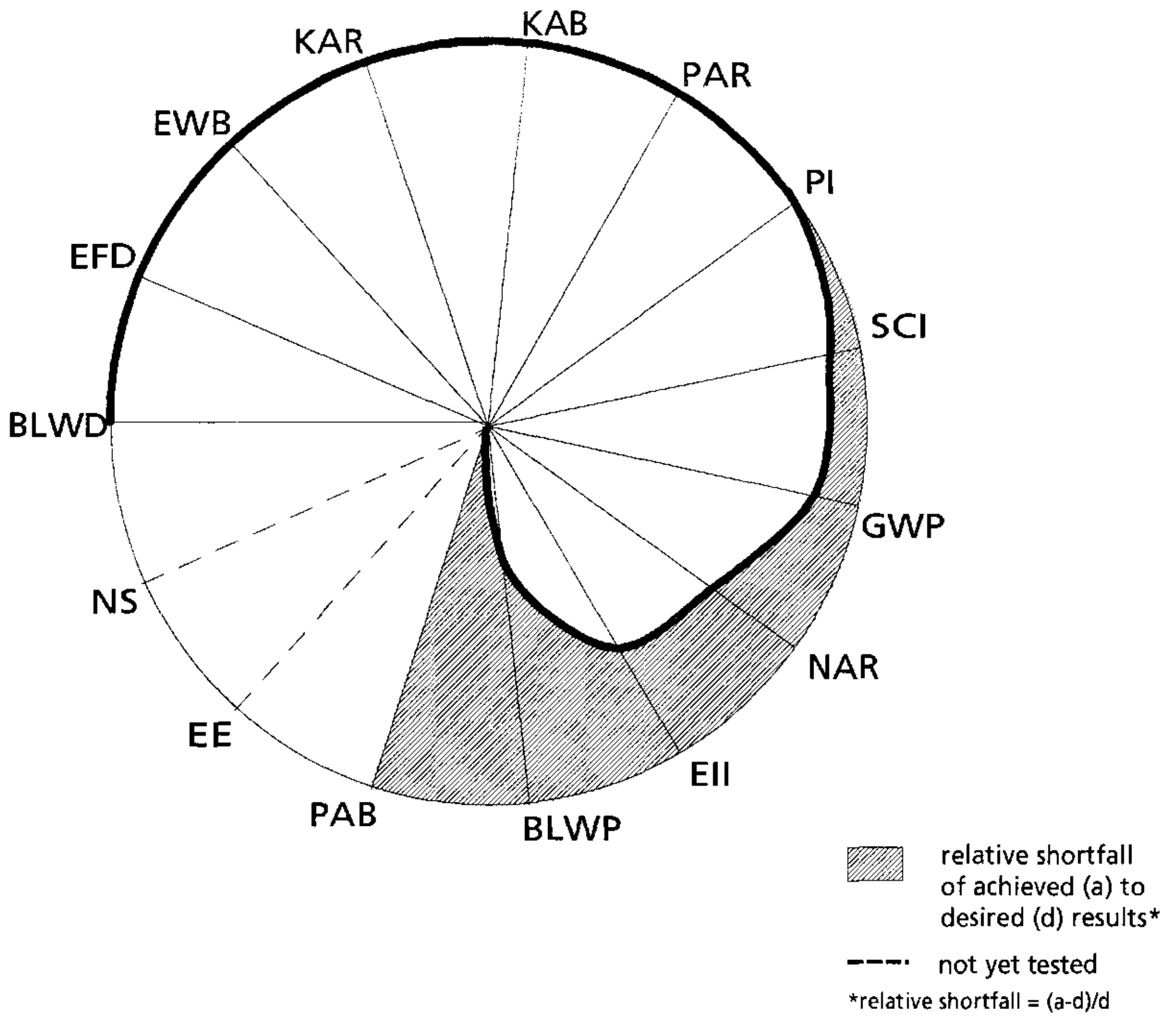
Parameters (see Parts 2 and 3)	Desired results (quantivied objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read. Accept. Manag. Effect. (see in Chapter 3)
EII	> 0.05	0.06		
OMAB	> 1	1		
NS	> 0 SEK/ha	539		
PAB	< 1	< 1		
QPI	1 (wheat)	1		
SCI	> 0.8 (year)	0.75		
NAR	< 30 kg/ha (0-100cm)	40	MCR, ENM	MCR ENM
EE	> 6	1.9		
PAR	4 - 12	25	slow response	
SR	?	?		
SSC	?	?		

Figure 10.5.2 State of the art in 1995 for EAFS of Logården (S 1)



Parameters (see Parts 2 and 3)	Desired results (quantified objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read. Accept. Manag. Effect. (see in Chapter 3)
EII	> 0.05	0.09		
SCI	> 0.75 (year)	0.78		
KAB	< 1	< 1		
NAR	< 60 kg/ha (0-100cm)	55		
NGW	< 50 ppm	28		
NS	> 0 EP/ha	9		
PAB	< 1	< 1		
SER	< 1 t/ha	0		
PSD	> 40 species	38		
PI	< 0.7	0.76		
KAR	120	105	slow response	
PAR	15	12	slow response	
QPI	1 (wheat)	0.77	INM, (ICP)	INM

Figure 10.6 State of the art in 1995 for IAFS of LIFE (UK 1)



Parameters (see Parts 2 and 3)	Desired results (quantified objectives in Part 2)	Achieved results 1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read. Accept. Manag. Effect. (see Chapter 3)
BLWD	> 1	1.1		
EFD	> 1	1.1		
EWB	> 1	1		
KAR	60-240	180		
KAB	< 1	0.7		
PAR	15-45	36		
PI	< 1	0.8		
SCI	> 0.7 (year)	0.65	MSC	MSC
GWP	< 1	1.1	ICP	ICP
NAR	< 60 kg/ha (0-100cm)	75	INM	INM
EII	> 0.05	0.035	EIM	EIM
BLWP	< 1	1.65	ICP	ICP
PAB	1	3.1	INM	INM
EE	?	?		
NS	?	?		

Figure 10.7 State of the art in 1995 for IAFS of LINK (UK 2)

8.2 State of the art in testing and improving

Step 4 of the methodical way to I/EAFS involves testing and improving the prototype, in general, and the methods, in particular, until the objectives as quantified in the set of parameters have been achieved. The prototype is tested by comparing the achieved with the desired results of the parameters, as quantified in Step 2 (Part 2 of the prototype's identity card). The prototype is improved by relating the achieved and desired results to those methods that are linked to the parameters in question in Step 3 (theoretical prototype). Subsequently, it is established why the methods are causing shortfalls: are they not ready for use, not manageable by the farmer, not acceptable to the farmer or not effective? The improving part of Step 4 is finalised by establishing targeted improvements of the methods causing shortfalls to make them fulfil all 4 criteria and achieve all desired results. Usually this will take several years of repeated layout, testing and improving.

The results in Chapters 4-7 on testing and improving with single parameters during 3 consecutive years (1992-1995) and the general state of the art (1995) in Section 8.1 show that in practice Step 4 is not easy. For 11 I/EAFS prototypes in the 7 projects on experimental farms, 27 parameters have not yet been tested; for 54 parameters the desired results have not been achieved; and for 64 parameters the desired results were achieved in 1995. Considering the high number of parameters with desired results achieved, it can be concluded our methodology of prototyping is working, although in many cases desired results have been established with such little ambition that they can easily be achieved. However the majority of parameters have not yet been tested or as yet have shortfalling results. Since all 7 projects have been going for 5 years or more, it must be concluded that there are still a lot of problems and constraints. These will be discussed in the following subsections.

8.2.1 Establishing desired results

Desired results should be set based on two basic considerations:
- which results are already being achieved in current systems, according to good agricultural practice;
- which results should be achieved on the short term (IAFS) or the long term (EAFS) that would signify a break-through as compared to good agricultural practice.

Foregoing chapters point to various ways of establishing desired results inappropriately:
- too conformistic, for example PI < 0.7 (equal to or slightly better than good agricultural practice) or EII > 0.05 (equal to other teams);
- too idealistic, for example QPI = 1 (losses before and after harvest to be reduced to 0 and top quality price to be achieved);
- too vague, for example 60 < KAR < 250 (risk of agronomical shortage included in the lower limit and risk of environmental excess included in the upper limit).

8.2.2. Establishing achieved results

Achieved results should be established:
- in accordance with the agreed definitions of the parameters;
- by appropriate methods of sampling, observation and data processing to prevent the overall error from obscuring the trends in the achieved results.

The foregoing chapters have indicated various ways of erroneously setting achieved results:
- large annual variations in parameters that are in principle stable and only slowly respond to changing conditions, for example PAR and KAR (samples too small or taken at wrong time?);
- little or no variation in parameters that in principle vary from crop to crop (and so from crop rotation to crop rotation) and from year to year, for example SCI (no observations, only estimates?);
- easily achieving or even exceeding the desired results in parameters that in principle respond slowly (because the major method takes time to be made ready for use, acceptable, manageable and effective), for example EII (incorrectly accounting for buffer strips that are not buffering any element of the EI?).

8.2.3 *Establishing the main cause of shortfalls in results*

Shortfalls between desired and achieved results can be caused by:

- either the major method, as indicated in the theoretical prototypes (which is likely in initial years of testing);
- or a minor method, as indicated in the theoretical prototype (which may occur in later years of testing);
- or a slow response of the parameter in question (which may occur in early years of testing and is likely in later years of testing for inert parameters such as PAR, KAR and PSD).

Section 8.1 indicates some ways of erroneously establishing main causes of shortfalls in results:

- 'slow response', instead of the major method, for example PAR or KAR (INM or ENM not working due to inconsistent PAB or KAB), or PSD (EIM not working due to inappropriate layout or management);
- two or more methods instead of one, for example NAR (INM, MSC and MCR jointly established as the main cause, so there is no clear key for improvement).

Though not apparent from Section 8.1, there are other ways of erroneously establishing main causes of shortfalls in results:

- minor method, instead of the major method, for example PI and EEP (ICP instead of MCR in case of cereal-dominated rotations with an intrinsic need of pesticides);
- wrong method, for example with parameters driven by 3 or more methods (too many potential causes in the case of too-complicated theoretical prototypes) or with parameters driven by 1 or 2 methods (too little potential causes in the case of too-simple theoretical prototypes).

8.2.4 *Establishing the first criterion not yet fulfilled by a method*

A method may cause shortfalls in results if it does not yet fulfil one or more of 4 consecutive criteria:

- ready for use;
- manageable by the farmers;
- acceptable to the farmers;
- effective.

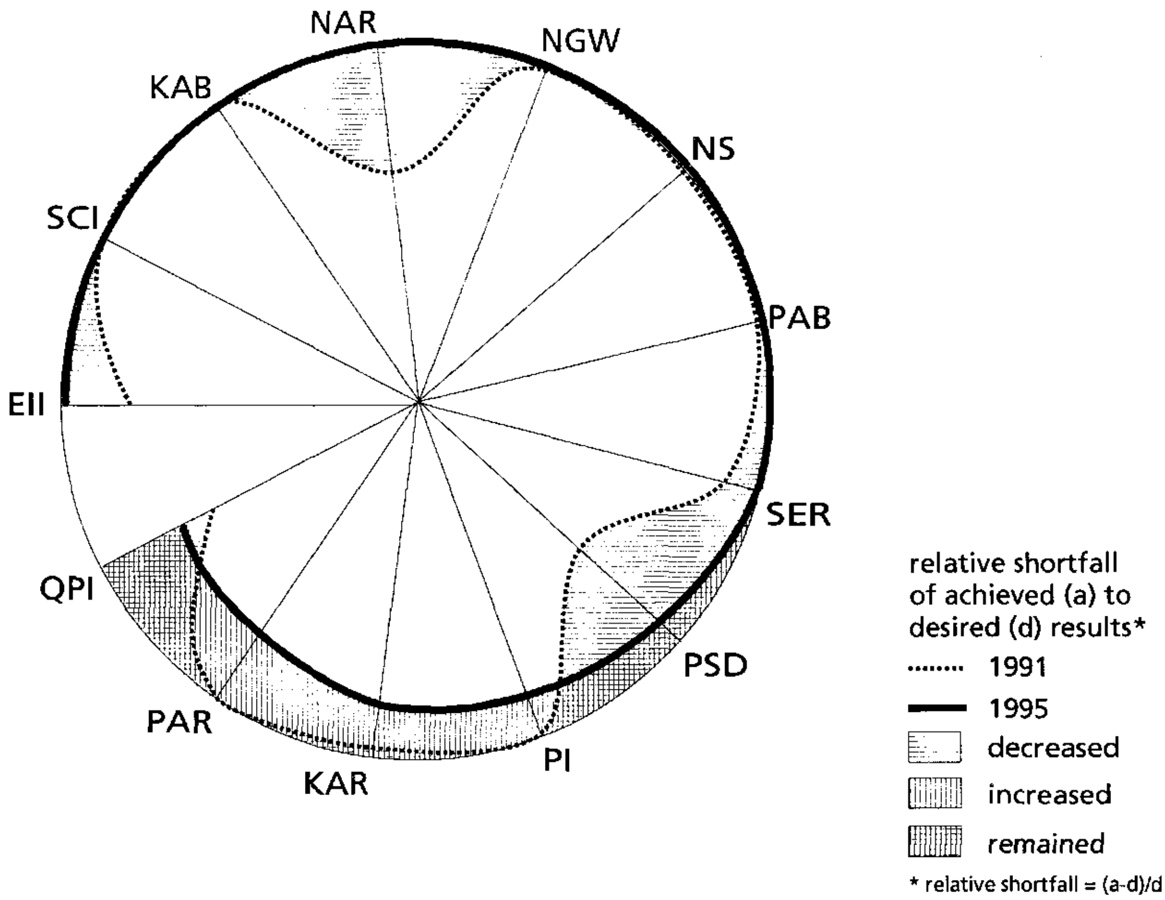
Section 8.1 indicates some of the ways of erroneously establishing criteria not yet fulfilled:

- 'manageable' or 'effective', instead of one of the preceding criteria, for example PKN parameters (INM or ENM not working because not ready for use, manageable or acceptable).

Since most of the methods on the EU shortlist are new, it is hardly possible to state within just a few years whether any of them is ready for use, manageable and acceptable, though not effective in achieving the desired result. Therefore the 'effective' criterion should be used with great care. Another reason to be careful in establishing that a method is insufficiently or not at all effective is that this calls for correction of the theoretical prototype by introducing a supporting method or completely skipping the method in question.

8.2.5 *Establishing improvements of methods to fulfil consecutive criteria*

The improving part of Step 4 is finalised by establishing targeted improvements of the methods causing a shortfall in results to make them fulfil all 4 consecutive criteria. Subsequently, the testing part of Step 4 should be repeated to see if desired results will eventually be achieved (if not, a new cycle of improving and testing is needed). Finalising the improving part of Step 4 places high demands on the expertise and creativity of the research and farmers involved. This vital stage of Step 4 has been explicitly mentioned in the inquiry circulated among the teams to assess the state of the art (see Chapter 3, last column of format 4B). Nevertheless, their response has been too little for presentation in this report.



Parameters (see Parts 2 and 3)	Desired results (quantified objectives in Part 2)	Achieved results 1991	1995	Main causes of shortfall (see Part 3)	Methods to be improved in: Read. Accept. Manag. Effect. (see in Chapter 3)
EII	> 0.05	0.04	0.09		
SCI	> 0.75 (year)	?	0.78		
KAB	< 1	< 1	< 1		
NAR	< 60 kg/ha (0-100cm)	82	55		
NGW	< 50 ppm	38	28		
NS	> 0 EP/ha	4	9		
PAB	< 1	< 1	< 1		
SER	< 1 t/ha	1.1	0		
PSD	> 40 species	26	38		
PI	< 0.7	0.62	0.76		
KAR	120	116	105	slow response	
PAR	15	15	12	slow response	
QPI	1 (wheat)	0.66	0.77	INM, (ICP)	INM

Figure 11 Progress in prototyping IAFS in LIFE (UK 1), 1991 - 1995

9 Focus on testing and improving an IAFS prototype in LIFE (UK 1)

Research Team: V.W.L.Jordan, J.A.Hutcheon

The entire way of designing, testing,improving and disseminating the IAFS prototype is being covered (Steps 1-5) in the experimental farm project LIFE (UK 1). The last two steps are also being addressed in a pilot-farm project in order to provide competitive, environmentally safe and sustainable production systems with the flexibility necessary to meet varying ecological, environmental, political and economic requirements.

9.1 Progress 1991-1995

In 1991, the IAFS prototype was laid out and tested for the first time.Considering the current theoretical prototype (Chapter 4, Fig. 1.6), desired results for 6 out of 13 multi-objective parameters were not achieved. They are EII,NAR,SER,PSD,KAR and QPI. Besides, SCI was not tested. From 1991-1995, the IAFS prototype has been through another 5 cycles of testing and improving. As a result, shortfalls have been made good in EII,NAR,SER and almost in PSD. Furthermore, desired results in SCI were achieved. However, shortfalls in QPI have largely remained and even new shortfalls have occurred in PI,KAR and PAR (Fig.11). How this all has been achieved, will be highlighted for each of the 6 methods, as established in the theoretical prototype.

9.2 Multifunctional Crop Rotation (MCR) and Minimal Soil Cultivation (MSC)

To achieve the desired Net Surplus (NS), this rotation has more wheat than the network demand for multifunctionality (< 25 %). Consequently, some cereal pests and soil-borne diseases are favoured. To achieve the desired Pesticide Index (PI < 0.7) in spite some of that, the cereals and the rape are sown with MSC (non-inversion tillage). As a result,beneficial soil life is favoured, limiting the carry-over of some pests and diseases. However damage from pests such as slugs is minimised primarily by MCR. MSC is also needed to achieve the desired result in Soil Erosion Rate (SER).
The combination of a cereal-dominated rotation and MSC favours weeds, especially grass weeds. It confines weed seeds to the topmost soil layers where they germinate more synchronously and in massive numbers. As a consequence, there is a perceived need for herbicide use unless alternative control strategies can be developed. The main cropping measures to maximise the positive and minimise the negative effects on the parameters involved are outlined briefly, in order of the crop rotation:

Winter wheat
Control of increased weed populations by targeting broad-leaf weed control and tolerating of grass weeds up to economically acceptable levels (PI).

Winter oilseed rape
- targeting grass-weed control:
- tolerating broad-leaf weeds (rape is sufficiently competitive) and pests (pollen beetle,weevil);
- setting disease control- thresholds (PI).

Winter wheat
- targeting slugs, the main pest in "first-wheat after rape",
- targeting remaining pests and diseases according to a decision model (PI).

Winter oats
- abandoning disease control completely in this "second- cereal", non susceptible to wheat-trash pathogens, or take-all(PI),
- controlling weeds with low-input, because oats is readily competitive.

10 Conclusions and recommendations

The following conclusions and recommendations have been drawn up in the light of the results of this third year of concerted action with the scope on testing and improving I/EAFS (Step 4).

10.1 State of the art in preceding 3 steps

Step 4 of the methodical way to I/EAFS implies repeated layout, testing and improving during at least one full crop rotation. So it takes at least 4 years for IAFS and 6 years for EAFS. It is, therefore, the most time-consuming and expensive step. To carry out Step 4 with maximum progress and minimum cost, the preceding 3 steps should be completed with great careness to provide for a sound base. The 3 initial steps imply:

(1) making a hierarchy of general and specific objectives (Part 1 of prototype's identity card);
(2) transforming the major (10) objectives into multi-objective parameters to quantify them, and establishing the multi-objective methods needed to achieve the quantified objectives (Part 2);
(3) designing a theoretical prototype by linking parameters to methods and designing the methods in this context until they are ready for initial testing (Parts 3 and 4).

Steps 1 and 2 were studied during the first year of the concerted action, which included a workshop at Wageningen (1993). The prototyping methods and the state of the art of most ongoing projects were presented in the first progress report.

Step 3 was studied during the second year of the concerted action, which included a second workshop at Wageningen (1994). The prototyping methods and the state of the art of the ongoing projects on pilot farms were presented in the second progress report. The ongoing 7 projects on experimental farms present their state of the art in Step 3 in this, third, progress report. It involves the theoretical prototype as Part 3 and Multifunctional Crop Rotation as Part 4 of their prototype's identity cards.

The 7 selected projects involve 7 IAFS and 4 EAFS prototypes. The theoretical prototypes vary from 12 parameters driven by 3 methods (DK 1) to 17 parameters driven by 7 methods (I 1). Most of the teams have made various drafts to come to the Parts 3 as presented in Chapter 2. It indicates their care, but also the trouble they had drawing up a theoretical prototype while a programme of on-farm research of a highly comparative character is already in progress. Nevertheless, most teams have succeeded in changing the character of the research to prototyping.

Subsequently, because it is the central method and the first to be designed, MCR is described as Part 4 of the prototype's identity card (Chapter 2). The Parts 4 of the 7 IAFS and 4 EAFS prototypes show that most MCRs provide an insufficient base for Step 4. Only DE 2 has succeeded in designing an MCR fulfilling all demands. Most teams have not yet succeeded in designing an MCR with sufficient soil cover (SCI!) as a major preventive measure against erosion by wind or water and leaching or runoff of nutrients. Neither have most teams succeeded in sufficiently diversifying their MCR by limiting the share species^{-1} as a major preventive measure against weeds and soilborne pests and diseases. In particular, the teams of DK 1 and I 1 (EAFS), UK 1 and UK 2 (IAFS) have built in high risks, because their MCRs also have too high a share group^{-1} of phytopathologically related crop species. Except for NL 1 in IAFS, all teams have succeeded in designing an MCR with a balance between crops that degrade soil structure (by compaction at harvest) and crops that restore soil structure (by intensive rooting). Finally, all teams have succeeded in designing an MCR with a minimum need for N input, largely compensating for N offtake by-products, by fixing N biologically and transferring N from crop residues efficiently.

In view of the state of the art in designing an MCR, teams are recommended to revise MCRs to meet all multifunctional demands and so give their prototype the base needed to achieve an ambitious set of objectives.

10.2.5 Establishing improvements of methods to fulfil consecutive criteria

The improving part of Step 4 is finalised by establishing targeted improvements of the methods causing a shortfall in results, to make them fulfill all 4 consecutive criteria. Subsequently, the testing part of Step 4 should be done again to see if desired results will eventually be achieved (if not, a new cycle of improving and testing is needed). Finalising the improving part of Step 4 puts high demands on the expertise and creativity of the research team and farmers involved. This vital stage of Step 4 has been explicitly mentioned in the inquiry circulated among the teams to assess the state of the art (see Chapter 3, last column of format 4B). Nevertheless, their response has been too little for presentation in this report.

It is recommended to establish improvements of methods in an explicit way with the format (Chapter 3), to make progress in this vital stage of Step 4 visible to all who are interested.

Selected references to projects on experimental farms

DE 2

Wildenhayn, M., 1994.
Strategies in integrated farming systems - experiences from the INTEX-project in Goettingen (in German).
In: Universität-Gesamthochschule Paderborn and Fördergemeinschaft Integrierter Pflanzenbau e.V., Bonn (eds): Transfer of knowledge and technology for integrated farm management systems: conference, Soest, 29-30 June 1994: p. 88-98.

I 1

Vazzana C., E. Raso E. & S. Pieri, 1996:
Relazione dell'incontro sul tema 'Confronto tra diversi sistemi agricoli in colture erbacee', tenuto presso l'azienda Agricola Montepaldi S.p.A., 19 giugno 1996; A.R.S.I.A., Regione Toscana, Azienda Agricola Montepaldi, Università degli Studi di Firenze, Tip, EffeEmme. (in press).

NL 1

Wijnands, F.G., 1996:
Minimising Environment Exposure to Pesticides -an integrated approach. Fourth Congress of the European Society for Agronomy. Veldhoven, July 1996 (Submitted to Proceedings).

S 1

Helander, C.A., 1996.
Arable Farming System Research project Logarden. Fourth Congress of the European Society for Agronomy. Veldhoven, July 1996. (Submitted to Proceedings).

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Nordiska Jordbruksforskares Förening, 1995. Rapport Nr 3. Nordiska Jordbruksforskares Förenings XX kongress. Reykjavik, 26-29 June 1995.

UK 1

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Less- intensive farming and the environment (LIFE): an integrated farming systems approach for UK arable crop production. In: D.M., Glen, M.P., Greaves & H.M. Anderson, Eds: Ecology and integrated farming systems: proceedings of the 13th Long Ashton International Symposium. Eds pp. 307-318.

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Alternative production systems for efficient arable crop production and environmental protection. Proceedings 1996 National Tillage Conference, TEAGASC, Ireland. p. 19-22.

UK 2

Ogilvy S.E., 1996.
LINK IFS - An integrated approach to crop husbandry. Aspects of Applied Biology 47, Rotations and Cropping Systems. (in press - December 1996).

Annex I

Programme of Concerted Action AIR3-CT920755

Working group on Integrated Arable Farming Systems in EU and associated countries

1. Objectives

The general objective is to build a representative research network on Integrated Arable Farming Systems (IAFS) that involves all 12 EU member countries; contributes essentially to the sustainable development of European agriculture; and is based on a common methodology and the effective dissemination of the results throughout the Union.

Specific objectives are:

(A) 3 workshops on the methodology and layout of new research projects, to result in a manual on IAFS research (1993-1995);

(B) 4 workshops on the progress of ongoing research projects, to result in 4 progress reports (1993-1996).

2. Expertise and role of participants

The first initiative towards establishing European cooperation in the design and development of IAFS 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, in 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 in EU-associated countries (A, CH) were presented in a second report (Vereijken & Royle Eds, 1989). The EU institutes involved in this first wave of IAFS research projects joined forces in 1990 in a CAMAR project, 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 EU countries is being assembled around the small core of experienced participants (see Annex 2). The participants must be leaders in design, development and evaluation of prototype IAFS. Only 2-3 participants per country are being accepted, 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 Sub-annex 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 that also have extensive experience with IAFS, such as PAGV (NL), FIPP (DE), and LARS (UK) (participants X_2-X_4), who will jointly organise workshops and report in detail on their research projects.
- The other participants, who 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 their scientific and farming communities in their countries for the flow of information on IAFS. 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 IAFS research and a representative and interactive European network of IAFS 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 specific evaluation criteria.

4. Benefits

For CAP:	Availability of concrete results from IAFS 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 current farming systems.
For agricultural research:	a shift in activities from single-discipline 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 used 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 that covers 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	X4, All
	- draft Chapter III	1996/2	X_4
	- workshop (Stuttgart or another centre, first ½ week) to evaluate and standardise	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, based on a detailed description of the state of the art and main results, the local experiment will be considered in detail. As a result the progress report will contain a general review 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) consecutively.

Communication

Communication among researchers within the EAFS network will be by correspondence, workshops and 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 one publication on methodology and four publications on the state of art. One thousand copies of each publication will be printed and distributed through the network of participants and EU-DG VI.

Sub-annex 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 only as last resort, in sofar as allowed
   - 1.4 equipment, machines and buildings for 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); in UK, Long Ashton experinental farm (LARS); and 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 experimental farms meet the need in The Netherlands to develop prototype systems for specific soil types 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 (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 by 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

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Annex II
Research Network on Integrated and Ecological Arable Farming Systems for EU and associated countries

EU countries	Participants workshop Bristol 1995		Projects type	name	code
AUSTRIA **(A)**	Prof.dr Wilhelm Claupein	University for Soil Culture Institute of Agronomy Gregor Mendelstr. 33 A-1180 Vienna Fax no. 43-1476543342	I/EAFS 1 exp. farm (in prep.)	-	A 1
BELGIUM **(B)**	Ir. Vincent van Bol (absent)	Université de Louvain Lab. d'Ecologie des Prairies Place Croix du Sud 2, (bte 5) 1348 Louvain-La-Neuve Fax no. 32-10472428	EAFS 8 pilot farms	Mid-Belgium	B 1
GERMANY **(DE)**	Dr Adel El Titi	State Inst. for Plant Protection Reinsburgstrasse 107 70197 Stuttgart 1 Fax no. 49-7116642498	IAFS 15 pilot farms	Baden-Württemberg	DE 1
	Dr. Michael Wildenhayn DE 2	Forschungs- und Studienzentrum Landwirtschaft und Umwelt Von-Siebold-Str. 8 D-37075 Göttingen Fax no. 49-551394601	IAFS 1 exp. farm	Niedersachsen	
	Dr Petra Zerhusen-Blecher (absent)	University of Paderborn P.O. Box 1465 59474 Soest Fax no. 49-2921378200	IAFS 10 pilot farms	Nordrhein Westfalen	DE 3
DENMARK **(DK)**	Dr. Gunnar Mikkelsen	Research Centre Foulum Dep. Forage Crops and Potatoes Postboks 23 8830 Tjele Fax no. 45-89991619	I/EAFS 1 exp. farm	Foulum	DK 1
	Dr Ib Sillebak Kristensen	Research Centre Foulum Nat. Institute Animal Science Postboks 39 8830 Tjele Fax no. 45-89991200	EAFS 20 pilot farms	National Network	DK 2
SPAIN **(ES)**	Dr Ricardo Colmenares	Centro Invest. 'F.G. Bernaldez' C/ San Sebastián, 71 28791 Soto del Real (Madrid) Fax no. 34-18478130	EAFS 2 pilot farms (in prep.)	Manzanares	ES 1
FINLAND **(FIN)**	Dr Tapio Poutala	University of Helsinki Dep. of Plant Production P.O. Box 22 00014 Helsinki Fax no. 358-9 708 5463	IAFS 8 pilot farms 1 exp. farm	South Finland	FIN 1

FRANCE **(F)**	Dr Françoise Ansay	ITCF 10, rue Dieudonné Costes 28024 Chartres Fax no. 33-237244677	IAFS 8 pilot farms	Ferté-Vidame	F 1
	Dr Philippe Girardin	INRA B.P. 507 68021 Colmar Cedex Fax no. 33-89724933 Fax no. 33-389224933	IAFS 17 pilot farms	Rhénane	F 2
GREECE **(GR)**	Dr Kiriaki Kalburtji	University of Thessaloniki Faculty of Agriculture Lab. Ecology and Env. Protection 54006 Thessaloniki Fax no. 30-31471795	EAFS (in prep.)	Kerkini	GR 1
IRELAND **(IRL)**	Dr Finnain Mac-Naeidhe (replaced by dr Mary Lynch)	Johnstown Castle Research Centre - Wexford Fax no. 353-5342213	EAFS 10 pilot farms	Southeast and Midwest	IRL 1
ITALY **(I)**	Prof. dr Concetta Vazzana (replaced by dr Enrico Raso)	University of Florence Dept. of Herbal Production Piazzale delle Cascine 18 50144 Florence Fax no. 39-55332472	I/EAFS 1 exp. farm	Montepaldi	I 1
	Dr Gemini Delle Vedove	University of Udine Dept. of Plant Production Via delle Scienze, 208, 33100 Udine Fax no. 39-432558603	I/EAFS 10 pilot farms (in prep.)	Friuli	I 2
	Dr Giampaolo Sarno	C.E.R.A.S. Via Emilia Levante, 18 40026 Imola (Bo) Fax no. 39-542609230	IAFS 3 pilot farms (in prep.)	Emilia- Romagna	I 3
NETHERLANDS **(NL)**	Ir Frank Wijnands	Exp. Station of Arable Farming P.O. Box 430 8200 AK Lelystad Fax no. 31-320230479	I/EAFS 1 exp. farm	Nagele	NL 1
	Dr Pieter Vereijken	Research Institute for Agrobiology and Soil Fertility (AB-DLO) P.O. Box 14 6700 AA Wageningen Fax no. 31-317475952	EAFS 10 pilot farms	Flevoland	NL 2
PORTUGAL **(PT)**	Dr Mario Carvalho	University of Evora Department of Agronomy 7000 Evora Fax no. 35-1-66711163	IAFS (in prep.)	-	PT 1

SWEDEN **(S)**	Dr Carl-Anders Helander (absent)	Agricultural Society P.O. Box 124 532 22 Skara Fax no. 46-51118631	I/EAFS 1 exp. farm	Logården	S 1
UNITED KINGDOM **(UK)**	Dr Vic Jordan and Dr Paul Farmer	Long Ashton Research Station Long Ashton Bristol BS18 9AF Fax no. 44- 1275 394007	IAFS 1 exp. farm (6 pilot farms)	LIFE, (Southwest England)	UK 1
	Dr Sue Ogilvy	ADAS-High Mowthorpe Duggleby, Malton Y 017 8BP North Yorkshire Fax no. 44- 1944 738434	IAFS 6 exp. farms	LINK	UK 2

Countries outside EU

HUNGARY **(H)**	Dr László Radics	University of Horticulture Dept. of Ag. and Ecol. Farming P.O. Box 53 H-1052 Budapest Fax no. 36-11664355	I/EAFS 1 exp. farm (in prep.)		H 1
POLAND **(PL)**	Dr Edward Majewski	Agricultural University Dep. Farm Management Nowoursynowska 166 02-787 Warsaw Fax no. 48-22431877	IAFS 15 pilot farms	Mazovia	PL 1
SLOVAKIA **(SL)**	Dr Karol Kovác	Res. Inst. Plant Production Bratislavská 122 921 68 Pieštany Slovakia Fax no. 42-83826306	EAFS 7 pilot farms (in prep.)	Slovakia	SL 1