4. Improving and disseminating 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 fourth 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 - 1998).

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 fourth progress report focuses on Steps 4 and 5. Three teams, each with a project on pilot farms, have been selected for presentation in this step of the state of the art. They present their progress in Steps 4 and 5 during the last 3 years, at least.

The Parts 6 of the identity cards clearly show the similarities and differences between the 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 call for further progress on developing methods for prototyping more sustainable arable farming systems in Europe, for both the short (IAFS) and long term (EAFS).
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Annex II List of participants 4 pp
1 Introduction to the concerted action

In agreement with the programme of the concerted action (Annex 1), the third progress report dealt with testing and improving of prototypes, particularly on experimental farms.

In this progress report, the scope has been widened to include dissemination of prototypes. The method of dissemination is elaborated and the state of the art in improving and disseminating prototypes is presented for B 1, DE 1 and NL 2, the 3 teams with pilot farms in the EU network that have at least 3 years of experience in this activity.

Data for at least 3 years of testing is needed to be able to judge whether a team is improving successfully, i.e. the shortfall between achieved and desired results is gradually being made good.

1.1 The third year reviewed

The first two steps of 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 third report was to elaborate the improving part of Step 4, and to present the state of the art up to Step 4 of 7 selected projects on experimental farms, that have at least 3 years data on testing and improving. The 7 selected projects involved 7 IAFS and 4 EAFS prototypes. The theoretical prototypes varied from those with 12 parameters driven by 3 methods (DK 1) to those with 17 parameters driven by 7 methods (I 1). Most of the teams had drawn up various drafts to reach the Parts 3 presented. That was an indication of 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 was already in progress. Nevertheless, most teams succeeded in changing the character of the research to prototyping.

Subsequently, because it is the central method and the first to be designed, MCR was described as Part 4 of the prototype's identity card. The Parts 4 of the 7 IAFS and 4 EAFS prototypes showed that most MCRs provided an insufficient base for Step 4. Only DE 2 succeeded in designing an MCR fulfilling all demands. Most teams had not 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 had 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), and UK 1 and UK 2 (IAFS) had built in high risks, because their MCRs also had too high a share group\(^1\) of phytopathologically related crop species. Except for NL 1 in IAFS, all teams had 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 had 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 were strongly advised to revise MCRs to meet all multifunctional demands and so give their prototype the base needed to achieve an ambitious set of objectives.

From Part 6 of the 11 I/EAFS prototypes it appeared that overall 27 out of 145 parameters had not been tested. So it could be generally concluded that in 1995 80% the theoretical prototypes were laid out, tested and improved. Besides, it appeared that overall desired results had been achieved for 64 out of 145 parameters. So, it could be generally concluded that in 1995 the prototypes were almost halfway through Step 4.

Given that state of the art it could be concluded our new methods of prototyping are manageable and effective. However, since all 7 projects had already been ongoing for 5 years or more, it also had to be concluded that there had still been too little progress. To increase progress in Step 4 various problems and constraints still had to be solved; these are summarised below.

Establishing desired results

Desired results had in many cases not been established in an appropriate way:
- too conformistic, for example PI < 0.7 (equal to or slightly ahead of good agricultural practice) or INRI > 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 (risks of agronomic shortage were included in the lower limit, and risks of environmental excess were included in the upper limit).

It was recommended that desired results be established in a balanced way: ambitious enough to be recognised as a break-through compared to good agricultural practice, but not too ambitious to be achieved in the short (IAFS) or the long term (EAFS) by the farmers.

Establishing achieved results

There were some indications that achieved results were set incorrectly:
- large annual variation in parameters that are in principle stable and only respond slowly 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 largely exceeding the desired result 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 INRI (wrongly accounting for buffer strips that do not buffer any element of the EP?).

It was recommended that achieved results be established in accordance with the agreed definitions of the parameters (Report 1; Chapter 5) and by appropriate methods of sampling, observing and data processing, to prevent overall error from obscuring trends in the achieved results.

Establishing the main cause of shortfall in results

There were some indications that the main causes of incorrectly estimating the shortfall in results were:
- 'slow response' instead of major method, for example PAR or KAR (INM or ENM not working due to inconsistent PAB or KAB) or PSD (INR 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 the state of the art, there are other ways of erroneously establishing main causes of a shortfall in results:
- minor method instead of 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 due to too complicated theoretical prototypes) or with parameters driven by 1 or 2 methods (too few potential causes due to too simple theoretical prototypes).

It was recommended that in principle only one main cause of a shortfall in results be established:
- 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 initial years of testing and is likely in later years for inert parameters such as PAR, KAR and PSD).

Establishing the first criterion not fulfilled by a method

There were some indications that the first criterion of a method that produces a shortfall in results was not identified critically enough:
- The criteria ‘manageable or ‘effective’ were too readily identified as the first not being fulfilled, 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 were new, it was hardly possible to state within a few years whether any of them would be 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 for care in establishing whether a method is insufficiently or not effective, is that this would call for revision of the theoretical prototype by introducing a supporting method or skipping the method in question.

It was recommended that the first criterion not yet fulfilled by a method that is causing a shortfall in results be carefully established:
- either ready for use (which is likely in initial years of testing),
- or manageable for the farmers (which may occur in initial years);
- or acceptable to the farmers (which may also occur in initial years);
- or effective (which may only occur in later years of testing).

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. Nevertheless, their was too little response to be presented in this report.

It was 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.

1.2 Scope of the fourth year

The scope of this fourth year was to elaborate the methodology of Step 5 and to present the state of the art in improving (Step 4) of the pilot projects that have at least 3 years of data.

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

This fourth progress report is laid out as follows.

Improving a prototype is explained and a format is proposed for improving farming methods according to a set of 4 criteria (Chapter 2). Based on this format, the 3 selected projects on pilot farms present the state of the art in improving their prototypes (Step 4) for various parameters of the EU shortlist. The selected projects are:
- Mid Belgium (B l) (Chapter 3);
- Baden-Württemberg (DE 1) (Chapter 4);
- Flevoland (NL 2) (Chapter 5).
Dissemination of a prototype is introduced as the final Step 5 (Chapter 6), and the state of the art in this step is presented for Baden-Württemberg (DE 1)(Chapter 7).

This fourth progress report ends with conclusions and recommendations (Chapter 8), and a list of selected new references.

1.4 Selection of projects in prototyping I/EAFS

Research leaders and their projects have been selected for the workshops and progress report of this fourth year of concerted action on the same sets of general and specific criteria as were used in the third year (see Page 5).

Although the 7 specific criteria are far from ambitious from a professional point of view, of the 8 projects on pilot farms in 1996 -1997, only DE 1, DE 3, DK 2 and NL 2 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).

Table 1. List of European projects in I/EAFS prototyping on pilot farms, ongoing in 1996 -1997

<table>
<thead>
<tr>
<th>Specific criteria (explained in 1.4)</th>
<th>B 1 Mid-Belgium</th>
<th>DE 1 Baden-Württemberg</th>
<th>DE 3 Nordrhein Westfalen</th>
<th>DK 2 National Network</th>
<th>FIN 1 Uusimaa</th>
<th>IRL 1 Southeast and Midwest</th>
<th>NL 2 Flevoland</th>
<th>PL 1 Mazovia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IAFS</td>
<td>4</td>
<td>-</td>
<td>5</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>EAFS</td>
<td>6</td>
<td>4</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>4</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Number of farms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IAFS</td>
<td>10</td>
<td>-</td>
<td>15</td>
<td>10</td>
<td>-</td>
<td>7</td>
<td>-</td>
<td>15</td>
</tr>
<tr>
<td>EAFS</td>
<td>10</td>
<td>7</td>
<td>-</td>
<td>20</td>
<td>-</td>
<td>10</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Project’s main objective</td>
<td>= 1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Prototyping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientist years farm-1</td>
<td>0.1</td>
<td>0.13</td>
<td>0.15</td>
<td>0.13</td>
<td>0.1</td>
<td>0.25</td>
<td>0.2</td>
<td>0.15</td>
</tr>
<tr>
<td>Project full-timers</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Research leader</td>
<td>% time involved</td>
<td>40</td>
<td>100</td>
<td>100</td>
<td>70</td>
<td>100</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>Main activity of leader</td>
<td>Prototyping farming systems</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
General criteria

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

Based on these 3 general criteria, 25 research leaders from ongoing projects or projects in preparation were invited to the workshop held 2-7 July 1996 in Bruchsal (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 are useful, of course, but should be subordinate to prototyping.

(4) Scientist years in prototyping ≥ 1
Prototyping projects on I/EAFS require an input from scientists equivalent to at least 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.
Improving I/EAPS prototypes by carrying out 4 tasks

<table>
<thead>
<tr>
<th>(1) Establishing parameters with shortfalls</th>
<th>(2) Establishing the main cause of any shortfall</th>
<th>(3) Establishing the first criterion not yet fulfilled by any method listed under (2)</th>
<th>(4) Establishing improvements of any method listed under (2), to fulfill the criterion under (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>para- desired achieved relative parameters results results shortfalls</td>
<td>slow major minor response methods methods</td>
<td>ready man accept effect for use age ability worthness ability</td>
<td></td>
</tr>
</tbody>
</table>

1 Tasks 1 - 4 are explained in Sections 2.1 - 2.4
2 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 for 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, fulfill 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 for 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 execution of Tasks 1 - 4 of Step 4B, a format is proposed (format 4B). The tasks are elaborated and the format is explained in Sections 2.1 - 2.4.

2.1 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).
2.2 Establishing the main cause of any shortfall

Task 2 entails establishing whether 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.

2.3 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 criterion is the first that has not been fulfilled:
- either not ready for use;
- or not manageable for the farmers;
- or not acceptable to 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 2.3.1 - 2.3.4.

2.3.1 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.

2.3.2 When is a farming method not manageable?

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

2.3.3 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.

2.3.4 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 before 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.

2.4 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 2.3.1 - 2.3.4 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 3.1  Theoretical EFS prototype (arable farming mixed with cattle husbandry) of Mid-Belgium (B 1)

Figure 3.2  Grazing Index (Gl) of 6 pilot farms in 1996 (mean cm May-September)

Figure 3.3  Milk from Roughage Index (MRI) of 6 pilot farms in 1995-1996
Focus on improving an EMFS prototype in Mid-Belgium (B1)

Research Team: V. Van Bol and A. Peeters

In B1 an EM(mixed)FS prototype was designed, tested and improved from 1994 to 1996 on 7-8 pilot farms. The theoretical prototype has been changed and is presented again (Figure 3.1). This chapter focuses on the state of the art in improving the 4 major methods to achieve desired results in the parameters linked, according to the updated theoretical prototype. The prototype, which is typical for the region of Mid-Belgium with loamy soils, involves mixed farming with milk, meat, potato and wheat as main products for the market.

In Mid-Belgium, the major 10 objectives as quantified in 14 parameters are achieved by 5 multi-objective farming methods, designed and made ready for use as follows:

1. Multifunctional Grassland Management (MGM) is the major farming method for achieving the desired Quality and Production Index (QPI) for animals and grasslands. This is also a supporting farming method for Total Labour Income (TLI), Milk from Roughage Index (MRI>3000 l/year cow) and Grazing Index (GI).

2. Multifunctional Crop Rotation (MCR) is the major farming method for achieving desired results in quality production of plants without using pesticides, TLI, N Available soil Reserve (NAR) and Rotation Health Index (RHI). In addition, it is a supporting farming method to PKN Balances and Reserves.

3. Ecological Nutrient Management (ENM) is the major farming method for achieving desired results in PK Annual Balances, PK Available Reserves, and NAR. In addition, it is a supporting farming method to QPI.

4. Ecological Infrastructure Management (EIM) is the major farming method for achieving desired results in an Ecological Infrastructure Index (EII) oriented to promote a regionally adapted Plant Species Distribution (PSDN). In addition, it is a supporting farming method to a general biodiversity useful for QPI (label of biodiversity).

5. Farm Structure Optimisation (FSO) is the major farming method for achieving the desired results in TLI, QPI and for continuously adaptation of the EFS variant to socio-economic conditions. In addition, FSO should be used to redesign the farm structure (herd size, cattle-housing, agriculture area, etc.) when it strongly influences the failure of the other farming methods.

3.1 Multifunctional Grassland Management (MGM)

The Grazing Index (GI) is a basic parameter of MGM. It is the mean deviation (cm) of observed and ideal sward height per month or per entire grazing season. In contrast with 1995, in 1996 the pilot group exceeded the maximum norm for GI (Figure 3.2). Only Farm 6 achieved the desired result. The manageability of MGM during the very dry summer of 1996 was the main cause of the shortfall between achieved and desired result. The slow regrowth of grass was insufficiently compensated by inserting new paddocks into the grazing rotation. It was primarily the fear of shortage of winter forage that made farmers preserve too much grassland for mowing. As a result overgrazing occurred, with adverse effects on grass regrowth over the whole season. To prevent this from happening again, farmers want to save more silage (single ball silage) for when there is not enough grass for grazing of dairy cows in lactation. The alternative is to decrease the number of cows whilst increasing the productivity per cow, in order to maintain milk output.

A second parameter is the Milk from Roughage Index (MRI) with a provisional minimum norm of 3,000 l milk/cow-year (4 % fat). Figure 3.3 shows that 4 out of 6 farms achieve the norm. Farms 2 and 8 have a very low MRI, which is caused by either excessive use of additional feeding or insufficient MGM. On Farm 2 the first cause prevails.
The desired result in the third parameter, $QPI_{milk}$, has (almost) been achieved by all 4 farms tested (Figure 3.4). This means that these farms produce milk equal in quality to conventional farms.

Only 2 out of 4 farms achieved the desired $QPI_{meat}$ (Figure 3.5). The shortfalls of Farms 5 and 8 are mainly caused by high animal mortality. On average, 20% of animal production was lost, against only 15% in conventional farms. The main cause of animal mortality on Farm 5 is too little space per animal in barns. On Farm 8, five cows died of bloat after grazing a rye-grass + red clover grassland meant for mowing. The too small area for grazing has been caused by an increase in the area put to cash crops. For both farms, these problems could be solved by Farm Structure Optimisation (FSO).
Total Labour Income (TLI) is the ultimate parameter to test the effectiveness of MGM. In 1996, 3 out of 4 farms achieved the desired norm (Figure 3.6). Only four farms were tested because the others did not have a complete book-keeping. Nevertheless, the TLI of the pilot farms in 1996 is generally higher than the conventional reference in the region. The differences between TLI/ha and TLI/labour unit of Farm 6 are caused by its relatively small size (30 ha) and high labour intensity (2.5 labour units). Farm 9 is relatively large (73 ha) and is labour extensive (2 labour units).

On average, desired results in GI, MRI, QPI\textsubscript{milk}, QPI\textsubscript{meat}, and TLI have been achieved except for GI. To achieve the desired GI, too, MGM should be improved in management, which may further improve the other parameters. As well as MGM, appropriate choice of animal and plant varieties and care for animal health can also influence these 6 parameters. Therefore it is considered to include these in MGM.

### 3.2 Multifunctional Crop Rotation (MCR)

Most farm incomes are not or only partly based on cash crop production. So MCR is only a minor method for TLI. The major parameter linked to MCR is the Rotation Health Index (RHI): the proportion of cereal stem bases free of soil-borne diseases. From the very beginning it has remained far below the norm (Figure 3.7), mainly due to too high a share of winter cereals in the rotation, thus provoking soil-borne diseases. Some farms have reduced the share of cereals, but RHI will probably respond very slowly. In 1996 only Farm 9 achieved the desired result, because it only had spring cereals in the MCR.

No QPI could be established for the cash crops potato and winter wheat, because these products are sold at the farm-gate. Consequently, a top-quality ('Organic') price was not available for these products.
3.3 Ecological Nutrient Management (ENM)

ENM is the major method for achieving desired results in PKN parameters.

![Figure 3.8 Phosphorus Available Reserve (PAR) of 7 pilot farms in 1996](image)

![Figure 3.9 Phosphorus Annual Balance (PAB) of 6 pilot farms in 1996](image)

P Annual Balance (PAB) is the parameter for appropriate management of ENM of the P Available Reserves (PAR), a major parameter for soil fertility and environmental impact in the long term. The pilot farms differ widely in PAR: Farm 5 is below the desired range; Farms 8, 7 and 6 are within the range; and Farms 3, 2 and 9 are beyond it (Figure 3.8). The average of the pilot group is decreasing and is now in the desirable range. This is partly the result of a strong decrease in PAB (Figure 3.9). However, P fixation has probably occurred too, considering a decrease of PAR of 1 mg/100 g of dried soil in three years.

![Figure 3.10 Potassium Available Reserve (KAR) of 7 pilot farms in 1996](image)
There has also been a considerable decrease in KAR (Figure 3.10), which cannot be explained by the slight decrease in KAB (Figure 3.11). Is it the result of fixation and or leaching? A follow-up should give the answer.

NAR per farm doubled in 1996, compared to 1994 and 1995, though it has remained within the provisional norm, which is derived from the EU norm for drinking water (Figure 3.12). The higher NARs are still found on the same farms as before. The relatively high NAR for 1996 is probably mainly due to an extremely dry summer with low yields and a consequent low nutrient uptake from the soil.

NAR per crop in 1996 is in line with those of previous years (Figure 3.13). The main risk crop for N leaching is still potato; set-aside and mown grassland are less risky. In 1996, NAR of grazed grassland exceeded the provisional norm, but standard deviation was very high.
3.4 Ecological Infrastructure Management (EIM)

Figure 3.14 Ecological Infrastructure Index (Ell) of the 7 pilot farms in 1996

Ell has not improved since 1994 (Figure 3.14). A small part of the El includes road verges, riversides, etc., from adjacent properties. In some cases these areas are managed as EI by the farmer in agreement with the official owner (city council, river authority, railroad company, etc.), so the current Ell represents the maximum area farmers wanted to manage for a financial support of 23 000 BF/ha (simulation of an EI financial compensation).

Figure 3.15 Plant Species Distribution (PSDN) on the 7 pilot farms in 1996

PSDN (Figure 3.15) is evaluated by the Shannon-Wiener index. When only dicot species were counted, on average 18 species were found in the EI. This is 5 less than in 1995, probably due to the vanishing of annual species. The increase of the Shannon-Wiener index is caused by a better distribution of the surviving species, due to less dominance of nitrophilous species in the vegetation.

3.4 State of the art

After 3 years of testing and improving, 3 parameters still have a large shortfall between achieved and desired result (Figure 3.16). The major shortfall is in RHI. MCR is the major method to improve, first of all in acceptability. More farmers need to be convinced of the need to grow less winter cereals, thus preventing soil-borne diseases. The problem is that the response of Rl and subsequently that of QPI will be slow. The second shortfall is in Ell. Again, acceptability of the major method (EIM) should first be improved probably by offering more financial compensation. The third shortfall is in CI. The manageability of the major responsible method, MGM, should first of all be improved in this case in relation to cattle housing, herd size, paddock design, etc. Since the various P, K and N parameters show little or no shortfalls, it can be concluded ENM is now effective, acceptable and manageable. Finally, the right-hand circle shows a large variation per parameter in performance per farm. So, whilst the general prototype seems on average almost finalised, the single variants of the prototype per farm are still far from all-round.
Figure 3.16 State of the art in prototyping EMFS in Mid-Belgium (B 1), 1994-1996
a. Average per farm

b. Percentage of farms

Relative shortfall of achieved (a) to desired (d) results per farm:

\[ \text{relative shortfall} = \frac{a - d}{d} \]

- **1997 remaining**

<table>
<thead>
<tr>
<th><strong>Parameters</strong></th>
<th><strong>Desired results</strong> (per farm)</th>
<th><strong>Achieved results</strong> (per farm)</th>
<th><strong>Main causes of shortfall in 1996</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Relative shortfall</strong> of achieved (a) to desired (d) results per farm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Relative shortfall</strong> = (a-d)/d</td>
<td></td>
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</tr>
</tbody>
</table>

**Figure 4.1** State of the art in 1996 of IAFS pilot project Baden-Württemberg (DE 1)
4 Focus on improving an IAFS prototype in Baden-Württemberg
(DE 1)

A. El Titi

To control severe erosion and improve farm income, in 1988 17 farmers, together managing some
1200 ha of arable land in the Bruchsal region (Baden-Württemberg /Germany), founded the AKIL
pilot-farm group, encouraged by the progress of the IAFS prototype on our experimental farm at
Lautenbach (Report 1). In interaction with this IAFS pilot group, we started a project to design
variants of the Lautenbach IAFS-prototype for their specific farm conditions. Currently AKIL includes
more than 50 farms with a total of 5000 ha arable land. A considerable number of newcomers are
still converting and adapting to IAFS. Consequently, data of these farms are not yet available.
Therefore, this report focuses on the first 15 member farms of the AKIL group. Book-keeping data,
as well as various measurements and observations, of at least 10 farms served as a data-base for
assessing the state of the art.

4.1 State of the art

Continuous testing and improving of the prototype variants from 1990 to 1996 led to most
promising results that have had significant impact in and outside the region (Figure 4.1). The
desired results in all 13 parameters have, on average, been achieved, except for KAR, PAR and PI
(left-hand circle). However, in the case of the latter 3 parameters and PAB, EII and PSD, the
percentage of farms achieving the desired result is still too low (right-hand circle). How these
results have been achieved and can be improved will be discussed per parameter, (in order of
increasing shortfall between achieved and desired results) in the remainder of this section.

NS
The financial Net Surplus (NS) of all member farms is positive, though with considerable variations
among farms and among gross margins of crops. Overall surpluses at farm and crop levels are
rather low, despite state subsidies, especially payment per unit of area cropped and payment for
water protection.

QPI
The quality criteria for both wheat and sugar-beet are fixed by contracts between farmers, millers
and sugar companies. Product qualities exceeding the contract standards are usually rewarded
with a premium. On average, 80% of winter wheat and 70% of spring wheat meet the quality
needed to be awarded a premium. Some farmers produced wheat for fattening bulls on their farm,
so they did not obtain any price premium. Crude protein higher than that achieved by the pilot
farms is only possible by supplying more N before ear emergence. But this is likely to cause an
increase in the residual soil nitrogen and consequently in NO3\(^{-}\) leaching. This relates to the usually
low rainfall of the region during the maturing of wheat, which limits N uptake by the crop. The
price premiums for high crude protein are the main reason to farmers to apply too much nitrogen
in wheat. As long as milling enterprises continue not to define a minimum crude protein content
that can be combined with an acceptable risk of N leaching, farmers will keep trying to achieve the
highest grain protein value, irrespective of N leaching.

MSC
Although non-inversion tillage is commonly accepted among the pilot farms, in some cases
cropping is hardly possible without ploughing, for example if potato and cichory are grown on
compacted sandy soils. Therefore, the desired result in Minimum Soil Cultivation (MSC) has been
fixed at >80% of the cultivated area, leaving some space for exceptional ploughing.

SCI
The Soil Cover Index (SCI) is closely linked to two major methods: Multifunctional Crop Rotation
(MCR) and Minimum Soil Cultivation (MSC), with a significant role for green manure crops. AKIL
farms have successfully adopted adequate combinations of these two methods. However, sometimes a farm has some fields on sand or another soil on which the choice of crop is restricted. In such exceptional cases, a part of the farm, usually not more than 20% of the total area, may be left fallow for one or two months. Further improvements in achieved results are hardly possible, because of natural limitations and lack of a market for crops for which a higher soil cover is possible.

EEP water
In removing all leachable pesticides from the list of compounds allowed for IAFS use, AKIL farms reduced the exposure of groundwater to pesticides to zero. This restriction in pesticide use is a part of IAFS Guidelines of the AKIL group, so the desired results have been achieved completely.

NAR
The N Available Reserves (NAR) - measured between 15 October and 15 November - is officially used to assess the NO₃ leaching risk to groundwater. AKIL farmers had been using this parameter as a IAFS guidance tool long before legal directives for water conservation zones were put into action. The results show that all farms manage to maintain NO₃-N at desired levels. This is true for all crops except potato, and, in few cases, oilseed rape. These risky crops are found in no more than 5% of farms.

PSD
Plant Species Diversity (PSD) is linked to the number of wild native species occurring on a farm. So, to enhance PSD is to increase the number of species within the existing vegetational communities, mostly by introduction or re-establishment of lost species. However, this will only succeed if the habitat requirements of the 'new' species are met, e.g. low nutrient reserves to be able to compete with fast growing species. Since measures to increase the number of species are unlikely to achieve the desired results in time, the German team decided to focus on new habitats for endangered or extinct plant species of the region. Therefore PSD was limited to endangered or expired wild plant species to indicate improvements of nature habitat due to IAFS. The official (legal) Red Lists were used as a reference for endangered or extinct species of the Bruchsal region. The desired result is to re-establish more than one species of endangered or extinct flora. Due to huge labour demands, we have only monitored 7 of the 15 pilot farms. Depending on farm location, soil properties, topography, etc., 2 to 8 endangered or extinct plant species were recorded on fields and field margins. The percentage of farms achieving desired results (right-hand circle, Figure 4.1) can hardly be improved since essential habitats cannot be created on some farms.

Ell
The Ecological Infrastructure Index (Ell), i.e. the proportion of farm land managed as natural habitat, lineal corridors or flowering field margins, still falls short on some farms. Despite supporting national programmes, IAFS farming guidelines and the farmer's ambition to consider Ell, at least 30% of the AKIL farmers are still facing constraints. The main one is the legal basis for renting land in Germany. Most of the farmland operated by AKIL farmers is rented on time-limited tenancy. Long lasting ecological infrastructures implies less cropping area to be paid for, yet most of the owners (e.g. banks) will not accept this. In addition, inheritance over many generations has left the land divided in small land lots or fields, mostly widely scattered. This limits planting hedgerows and other elements of Ell. Some farmers are reluctant to include Ell now because of landscape protection laws, which may forbid future adaptation or removal. As a result, improving Ell among the AKIL group, in particular among the newcomers, demands an IAFS-based legal framework for ecological infrastructures on farmland. Farmers should be able to know the consequences of their decisions. If cross-compliance would be introduced in the EU (agenda 2000), the Ell could be an element, too.

PAR/PAB/KAR and KAB
For these parameters the desired results can be considered as achieved, although shortfalls are apparent in the proportion of farms that has achieved PAB targets. That shortfall is mainly caused by P fixing soils on some farms. To compensate, farmers put more P in than is output. To improve this, MCR should include crop species of high P-resolving potential that are based on a large root system or symbiosis with mycorrhizal, such as legumes and cereals. In addition, management of
soil physical structure should improve. A better timing of P and K supply (INM) to match more precisely the crop uptake pattern should also help to reduce fixation and compensate for input. Only 10% of the farms are facing K fixation in clay and silty-clays soils.

**PI**
The Pesticides Index (PI) relates the IAFS pesticide input to the average pesticide input of conventional farms of comparable size and crops. Initially, conventional plots were included on three of the pilot farms. Since AKIL is expanding and traditional intensive farmers are adopting more and more IAFS technology, the reference input of pesticides for conventional farming is changing (Table 4.1).

**Table 4.1** Average pesticide input (kg active ingredients ha⁻¹ year⁻¹) in conventional farms 1991 - 1994

<table>
<thead>
<tr>
<th>Herbicides</th>
<th>Fungicides</th>
<th>Insecticides</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2</td>
<td>0.95</td>
<td>0.30</td>
<td>3.45</td>
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Reduction of PI in IAFS to one third of conventional is the 'desired result'. This has been achieved by only some farms, so there is a clear shortfall. To assess the cause and find ways of improving, we should look at pesticide inputs in detail. In contrast to insecticides and fungicides, reduction of herbicide input below the maximum norm (0.3 of the conventional) was not feasible. The PI for herbicides of the 15 AKIL farms varied between 0.2 and 0.7. The farm with the PI = 0.2 had contracted to apply no pesticides at all on winter wheat and winter rye, and it could also replace herbicides in maize, peas and spring barley by mechanical control. However, the majority of the other farms failed to reduce herbicides to more than one third of the conventional level. The following causes should be mentioned:

- As a result of including non-inversion tillage in MSC, weeds emerge in high densities, challenging farmers to react rapidly and effectively, with herbicides still as the best choice;
- Farmers are very much afraid of building up seed banks in the soil. The ideal of clean fields is related to this vision; this can best be achieved by herbicides;
- At present there are no cost-effective, non-chemical methods that can replace herbicides. Harrowing cannot compete with herbicides in effectiveness. Flaming techniques are still underdeveloped to fit into modern agricultural production concepts;
- Lack of weed control methods to fit the narrow drilling rows of mown crops, e.g. cereals;
- Lack of labour for weeding by hand. Insofar that labour is available, its high cost cannot compete with that of herbicides.

These constraints make improvement of PI a real research challenge. It requires a strongly innovative approach. Various ways are being explored in the Bruchsal region:

- Limiting the herbicides treated area
  Single fields, field sections, spotwise treatment, band sprayings, etc., are well-known methods to reduce herbicide input. In contrast with crops at a wide row distance (e.g. sugar-beet, maize, etc.), these options are not available to the same extent for densely sown crops. Demonstrations on pilot farms are still going on. They may help improve the PI of local farms.

- Integration of mechanical and chemical control
  The integration of low-dose herbicides and mechanical weeding (e.g. harrowing) is most promising for further reducing herbicides use. In both indoor and field experiments, low-dose herbicide applications gave encouraging results and appeared to be a key component in IAFS weed control after non-inversion soil tillage. A number of herbicides provided sufficient weed control at doses far below recommended rates. Thus a significant reduction of herbicide input and PI can be achieved on a most cost-effective basis. The expected effects of low-dose herbicide can be augmented by spring harrowing for sufficient control of, for example, cleavers (Galium aparine). Harrowing seems to increase vulnerability of weed seedlings, so low herbicide doses may be sufficiently lethal. These results must always be validated under regional circumstances.
Threshold control strategy
Weed control may be decided annually according to predicted yield losses (economic threshold). Though this is useful, it brings with it the risk of inappropriate timing or insufficient effect of weed control measures. Some weed species are easier and cheaper to control in some crops than in others. The control of thistles (*Cirsium arvense*) in cereals, for example, is far more cheaper and effective than in sugar-beet. Using thresholds at the level of crop rotation is likely to improve both timing and efficiency. By spot-wise abandoning mechanical weed control at pre-sowing or post-harvest stages, 'windows' on weed pressure are created to judge ways and timing of weed control. This option is still in an experimental stage.

Focus on control of surviving weeds
Minimum Soil Cultivation (MSC) usually changes the soil as a biotope. Under non-inversion tillage, soil layers maintain their natural position, with the highest seed density remaining at the top. Weed seeds present are likely to germinate in due course, which favours control of weeds. The more effective the control, the less weed plants will fill the soil seed bank again. Up till now, mechanical weed control in IAFS has not been effective enough to prevent weeds from refilling the seed bank. Controlling weeds at early stages of crop growth, either mechanically or in combination with low-dose herbicides and hindering seed setting by surviving weeds would be more effective for IAFS. However, harrowing or hoeing during advanced crop stages is commonly considered risky and damaging, especially for dense crops, due to lack of appropriate implements. In addition, the row space in cereal crops (11 cm) heavily obstructs any hoeing efforts using traditional hoes, because of crop damage and labour costs. To overcome these constraints, a new hoeing concept has been thought out, prototype machines built and evaluations carried out in winter wheat under both experimental and practical conditions. A prerequisite for this approach was drilling cereals in double rows (22 cm) or in enlarged row spaces (> 17 cm). Results show a significant reduction of surviving weed populations, e.g., an average reduction of 50% after a single pass for cleavers. Testing and improving this ICP method within the AKIL group is essential, if farmers are to purchase and use this machine for themselves.
Relative shortfall of achieved (a) to desired (d) results per farm:

\[ \text{relative shortfall} = \frac{(a-d)}{d} \]

1992 «» 1997
- Decreased
- Increased
- Remained

### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Desired results (per farm)</th>
<th>% farms</th>
<th>Achieved result (per farm)</th>
<th>% farms</th>
<th>Desired results in 1997</th>
<th>% farms</th>
<th>Methods last of all to be improved in:</th>
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<td>90</td>
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<td>50.30</td>
<td>90</td>
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<td>25.33</td>
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<td>75.75</td>
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<td>90</td>
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<td>90</td>
<td>40</td>
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<td>1.21</td>
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<td>10</td>
<td></td>
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<td>90</td>
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<td>90</td>
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<td>1.21</td>
<td>90</td>
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</tr>
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</table>

Methods first of all to be improved:
- Readability
- Acceptability
- Manageability
- Effectiveness

* Biological control of non MCR sensitive diseases
* Various measures against non MCR sensitive weeds

### Figure 5.1

State of the art in prototyping EAFS in Flevoland (NL 2), 1992 - 1997

(Part 6 of the prototype's identity card). The prototype is all-round if achieved results match the desired results.
5  Focus on improving an EAFS prototype in Flevoland (NL 2)

Research Team: P. Vereijken, R. Visser and H. Kloen

The entire way of designing, testing, improving and disseminating the EAFS prototype is being covered (Steps 1-5) in the pilot project Flevoland (NL 2), in which our team is cooperating with 10 pilot farms.

5.1 Progress 1992-1997

Some parameters have been changed in the theoretical prototype (Report 2, page 31). Soil Cover Index (SCI) has been abandoned as less relevant for the flat and heavy soil of the region. This soil type is not sensitive to erosion, but rather to compaction. To reduce the risk of that, we have proposed a Soil compaction Risk Index (SRI), but most pilot farms are unwilling to accept earlier harvest schemes for late crops, to reduce the risk for harvesting under wet conditions and thus compaction. They are not convinced that the loss in yield is sufficiently made good by the higher quality production of subsequent crops. Bird Species Diversity (BSD) has been abandoned because of lack of labour. N Available Reserves (NAR) and N in Drainage Water (NDW) have been given more appropriate names: Potential N Leaching (PNL) and Actual N Leaching (ANL). Ecological Infrastructure Management (EIM) and Ecological Infrastructure Index (EII) have also been given more appropriate names: Infrastructure for Nature and Recreation (INR) and Infrastructure for Nature and Recreation Index (INRI). Finally, two new local parameters have been inserted: Relative Area according to MCR (RAM) and Side Elements Diversity (SED).

In 1992, the EAFS prototype was laid out and tested for the first time. Since then, the prototype has been through another 5 cycles of testing and improving. As a result, average shortfalls per farm between achieved and desired results have been made good in INRI, ANL, PSD, almost in QPI of onion, PAB, SED, RAM, PSDN and FDI (Figure 5.1, left-hand circle). However, average shortfalls in QPI of potato and carrot and HHW have largely remained and shortfalls have even increased in PNL, KAB and KAR. In most parameters there is a large variation in performance per farm, which is hidden by the average presented in the left-hand circle. It can be seen, however, in the right-hand circle, which presents shortfalls if in any parameter less than 9 out of 10 farms have achieved the desired result. The left-hand circle presents the state of the art for those interested in the average performance of the prototype at the regional level, accepting underperforming farms are compensated by overperforming farms. The right-hand circle presents the state of the art for those interested in the performance of the prototype at the farm level, considering its variation in manageability, acceptability and effectiveness in the context of the region. How the state of the art can be improved, both for the region and for single farms, will be highlighted for each of the 4 methods, as established in the theoretical prototype.
5.2 Multifunctional Crop Rotation (MCR)

The ten pilot farms are located in the central clay area, where conditions are favorable for high-yielding lifted crops, notably potato, onion and carrot. Mown crops, such as cereals and pulses, yield less but they are indispensable to sustaining soil fertility for the high-yielding lifted crops. Consequently, an MCR has been designed with three blocks of lifted crops and three blocks of mown crops, alternating in time and space (Report 2, Page 41; Report 1, Page 72).

Acceptability and manageability of MCR

For each farm, MCR has been elaborated in a variant, meeting the demands of soil, farmer and market. However, the market is changeable and limited for many products, so the implementation of the blocks by crops needs annual adjustment on each farm. Even so, farms have learned to manage their MCR variants, witnessed by the gradual increase of the Relative Area in line with MCR (RAM) (Figure 5.2). Some farms are still not alternating green manure crops enough. As a result, they exceed the maximum of 0.33 for crop groups such as legumes (by red or white clover) and crucifers/chenopodes (by yellow mustard). Note that we only started accounting for green manures (as half a main crop) in 1996, after becoming alarmed by the increase of Sclerotinia sclerotiorum, a polyphagous soil fungus, that is strongly enhanced by legumes. Another deviation of MCR is that in some farms rotational spacing is insufficient, so crops are moved to an adjacent field, offering pests and diseases the opportunity to follow their favorite crop. On one farm this was inevitable, because of its shape. In general, the limitations set by MCR are accepted, since farmers recognise they ensure long-term soil fertility and thus the vitality and quality production of crops.

Figure 5.2 Multifunctional Crop Rotation (MCR) in its variants on the 10 pilot farms tested in 1997.
**Effectiveness of MCR**

First of all the slowness with which MCR affects soil fertility should be pointed out. It takes six years for any field to complete the cycle of rotation! So, effectiveness may only appear from gradual improvement of the Quality Production Indices (QPI) of crops and gradual decrease of Hours of Hand Weeding (HHW). However, both parameters are also sensitive to the improvement of cropping systems and management. Therefore at annual testing of QPI per crop, losses at harvest, sorting and marketing are specified according to their main causes. Subsequently, recommendations are drafted for targeted improvement of MCR, cropping systems and management.

**QPI and QPI-corrected yield as first parameter**

At current quality demands, the QPIs of 5 out of 9 major crops, averaged over the 10 pilot farms, fall short of the desired (innovation norm) QPI (Figure 5.3a). Besides, in all 9 crops the QPI-corrected yields do not tend to increase through the years (Figure 5.3b-c), which would be desirable because the 30-50 % lower yields compared to conventional farms bring considerably higher prices for consumers (less accessible food supply!). However, there are large differences between farms, as is illustrated in carrot, the crop performing least (Figure 5.4). In 1995 and 1996 some farms lost a large part of the yield, and even their entire yield because of infestation by *Alternaria caricina*, a seed-borne and airborne fungus insensitive to MCR. Consequently, this fungus is the main cause of the insufficient average OPI in carrot (Figure 5.4b). Similarly, the seed- and soil-borne, polyphagous fungus *Rhizoctonia solani* is a major cause of insufficient QPI in seed and ware potato. In ware potato, the airborne fungus *Phytophtora infestans* is the major cause of the low on-field yield, due to premature defoliation of the crop.

How can QPI of various crops be improved? From the foregoing, it must be concluded that for more effective quality production MCR needs support through better cropping systems and better management. In carrot, *Alternaria caricina* could be controlled by coating the seed and possibly spraying the crop with antagonists, something currently being studied by colleagues from CPRO-DLO and IPO-DLO. In addition, farmers could improve their soil management to reduce rejection of carrots malformed by soil degradation, the second cause of the low QPI of carrot (Figure 5.4c). In potato, *Rhizoctonia solani* is insufficiently controlled by the use of clean seed tubers. This fungus is polyphagous and can as sclerotia survive longer than the 6 years of the rotation. To control the sclerotia, the harvest residues of the crop could be sprayed with the antagonist *Verticillium biguttatum*, something currently being studied by colleagues from IPO-DLO. The most noxious fungus, *Phytophtora infestans*, could be controlled by better management, thus improving the vitality of the crop by more care for soil structure and N dosage and by intensively monitoring the crop to remove the first plants infested in order to slow down the spread of the disease. In addition, natural fungicides could help suppress the fungus; we are currently studying etheric oils from citrus pits for this purpose. Nevertheless, more resistant varieties should be bred too, since current varieties are highly vulnerable.
a. HHW by farm and share of crop groups (hours)

b. Area (ha) by farm and distribution over crop groups

c. HHW per hectare by farm

d. HHW per hectare of group A crops by farm (hours/ha)

Figure 5.5 Hours of Hand Weeding (HHW) in weed control at the 10 pilot farms in 1997, including averages 1992-1997.
Hours of Hand Weeding as second parameter

The strict alternation of mown and lifted crops in MCR has also been designed to combine optimally competition of crops (for light, nutrients and water) and mechanical weed control. Thus MCR can reduce the large amount of manual labour needed from within and outside the farm, which is typically a major impediment for the dissemination of EAFS. Therefore the effectiveness of MCR is also tested by the need for weeding by hand, as expressed in Hours of Hand Weeding (HHW).

In 1997, HHW varied from 500-2400 per farm (Figure 5.5a). So to date, only 1 of the 10 pilot farms has achieved the desired result HHW < 500, i.e. no dependency on manual labour from outside the farm. The large variation in HHW per farm remains, after correction for the variation in farm size (Figure 5.5b-c). HHW requires 1 - 4.8 manual labourers at least (500 HHW per weeder during the weeding period of 4 months). The need for weeding by hand may increase up to double these amounts because of wet weather and soil. It means that farmers who also weed themselves need at least 0 - 3.8 manual weeder from outside, and at a maximum 1 - 7.6 from outside. Most of HHW (75% on average) is accounted for by scarcely competitive crops (onion, carrot, beet and chicory).

HHW per ha in these crops (Group A) varies strongly between farms (Figure 5.5d) and seems to be the main cause of variation in HHW per farm. This variation can be caused by variation in weed pressure and/or the persistence and capability of the farmer and his weeder. Weed pressure depends on soil type and soil history. But if MCR is effective, weed pressure should, on average, be decreasing and so be reflected in decreasing HHW. Figure 5.5 shows, to the contrary, that from 1992 to 1997 HHW per farm increased, because of increase in the area of Crop Group A. However, HHW per ha of Crop Group A has hardly changed (Figure 5.5d). As a result, the organisation and implementation of hand weeding remains a serious problem.
How can high HHW be reduced? From the foregoing it must be concluded that to be more effective MCR needs support through better cropping systems and better management, similarly to the case of quality production. A radical improvement would be to replace crops with a weak combination of competitiveness and mechanical weed control by crops with a strong combination. From Figure 5.6 it appears that the following replacements would help to reduce HHW considerably:

- bean (for canning) instead of pea (for canning);
- maize instead of wheat;
- white cabbage (or celeriac) instead of potato.

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**Figure 5.6** Hours of Hand Weeding (HHW) and multiplication of annual and perennial weeds per crop (standard deviation based on 4 farms, at least) in 1995.
Less radical steps would be to improve cropping systems and management by stale seed beds, greater distance between rows to enable better mechanical weed control, etc. The management of Farm 8 is a good example. On this farm weeds have been monitored intensively for more than 10 years to minimise weed pressure by picking any weed before seed setting and thus exhausting the seed bank. The fact that this farm is the only one that has achieved the desired result in HHW to date proves such a management strategy, requiring large labour inputs in initial years, can be successful in the long term (Figure 5.5). Finally, biological control of the dominant weed species *Stellaria media* (chick weed) will be studied. From Figure 5.7 it appears that this weed is by far the most successful in achieving the stage of seed production, because it can germinate at almost any time of the year and produce seeds after a few weeks. As a result its control requires almost half of the average HHW of the 10 pilot farms (Figure 5.8).

**Figure 5.7** Most frequent annual and perennial weed species in 1995 (average of the 10 pilot farms).

**Figure 5.8** Hours of Hand Weeding (HHW) per pilot farm in 1997 spent on *Stellaria media* and remaining weed species.
5.3 Ecological Nutrient Management (ENM)

ENM has been designed to tune input of nutrients to their output in such a way that soil reserves fit in a range which is agronomically desired and ecologically acceptable. ENM is much more complicated than INM, i.e. the nutrient management for IAFS, in which single nutrients can be applied (inorganic fertilizers). In ENM nutrients are applied in combinations (organic fertilizers) that rarely meet the need of single crops. Consequently, it may easily lead to shortage of some nutrients and excess of others, to the detriment of production and the environment. To prevent this, we have designed an ENM comprising 5 steps:

1) Estimating P and K need per field, based on the average output by harvest products and on remaining soil reserves (assuming crops do not need a specific dosage of P and K);
2) Estimating the N need per crop based on the foreseen uptake and remaining soil reserves at harvest (assuming crops do need a specific dosage of N);
3) Estimating the part of the N need to be covered by manure (i.e. estimating the N input by crop residues, green manure and organic matter);
4) Estimating the need of manure or a combination of manures, covering both P, K and N needs;
5) Partitioning the manure to fields based on the N need per crop whilst ensuring:
   - P need per field is also sufficiently covered by planning at Step 1 the proportion of legumes in the cropping plan according to P reserves in such a way that at high P reserves there is little need of manure for both P and N, and that at low P reserves there is a great need of manure for both P and N;
   - K need per field is also covered by supplying K as a single fertilizer (as natural salt or vinasse), if needed.

Acceptability and manageability of ENM

P and K Annual Balances (P/KAB) are the parameters to test acceptability and manageability of ENM. The pilot farms differ in innovation norms (desired results) for P/KAB (Figure 5.9a). Farms 12 and 9 have high PAB as a norm, since their P Available Reserves (PAR) are below the desired range. Farms 4, 5 and 1 have low PAB as a norm, since their PARs exceed the desired range. However, Farms 5 and 1 exceed the norm amply as they do not restrict manure application, because they want to cover their N need. ENM is difficult to manage for these farms, because the fields with excessive PAR cannot be cropped with legumes to cover the N need after abandoning manure. The complication is that these very fields are infested by polyphagous eelworms which would be favoured by legumes. The alternative is application of liquid manure in spring, with a high fraction of available N, though Farms 5 and 1 do not accept liquid manure as main N source. Figure 5.9a shows that Farms 11 and 6 also exceed the innovation norm of PAB. If this remains an incident, it will not influence PAR on the long term.
The pilot farms differ little in KAB (Figure 5.9b). Most farms have low KAB as a norm, because their KAR exceeds the norm, usually considerably. The average KABs show a trend of excessive K input, which could lead to increasing K content of soil and shallow waters, thus reducing the prospects for drinking water production. However, most farms can prevent this by reducing K input as cattle manure, because they already apply too much P. Farms 12 and 9 should rather replace cattle manure with its low P/K rate by chicken or pig manure, which has a high P/K rate.

In the Netherlands, the 10 pilot farms are quite unique since their means P/KABs are nearly 1. Nevertheless, the overall tendency to exceed the norms indicates limited acceptance by farmers, based on their fear of N shortage. The N parameters show whether this fear is justified or not.

**Effectiveness of ENM**

Effectiveness in care of soil fertility is tested by Cover of N Need per crop (CNN) and by P/K Available Reserves (P/KAR). Effectiveness in care of the environment is tested by Potential N Leaching (PNL) and Actual N Leaching (ANL).

**Cover of N Need (CNN)**

A top 5 has been drafted for QPI corrected yields for each main crop on pilot farms during 1993-1996 that meet the PNL norm of $<70$ kg/ha N in the soil layer 0-100 cm at start of leaching period. From this, a range of N need has been derived corresponding to the highest and lowest sum of N uptake and N residue at harvest within the top 5. Subsequently, it was assessed per crop which fields in 1993-1996 were below, within or beyond the range of N need. It appears that in most crops the N need was met on less than half the fields. In onion and carrot, there were many overfertilized fields; in cereals there were many under-fertilized fields. So, except for cereals, the fear of shortage of N supply is not justified.
P/K Available Reserves (P/KAR)

Since 1992-1997 mean PAR of the pilot farms has decreased 5 units, though PAB was 1.1 in that period (Figure 5.10a). So, notwithstanding some net input, available P has been immobilised, in the same period, mean KAR increased 6 units. Normally, it takes 100 kg/ha K₂O to increase KAR by 1 unit. Since mean KAB was 1.1 during this period, equivalent to 15 kg/ha K₂O net input per annum, increase in KAR can only be explained by mobilisation of K from the solid reserves. As a result, the pilot farms should greatly reduce their KAB to control KAR. The best solution would be to change from applying cattle manure, with a low P/K rate, to applying poultry or pig manure, which has a high P/K rate. However, such manure is not available from acceptable husbandry systems that conform EU guidelines for the organic label. Consequently, the pilot farms should just await the evolution of KAR, while in the meantime we will carefully monitor K leaching, which up until now has not been related to KAR. The latter suggests that it would be ecologically acceptable to raise the upper limit of the desired range of KAR.

a. P Available Reserves (PAR = Pw-count)

b. K Available Reserves (KAR = K-count)

Figure 5.10 P and K Available Reserves (P/KAR) of the 10 pilot farms in 1992 and 1997 (farms ranked according to increasing reserves). Farm 12 is quite different from the rest and has only been participating since 1995, therefore it is excluded from the averages.
Potential N Leaching (PNL) and Actual N Leaching (ANL)

The innovation norm for ANL is the same as that legally established by the EU for drinking water. The provisional norm in PNL is an equivalent of this, assuming half of the 70 kg/ha N_{min} in the first metre of soil at start of the leaching period will actually leach at the local precipitation surplus of 300 mm. By testing crops and farms for both parameters for several years, the definitive norm in PNL can be established. Once that has been done, it would suffice to test only PNL, saving a lot of time and money. Most recent data on ANL of the drainage system are from 1996.

On average the pilot group achieved the ANL norm, as it did in 1994 and 1995 (Figure 5.11a). (In 1995 there was hardly a precipitation surplus, so no drainage water could be tapped). The crops exceeding the norm (maize, onion, pulses and potato) account for 70% of ANL, though their share in the rotation is only 35%. ANL varies greatly among the farms, generally following variation in PNL (Figure 5.11b). However, the lutum content of the soil is important. Farm 8 with 40-50% lutum has a PNL that far exceeds the norm, though its ANL is amply within the norm! In contrast, Farms 5 and 1, with 5-30% lutum, have PNLs slightly below the norm, though an ANL beyond the norm! Farms 2, 11 and 3 with intermediate lutum contents remain within the ANL norm, though they exceed the PNL norm. So, the innovation norm in PNL needs to be determined in relation to the lutum content.

ENM is quite effective in achieving desired results, except for KAB/R, which has been given too little attention up till now. But the large differences between farms indicate that ENM needs to be improved in manageability, acceptability and effectiveness. As highlighted in this section (5.3), there are a sufficient number of ways of achieving this.
5.4 **Infrastructure for Nature and Recreation (INR)**

INR is a farming method that has a double objective. The first is to make a farm accessible and livable again to wild flora and fauna, whose biotope would historically have included the farm. The second is to make the farm accessible and attractive to recreationists from rural and urban areas. In NL 2, INR has been designed and laid out as a network of ditches, that meet the following requirements:

- the network offers variation and continuity to plants through periodic mowing and removal of hay to prevent suffocation and eutrophication, and by maintaining permanent grass strips alongside the ditches, as a buffer against erosion and eutrophication from fields;
- the network offers variation and continuity to animals for feeding, hiding and nesting, supported by various side-elements in the banks of ditches and in the yard (shrubs and trees, haystacks, wood piles, etc.);
- the network offers variation and continuity to recreationists through a variety of images, colours, smells and sounds, from early spring through to late autumn;
- the network comprises at least 5% of the farm area (2.5% ditch banks and 2.5% production area), that meets these criteria.

**Acceptability and manageability of INR**

INR is manageable and acceptable considering that all farms but one have achieved the innovation norm of 5% of farm area devoted to INR, although it took 4 years to achieve this (Figure 5.12). The major cause of this slow response was the reluctance of some farmers, to reduce their production area in favour of permanent grass strips to protect and manage the ditches, for which, currently, there is no financial compensation in terms of direct payment or a better market for products because of their added ecological value. At the start of the project in 1991, the banks of ditches, targeted as the main element of INR, were highly eroded and covered with weeds, such as *Elymus repens* (cough grass). It took 2 years to create banks covered with various non-weedy grass species. In 1991 less than 10 wild plant species with conspicuous flowers grew there spontaneously. So we decided to collect and spread seeds of conspicuously flowering plant species that can thrive on the sandy clay soil, rich in lime. Of the 90 species sown amongst the existing grassy vegetation so far, some 40 have gradually succeeded in establishing themselves there. This success has been achieved by continual ditch management through mowing and removing the hay twice a year, which hinders fast growing grasses by depletion of nutrients in the soil. With the increase in flowers growing on the banks of ditches, the farmers and their families' appreciation of INR rose. To make it still more attractive for man and animal, farms have started to lay out various side-elements, such as willow shrubs, ribbons of reed, haystacks, wood piles and nesting boxes for kestrels and barn owls. The current innovation norm, i.e. at least 7 out of a list of 12 side elements, has been met by most farms.
**Effectiveness of INR**

The most important norms to be met are those for the flora. Flora should make the INR and the farm viable for animals and enjoyable for people, due to a varying bouquet of flowers that blossom from spring to autumn, well spread throughout the farm. Therefore, the first norm to be met is more than 10 flowers per m (ditch bank + grass strip) from April to September (Flower Density Index (FDI) = 1 if 12.5-25 flowers per m; = 2 if 25-50 flowers per m; = 3 if 50-100 flowers per m and = 4 if > 100 flowers per m). In 1997, 5 years after sowing the first target species, the first farms were close to the innovation norm in FDI (Figure 5.13a). The second norm, 25 target species per 100 m section INR and the third norm, 50 target species over the entire INR, are rapidly being achieved (Figure 5.13b-c). The growing potential of flowering this represents will enable a further increase of FDI. A list of 40 target species that were able to settle on the grassy banks of ditches on most farms is important for the dissemination of INR to other farms in the region. By collecting and sowing seeds of these species, farms could reduce the time needed to achieve FDI = 1 from 6 to 3 years. In a follow-up project, norms for quality and quantity of fauna could be considered.

![Figure 5.13](image-url) The three parameters for flora (in order of importance) in the INR of the 10 pilot farms in 1997.
5.5 Farm Structure Optimisation (FSO)

Some farms have hardly achieved a Net Surplus > 0, which is the desired result for our theoretical prototype (Report 2, Figure 2.2.4). The main cause is chronic yield reduction in the main crops, carrot and potato, by airborne and/or seedborne diseases such as *Alternaria* and *Phytophthora*. Consequently, quality production remains below the desired result. In this situation, FSO is considered premature. Therefore, in a follow-up project the first aim will be to improve QPI of carrot and potato (see Section 5.2).

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**PILOT FARMS**

- various farms situations

**RESEARCH TEAM**

- theoretical prototype

**designing**
- variants for single farms
- annual agreement on input needed from both sides

**testing**
- prototype in practice: is it acceptable?
- prototype in practice: is it manageable?

**improving prototype and management**
- group meetings
- interaction with single farms

**Figure 6.1** Interactive prototyping: designing, testing and improving a prototype through interaction between pilot farms and the research team
6 Disseminating prototypes (Step 5)

Generally, 'dissemination' refers to the spreading of new information and technology. If the information and technology has been produced by members of the target group or by outsiders in close interaction with members, it could be called bottom-up dissemination. If, however, the new information and technology has been produced by outsiders without or with only little interaction with group members, it should be called top-down dissemination.

Traditionally, agricultural researchers are outsiders in the farming community, because they produce information and technology without or with only little interaction with farmers. Up till now, this was not considered to be a problem, because researchers disseminate their results mainly amongst colleagues, extensionists and policy makers. However, it implies that research results only reach farmers in so far as extensionists and policy makers are willing and capable to incorporate those results in their policies, messages and guidelines! If I/EAFS would be disseminated in the traditional top-down way it would imply that researchers develop a general prototype on an experimental farm and policy makers and extensionists disseminate it amongst the farmers.

6.1 Promoting bottom-up dissemination through interactive prototyping with pilot farmers

There are various reasons why traditional top-down dissemination cannot be effective for I/EAFS:
- a general prototype cannot just be transferred from an experimental farm to any commercial farm in a region, because it requires adaptation to specific circumstances, notably the various types of soil and the various needs and goals of farmers in a region;
- the farm-specific adaptation of a general prototype mostly requires the adaptation of methods (MCR, VENM, EIM etc.) to such an extent that the resulting variant of the prototype should be tested again and improved;
- the elaboration of farm-specific variants of I/EAFS prototypes will exceed the capabilities of most extensionists.

These constraints can be overcome if research teams first elaborate a set of variants of prototypes covering regional variation in soil and farmers needs and goals and put that set at the disposal of the extension service! Consequently, sooner or later any research team should create a group of pilot farmers and draw up a representative set of prototypes variants with them. Interactive prototyping with pilot farmers is an excellent start for bottom-up dissemination, which would not only be more effective but also save a lot of time and money compared with traditional top-down dissemination of a general prototype from an experimental farm. For this reason the team of NL 2 has developed a model of interactive prototyping with pilot farms (Figure 6.1). Since it appears to work quite well, it has been accepted as a standard by the teams of the I/EAFS-Network. For interactive prototyping with 10 - 15 pilot farms, Step 4 can result in 10 - 15 variants of the prototype that cover the regional ranges of soil, climate and management.

Interactive prototyping can also create a group of capable and motivated pilot farmers, which is an indispensable technological and social base for dissemination throughout a region. Their farms can be used as demonstration farms and they can be involved in the training and guiding of farmers willing to convert. To disseminate the prototype variants in wider circles, regional extension services should be trained to participate in and gradually take over the innovation project. The interaction model (Figure 6.1) can be used to convert groups of farmers in a programme that lasts at least 4 years. Currently, a minority of the research teams in the I/EAFS network are still just prototyping on an experimental farm. The majority of teams have already formed a pilot group, though most of them have not yet put the model of interactive prototyping into practice.

6.2 Reinforcing bottom-up dissemination by top-down dissemination

Top-down dissemination by extensionists and policy makers, or even imposition of a prototype developed by researchers on an experimental farm, would meet a lot of resistance within a farming community and would not be effective. If, however, a region-wide set of prototype variants were to be made available through interactive prototyping with pilot farmers, bottom-up dissemination...
could be reinforced by a well-tuned top-down dissemination. This implies various measures and guidelines from policy makers, but also from processors, traders and consumer organisations, each directly or indirectly exerting pressure on farmers to convert to the available I/EAFS-variants. This is highlighted by A. El Titi and P. Denzinger (DE 1) in Chapter 7.
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could be reinforced by a well-tuned top-down dissemination. This implies various measures and guidelines from policy makers, but also from processors, traders and consumer organisations, each directly or indirectly exerting pressure on farmers to convert to the available I/EAPS-variants. This is highlighted by A. El Titi and P. Denzinger (DE 1) in Chapter 7.
Focus on dissemination of an IAFS prototype in Baden-Württemberg (DE I)

A. El Titi and P. Denzinger

Commercial enterprises acting as ‘pilot farms’ for testing and improving play a vital role in the desired wide transfer of IAFS technology within the State of Baden-Württemberg. This chapter focuses on dissemination methods used and their effectiveness within the environmentally sensitive Bruchsal region, but includes refers to both perception and implementation at the state level. In addition, conclusions and recommendations will be made for other EU member states.

7.1 State of the art in prototyping

To resolve severe erosion and farm-income problems and encouraged by the progress with an IAFS prototype on the experimental farm at Lautenbach (Report 1), in 1988 17 farmers, managing some 1200 ha of arable land in the Bruchsal region (Baden-Württemberg /Germany), founded the AKIL pilot-farm group. Their main intention was to design variants of the IAFS Prototype of Lautenbach for their specific farm conditions. Continuous testing and improving of the prototype variants from 1990 to 1996 led to promising results that had significant impact in and outside the region (Chapter 4, Figure 4.1). The desired results of NS, MSC, SCI, NAR, PSD, EEP can be classified as ‘fully achieved’, and those of PI, EII, PAR,PAB, KAR and KAB as ‘almost achieved’. In addition, a large number of farmers outside the pilot group switched to IAFS. A comparison of 15 AKIL with 30 non-AKIL farmers in the region showed that AKIL farmers responded significantly more to environmental issues than their neighbours in terms of perception and management. It also identified a high potential within the regional farming communities for environmentally safer, more sustainable approaches, provided NS can be maintained.

7.2 Methods of dissemination

Methods of dissemination can be classed as bottom-up or top-down, two complementary categories that are indespensable, as will be demonstrated.

7.2.1 Bottom-up

With bottom-up dissemination farmers are free to adopt or reject IAFS methods according to their own decision-making criteria. Feasibility and profitability are thereby key components to convincing farm managers. The guiding philosophy is: when farmers are convinced about new methods and techniques, they can convince others. The following methods of bottom-up dissemination have been effective within the AKIL group.

On-farm demonstration

Three pilot farms representative of the size and structure of an average farm in the region were used to demonstrate the effects of IAFS multifunctional methods. For example: MCR, MSC and IPM effects on SCI; erosion, SB (e.g. earthworms) and NS were repeatedly demonstrated on-farm for the main crops; focusing on feasibility for crop health status, weed control, etc. Large conventionally cropped plots (1-2 ha) provided a useful contrast for demonstrating the effects of, for example, MSC on sloping and erosion-sensitive fields. AKIL farmers and, from time to time, non-AKIL members (2-3 times per year) were invited to visit demonstration sites.

Group Extension

Exchange of experiences among the AKIL farmers has been a most effective tool for building confidence in and improve knowledge of IAFS methods. The scope and quality of information has been greatly improved by involving experts from the different fields of IAFS. The exchange of experience is considered as ‘inside-information’ and is greatly appreciated by farmers. Annually, 6-8 meetings have been organised, mostly during periods known to be critical for making decisions about the main crops. These meetings have been expanded to include non-AKIL farmers too.
Open-Gate invitation

Once a year, rural and urban communities in the region are invited to visit farms so that they can learn about IAFS methods and products. Professionals can also display new farm machinery and distribute pamphlets on the feasibility of ecological infrastructures and their profits. Announcements of such events are published in local newspapers. With photos and drawings of native wild species in field boundaries (El), a ‘display route’ is created within a pilot farm or in two neighbouring pilot farms. These open-gate invitations draw a highly significant response from both rural and urban communities, including reluctant non-AKIL farmers.

Involvement of the regional market

AKIL markets collectively wheat of guaranteed bread-making quality to regional mills. Contracts have been made to regulate crude protein content, variety, quantity and price range. To response to the identified regional market, the contracted mills passed the idea on to client bakeries. A ‘regionally produced & processed’ wheat flour has been received with remarkable commercial interest by many regional bakeries, and they have joined the AKIL club as full members. The positive response of the regional market has given AKIL pilot farmers more confidence and identification with their region. Furthermore, their efforts were honoured by a premium on their products. The regional marketing concept has been most effective in motivating pilot farmers, but it has also induced competition with cereal producers in the surroundings. The latter have responded by creating their own integrated farming clubs and establishing logos for their products. Some of them have joined AKIL, and adopted the IAFS guidelines.

Field-to-table approach

The AKIL pilot farms recognised the need to regain consumer confidence into food, landscape and environmental safety. An AKIL logo is displayed on AKIL fields, farm buildings, grain and potatoes stocks as well as on all food products from IAFS fields. The logo has been a great help in distinguishing AKIL pilot farms from all others. For the first time in the region, consumers are able to control the production chain from field to table, to inspect where and how their food is produced. The approach has stimulated competition but has also led to abuse of logos, due to lack of legally binding regulations for IAFS.

7.2.2 Top-down

Top-down dissemination includes all methods by which legal authorities encourage or press farmers to implement pre-defined methods or measures aimed at protecting the environment or reducing pollution. There are a number of legal regulations that are in force at regional, national or EU levels that fit the scope of either IAFS, EAFS, or both. These are either obligatory or voluntary (choice option). In the federal state of Baden-Württemberg, some of these regulations have had significant impact on the dissemination of IAFS in the Bruchsal region. The main regulations and their influence on the dissemination of IAFS will be described in the remainder of this subsection.

Water Protection Zones / N and Pesticides Directives

To minimise the risk of contaminating underground water reservoirs with nitrate and pesticides. State authorities have put 1988 Directives into effect (locally known as SCHALVO). Based on a hydrogeological map of the entire state, water conservation zones have been identified, independent of farm or field locations. In Water Conservation Zone I, all agricultural activities are forbidden, whereas in Zones II and III ‘restricted’ farming is allowed. The water conservation zones are managed according to a Bonus-Malus principle. Farmers are compensated by the State (up to DEM 320 /ha annually) for restricted (regulated) agro-inputs (mainly agrochemicals and manure); and punished if they fail to meet demands. Fields within SCHALVO areas are inspected annually by the authorities, who sample field soils, inspect farm records, etc.

Since the AKIL-farming Codex (IAFS Guidelines) meets the requirements for minimal NO3 leaching risk, which is expressed as the desired NAR (< 45 kg N/ha, 0-90 cm, 15 Oct.-15 Nov.), there was neither a conflict of interest with nor advantages to be gained from the directives for groundwater protection. Nevertheless, the directives appear to be a valuable tool for motivating non-AKIL
farmers. The same can be said for leachable pesticides (EEP\textsubscript{water} = 0). They are banned by the AKIL-farming guidelines and so the guidelines fully comply with the legal regulations in water conservation zones. Despite the clear objectives related to underground water protection, both AKIL and non-AKIL farmer operating fields within water conservation zones continue to need the advisory service to manage their farming systems in line with legal regulations. For example, the Water Protection Directives have made farmers more dependent on advisers. As a result they have come to appreciate IAFS as a way of coping with the law without the help of advisers. Thus, the legal regulations have promoted top-down dissemination of IAFS.

**Soil Protection Directives**

This is a far-reaching legal regulation that is applicable to different types of land use, including agricultural land use. Within an agricultural context it aims at sustaining soil fertility and productivity on farmland. It has an obligatory character in terms of farming methods. Husbandry techniques used on farmland should not conflict with these directives. In hilly areas, for example, runoff and soil erosion should be kept to the feasible minimum to minimise losses of soil and nutrients. This is likely to contribute to minimising the contamination of surface water sources with agrochemicals. For complying to such legal requirements, new farming methods such as MSC, MCR and INM, are indispensable. Consequently the directives encourage farmers to adopt IAFS.

**Set-aside**

As a EU regulation, set-aside is an incentive for diversifying crop rotations. Set-aside guarantees a fixed revenue and is thus considered as a safe and valuable element of MCR. Set-aside may provide additional profits and may facilitate management of NGW, NAR, PAR and KAR. In the region under consideration AKIL and non-AKIL farmers have responded strongly to this legal regulation. Thus, it supports the conversion of the entire farm to IAFS.

**Overproduction Control and Landscape Management (MEKA Program)**

The state government's MEKA Program encourages farmers to use environmentally benign farming measures that should reduce overproduction and maintain the rural landscape. The program's measures are described in an official leaflet, which indicates the required ranges and related payments. Each 'MEKA Measure' has a value, expressed in a specified number of points (point catalogue). Each point corresponds to a value of DEM 20. According to their specific situations, farmers can make a choice of different measures, collecting points up to a maximum annual value of DEM 520/ha. The emphasis is on MSC, ICP (only non-chemical methods), INM (no growth regulators) and El. The MEKA Program has strongly supported dissemination of IAFS not only in the Bruchsal region but also throughout the state. MEKA-contracted farmers can be considered half way in converting their farms into IAFS.

**Landscape/ Nature/ Species Preservation**

This is an additional incentive offered by the state government in the form of a legal regulation for conserving wild plant species, maintaining specific habitats and establishing ecological corridors. A wide range of possibilities are included in this regulation, from which farmers can make a voluntary choice; this is formally laid down in a contract. The allocation of 0.04 - 0.10 of farmland for El in IAFS has turned out to be a high threshold for conversion to IAFS on rented farmland (tenancy). Compensation payments from this regulation have lowered this threshold. Non-AKIL farmers remain reluctant to convert.

7.2.3 Supporting measures

Dissemination of IAFS in Baden-Württemberg is greatly assisted by, and in some cases even dependent on, the following:

**Training officers of the advisory service**

Farms converting to IAFS are highly dependent on technical and strategic advice, mainly to be able to face the day-to-day problems. Despite the availability of an effective official advisory service – in addition to consultants of the agro-industry - IAFS-know-how is in extremely short supply among
the traditional advisers. Annual training courses using field scenarios on AKIL pilot farms as a training ground have accelerated the growth of knowledge on IAFS techniques. Multi- and interdisciplinary courses based on a farming system approach are major elements of this training, which is offered to both agronomy and plant protection advisers. The appointment of an IAFS adviser has been most effective during testing and improving the farming prototypes within the AKIL group. Expert IAFS advisors are greatly needed to disseminate IAFS to other EU regions.

Training of farmers

Even motivated farmers can hardly cope with all the day-to-day decision making during the initial years of conversion. Education of farmers on how to deal with IAFS methods still needs improvement. In the Bruchsal region, ICP and, in particular, decision making in disease control (including thresholds for decision making) were identified as major problems for farmers. The special IAFS adviser, as well as the State Institute for Plant Protection, provided regular training appropriate occasions. AKIL pilot farms were used repeatedly for demonstrating 'decision making' in the control of leaf diseases of cereals and in weed control in corn. The exchange between farmers was so effective that experienced IAFS farmers were able to offer such advisory services using their own fields as a training ground. It promoted confidence in IAFS within the group.

AKIL Label

IAFS can hardly be expected to achieve sufficient product quality to justify trading under its own label, unless the term 'quality' is understood to mean environmentally safe and ecosystem-based farming. Therefore, AKIL pilot farms focused on the latter as a quality criterion. The introduction of an AKIL Label enhanced the confidence of farmers in their mutual commitment and contributed significantly to a better image of farmers in relation to the environment. The award of the 'Environment Prize' to the AKIL-Group in 1991 from the municipality of Bruchsal and the 1st Prize for 'Soil Protection' by the County of 'Karlsruhe' greatly assisted IAFS dissemination. In addition, guaranteed sales to millers and the premium paid for wheat and rye from IAFS have significantly contributed to the expansion of the AKIL group, which in 1996 included more than 50 farms together covering more than 5,000 ha.

State label

Comparable to the AKIL label, the state government has established a label to certify both product origin and product quality, emphasising farming methods such as nutrient management, ecological infrastructure, etc. Farmers must fulfil minimum requirements and accept on-farm control. Farms licensed to use this certificate get better access to markets, with the expectation of better profits. However, no payments or other obligations are associated to it. When the conditions for participation are fully met, the conversion to IAFS will be much easier. At least 80% of the IAFS desired objectives of the various parameters can be considered as achieved if the farm is authorized to use this State label. So this label supports the dissemination of IAFS, too.

7.3 Effectiveness of IAFS at regional level

7.3.1 Nitrate Leaching

The adoption of IAFS by commercial enterprises has been remarkable, extending far beyond the Bruchsal region to cover the entire State of Baden-Württemberg. However, levels of adoption differ between farms, ranging from full conversion to such reluctance that legal regulations were needed to introduce some single measures of IAFS. Differences in adoption are related to specific constraints of farms (e.g. erosion, water conservation), technical facilities available there, and to the motivation of farmers. Nevertheless, IAFS has been implemented throughout the state. To test if this has really reduced the risk of NO\(_3\) pollution to meet the legally required level (45 Kg/ha N in 0-90 cm layer in autumn), it was essential to measure NO\(_3\) content in soil profiles of a huge number of fields with different crops, locations, treatments, etc. Accordingly, between 1991 and 1996 analyses were made throughout the state. Between 17,000 – 20,000 fields were sampled every autumn (total 80,000 samples). All sampled fields were located within water conservation zones.
(representing 100,000 ha). Farming and fertilisation patterns of the sampled fields corresponded with the AKIL-IASF Farming Guidelines. The results obtained up to 1996 (Source: LUFA-Augustenberg) are summarised in (Figure 7.1).

![Graph showing mean NO3 content in soil profile (0-90 cm) in water conservation zones (NAR), Baden-Württemberg 1991-1996.](image)

The results clearly show a gradual decline in NO3 content over the sampling years, from 75 kg N/ha in 1991 to 29 kg N/ha in 1996, a reduction of more than 50% of initial average content in the soil profile. This decline has been achieved by implementation of INM and SCI in IAFS/water conservation zones of the state. Since the sampling period (autumn) is the most critical period for leaching, the NAR now meets the required official standards of 45 kg N/ha in soil profile. The large number of samples, covering a wide range of circumstances, makes it possible to assess the impact of crop, soil cover, tillage, etc. Grouped samples from set-aside fields (no crop, fertilisation) provided a reliable database for evaluating this option (Figure 7.2). Independent of specific site conditions, soil fertility levels, precipitation or temperature, the average NO3-N in the soil profile has never exceeded the officially required standards under a set-aside regime. On the contrary, within the IAFS concept the set-aside option has proven to be an effective tool for limiting NO3-leaching risk.
kg Nitrate-N/ha


LUFA Augustenberg- luK 4/97

Figure 7.2 Evolution of NAR under set-aside arrangement in IAFS zones of Water Conservation in Baden-Württemberg, Germany.

### 7.3.2 Species diversity / Endangered and expiring plant species

The desired improvement of PSD cannot be achieved if the habitat is not suitable for new or re-introduced species. For this reason, impact of IAFS on this parameter was assessed by surveying the occurrence of the endangered wild plant species after four years of implementing a package of integrated farming measures. The official 'Red List of Baden-Württemberg' (Harms et al. 1983) and results of botanical surveys of the Bruchsal region (Hassler 1993) were used as references. A full species survey of non-crop flora on both farmed and border lands was conducted on seven of the 15 pilot farms of the AKIL Group during the project period. The recorded species were then classified according to their risk category (Table 2).

Table 7.1 Classification of endangered plant species on farmland of seven AKIL farms according to the official risk categories of Baden-Württemberg.

<table>
<thead>
<tr>
<th>Risk category</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Endangered spp. (A3) * agric.type</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.14</td>
</tr>
<tr>
<td>b) Spp. to protect (A5) * agric.type</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>2.86</td>
</tr>
<tr>
<td>c) Endangered other spp. (A3)</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0.57</td>
</tr>
<tr>
<td>d) Other spp. to protect (A5)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0.35</td>
</tr>
<tr>
<td>Total number of species / farm</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>5.29</td>
</tr>
</tbody>
</table>

P1-P7: AKIL farms in Bruchsal region, Germany.

Depending on the specific habitat required by the species, IAFS has a remarkable potential to restore different native, but endangered or locally extinct plant species. This finding underlines once more the potential of the farming system to sustain agroecosystems.
7.4 Conclusions and recommendations

The final step of the methodical way to I/EAFS implies the elaboration of dissemination methods. It has been recognised that traditional dissemination schemes of advisory services cannot be used for the dissemination of comprehensive systems such as IAFS or EAFS. Through the testing and improving of the most promising prototype variants for a region, pilot farms obviously serve as an indispensable platform for dissemination. This has been most successful in Germany and in other member states. In addition to researchers, advisers are needed with innovative approaches. The role of advisers must be redefined in the light of the new system. Their close co-operation with research teams working on development, testing and improving of I/EAFS is meant to facilitate technology transfer to farmers. However, it will only work if potential farmers are interested. Consequently, the perception of farmers about specific farm problems, on one the hand, and about the impact of farming on the environment, agricultural resources and sustainability, on the other, plays an important role in dissemination. The perception of a problem, for example, erosion can motivate farmers to seek solutions on their own (bottom-up approach). Testing and improving of prototypes may be an effective tool for stimulating farmers, attitude to existing problems. Once they become involved, responses can be expected. In the case of AKIL (Germany) they even established a regional market for their own products and supported the dissemination both directly and indirectly. However, farmers’ own efforts can be severely restricted by some of the essential demands for I/EAFS. MCR was identified as being most supportive of various IAFS objectives, but the decision to convert is far from easy due to market limitations. This is especially so if the new crop(s) require additional financial investment. Conversion might be more readily contemplated if the agropolicy were to support such crop diversification. Set-aside was obviously successful because of the payments associated with. The fraction of leachable nitrate dropped because of directives for ground water protection. The integration of agropolicy and farmers’ motivation is likely to be the driving force for effective dissemination. Giving IAFS a legal status would also support dissemination by making the farming system worthwhile to adopt.

Final conclusion: I/EAFS requires both top-down and bottom-up dissemination!
8 Conclusions and recommendations

The following conclusions and recommendations have been drawn up in the light of the results of this final year of concerted action on the scope for improving and disseminating I/EAFS (Steps 4-5).

8.1 Improving prototypes on-farm (Step 4B)

After the 3 initial steps of designing (see Reports 2 and 3), the methodical way of prototyping I/EAFS is followed by:

(4) 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 (Parts 5 and 6 of prototype's identity card).

The second progress report presented the methods of layout and testing (Step 4A), and the layouts (Part 5) of the ongoing projects on pilot farms. The layouts (Part 5) of the ongoing projects on experimental farms had already been presented in the first progress report.

The third report presented the methods of improving prototypes (Step 4B) and the state of the art in Step 4 of the 7 ongoing projects on experimental farms, in total 11 prototypes. These projects were selected because they had results of Step 4 for at least 3 consecutive years (1993-1995). This time-span is a prerequisite for assessing whether the new methodology is manageable and effective.

This fourth and final report focuses on progress in Step 4B, since the final conclusion of the third report was that various problems and constraints still have to be overcome (summarised in Section 1.1) and that especially more progress is needed for the targeted improvement of methods in manageability, acceptability and effectiveness to achieve desired results in the parameters still falling short. Three pilot projects that have at least 3 years results available have been selected to focus on Step 4B: B 1, DE 1 and NL 2. To what extend have the three pilot projects met the needed progress?

8.1.1 Establishing desired results in any parameter: per farm and as percentage of farms

Compared with prototyping on an experimental farm, prototyping with pilot farmers has the advantage of a multiple layout of the prototype. This enables testing and improving with variations of soil, crops and management, which may lead to a set of prototype variants covering the regional variation in farms. The state of the art (Part 6 of the prototype’s identity card) of pilot projects can be expressed as the average achievement per parameter (left-hand circle, Figure 5.1) and as the percentage of farms achieving the desired result (right-hand circle). The latter could be done by just presenting the percentage achieved per parameter, but we have chosen to relate the achieved percentage to a desired percentage per parameter, which may be required or useful for the objectives covered. Consequently, in both circles the relative shortfall of achieved to desired result is presented for each parameter, which enables parameters to be ranked in ascending order of shortfall. In this way, the state of the art also indicates the future agenda: the work still to be done in order of priority.

To establish desired results in a parameter is not easy if there are no official (legal or trade) norms or guidelines at EU, state or regional level. Under such circumstances a desired result should be established by negotiation with the pilot farmers, and possibly with other groups whose interests are affected by the parameter in question. The third progress report gave examples of desired results that were too conformistic, too idealistic or too vague. This only concerned desired results in absolute terms, i.e. per farm. In this report, the 3 pilot projects also present desired results in relative terms, i.e. as the desired percentage of farms to achieve the (absolute) desired result in any parameter. The desired percentages vary in B 1 from 30-100%, in DE 1 from 50 -100% and in NL 2 they are all 90%. The varying percentages are not highlighted. The team of NL 2 has not negotiated with the pilot farmers or other groups; 90% is set as desired to ensure the prototype is made acceptable, manageable and effective in any parameter for almost any farm in the pilot group, and thus
for most farms in the region. Nevertheless, it is realised that regional farmers or other groups may be less demanding about the percentage of farms achieving the desired result in certain parameters. This would imply that achieving the desired result on average is the most important, and that certain farms may compensate through overperformance for the underperformance of others. However, this is socially and economically a delicate issue, because overperformers could claim a bonus and underperformers could refuse a malus!

In pilot projects, it is recommended that the desired percentage of farms to achieve the desired result in any parameter be established by negotiation with the pilot group and preferably other regional groups whose interests are affected. As long as this has not happened, the percentage should be fixed at 90, to ensure the prototype is made acceptable, manageable and effective for most of the farms in the region for the parameters in question.

8.1.2 Establishing achieved results

Progress report 3 gave various examples of incorrect setting of achieved results (summarized in Section 1.3). In addition, it should be pointed out that it may be erroneous to conclude that the prototype is profitable when the pilot farms achieve the desired Net Surplus. If the desired Net Surplus was already achieved in initial years, it may not be because the farm(s) in question converted to the prototype. The Net Surplus could even have been achieved in spite of the conversion! So only a stable level or a positive trend in the Net Surplus of farms for at least 3 years may be considered as a reliable indication of the profitability of the prototype.

It is recommended that achieved results be established by appropriate methods of sampling, observing and data processing, to prevent overall error from obscuring trends in the achieved results and from drawing premature or wrong conclusions.

8.1.3 Establishing the main cause of shortfall in results

Progress report 3 gave various examples of incorrectly establishing the cause of shortfalls in results. In addition, it should be pointed out that it is important to establish the cause of a persistent shortfall, to prevent stagnation in Step 4 and the risk of ending up with an unfinished prototype. It is also counterproductive to establish a wrong or a minor cause, such as 'slow response' or a minor method.

It is recommended that, in principle, only one main cause of a shortfall in results be established:
- 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 initial years of testing and is likely in later years for inert parameters such as PAR, KAR and PSD).

8.1.4 Establishing the first criterion not fulfilled by a method

There remain indications that the first criterion of a method that produces a shortfall in results is not being identified critically enough:
- in particular the criterion 'effective' is too readily identified as the first criterion not being fulfilled, instead of one of the preceding criteria, i.e. '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 a few years whether anyone 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 for care in establishing whether a method is insufficiently or not at all effective is that this would call for revision of the theoretical prototype, by introducing a supporting method or skipping the method in question.

It is recommended that the first criterion not yet fulfilled by a method that is causing a shortfall in results be carefully established:
- either ready for use (which is likely in initial years of testing),
- or manageable by the farmers (which may occur in initial years);
- or acceptable to the farmers (which may also occur in initial years);
- or effective (which may only occur in later years of testing).

8.1.5 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 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 places high demands on the expertise and creativity of the research team and farmers involved. This vital stage of Step 4 received little attention in the projects on experimental farms in Report 3. In this report, the 3 selected pilot projects provide various examples of targeted improvements of methods, though the impression remains that there is insufficient expertise and creativity available for sufficient progress.

**It is recommended to put more effort in establishing improvements of methods in line with the format (Chapter 2), to make more progress in this vital stage of Step 4.**

8.2 Disseminating prototypes (Step 5)

Generally, 'dissemination' refers to the spreading of new information and technology. If it has been produced by insiders of the target group or by outsiders in close interaction with insiders, it could be called bottom-up dissemination. However, if the new information and technology has been produced by outsiders without or in scarce interaction with insiders, it should be called top-down dissemination.

Traditionally, agricultural researchers act as outsiders of the farming community, because they produce information and technology without any or only little interaction with farmers. Generally this is not considered a problem, because researchers disseminate their results mainly amongst colleagues, extensionists and policy makers. However, it implies that research results can only reach farmers in so far as extensionists and policy makers are willing and capable to incorporate those results in their messages and guidelines! Considering l/EAFS, traditional top-down dissemination would imply that researchers develop a general prototype on an experimental farm and policy makers and extensionists disseminate it amongst farmers.

8.2.1 Starting bottom-up dissemination by interactive prototyping with pilot farmers

There are various reasons why traditional top-down dissemination cannot be effective for l/EAFS:
- a general prototype cannot just be transferred from an experimental farm to any commercial farm in a region, because it requires adaptation to specific circumstances, notably the various types of soil and the various needs and wishes of the farmers in the region;
- farm-specific adaptation of a general prototype usually requires the adaptation of any method (MCR, I/ENM, EIM, etc.) to such an extent that the resulting prototype variant should again be tested and improved;
- elaboration of farm-specific variants of l/EAFS prototypes is usually beyond the capabilities of extensionists.

For these reasons, any team is recommended to make the final step of the methodical way to l/EAFS as follows:
(5) disseminating the prototype by pilot groups (<15 farmers), by regional networks (15-30 farmers) and, finally, by national networks (regional networks interlinked), with a gradual shift in supervision from researchers to extensionists.

So, sooner or later any research team should form a group of pilot farmers and draw up with them a representative set of prototypes variants. Such interactive prototyping with pilot farmers is an
excellent start for bottom-up dissemination, which would not only be more effective but also save a lot of time and money in comparison to traditional top-down dissemination of a general prototype from an experimental farm. For this purpose the team of NL 2 has developed a model of interactive prototyping with pilot farms (Figure 6.1). As it appears to work quite satisfactorily, it has been accepted as a standard by the teams in the I/EAFS network. For interactive prototyping with 10 - 15 pilot farms, Step 4 can result in 10 - 15 variants of the prototype covering the regional ranges of soil, climate and management.

Interactive prototyping can also create a group of capable and motivated pilot farmers, which is an indispensable technological and social base for dissemination throughout a region. They can provide demonstration farms and can become involved in training and guiding of farmers willing to convert. To disseminate the prototype variants in wider circles, regional extension services should be trained to participate and gradually take over the innovation project. Currently, a minority of the research teams in the I/EAFS network is still just prototyping on an experimental farm. The majority of teams has already formed a pilot group, though in most cases the model of interactive prototyping has not yet been put into practice.

8.2.2 Reinforcing bottom-up dissemination by top-down dissemination

It would meet a lot of resistance within a farming community and would not be effective if extensionists and policy makers were to disseminate top-down, or even impose a prototype developed by researchers on an experimental farm. But if by interactive prototyping with pilot farmers a region-wide set of prototype variants were to become available, bottom-up dissemination could be reinforced by well-tuned top-down dissemination. This would imply various measures and guidelines from policy makers, but also processors, traders and consumer organisations, directly or indirectly exerting pressure on farmers to convert to the available I/EAFS variants. A. El Titi (DE 1) has elaborated a very successful and up till now unique combination of bottom-up and top-down dissemination in Baden-Württemberg (Chapter 7).

It is recommended that all teams try to reinforce bottom-up dissemination of their IAFS or EAFS prototype by a well-chosen set of top-down dissemination measures, as elaborated and highlighted by A. El Titi for the State of Baden-Württemberg, in general, and the Bruchsal region, in particular.
Selected references to projects on pilot farms

DE 1
El Titi, A., 1996.
Veränderungen der Unkrautzusammensetzungen nach 16 Jahren integrierter Bewirtschaftung
auf dem Lautenbacher Hof,

El Titi, A., 1997.
Mehrjährige Erfahrungen mit der Teleskophacke im Weizenanbau: Hacken gegen

NL 2
A methodical way of prototyping integrated and ecological arable farming systems (I/EAFS) in

NL 1
Integrated crop protection and Environment Exposure to Pesticides, methods to reduce use
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 X1) 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 X2-X4), 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.
Sub-annex I

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

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, insofar 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 experimental 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

References


Annex II

Research Group on Integrated and Ecological Arable Farming Systems for EU and associated countries

<table>
<thead>
<tr>
<th>EU countries</th>
<th>Participants workshop Projects Bruchsal 1996 and/ or Louvain-la-Neuve 1997</th>
<th>type</th>
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