VEGINECO

EU. FAIR PROGRAM

Ecological infrastructure management

VEGINECO Project Report No. 5

The Netherlands Italy Spain Switzerland

Ecological infrastructure management

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G.K. Hopster & A.J. Visser (eds.)

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1 Introduction

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1.1 Vegetable production in Europe: shortcomings and new farming systems

Although vegetables cannot be said to be a key issue within European Union market policy or political discussion, they are, nevertheless, a major constituent of the daily diet of hundreds of millions of European citizens. Consequently, it is very important to ensure the availability of a wide variety of relatively cheap, high-quality, fresh vegetables on a daily basis.
The farms throughout Europe producing field-grown vegetables are relatively small, and are mostly concentrated in certain regions (for practical market-oriented reasons). These farms are characterised by very intensive land use (all-year-round soil utilisation) and high (external) labour requirements per hectare. Thus, there is almost no 'space' to incorporate nature and landscape elements. Since the range of crops on a farm is limited, crop rotations are short and host crops are present all year round in a very small geographical area. Crops are thus under the constant risk of being decimated by pests and disease. This situation provokes the intensive, but increasingly ineffective, use of pesticides. Another contributory factor to the high use of pesticides and also of nutrients is the need to realise high yields and ever-increasing 'cosmetic' quality demands, forced on the industry externally by very highly competitive international markets.

Since the costs of nutrient en pesticide inputs are relatively low compared to market value of the crops in production, there is little economic incentive to reduce these costs and thus the inputs. The high inputs are seen as 'insurance' costs. At present, vegetable-growing enterprises are experiencing very strongly fluctuating, generally low, profitability. Viewed against a background of necessary (socially acceptable) wage increases for hired labour (field workers) and increasing overproduction (due to free market competition), future prospects are even gloomier.
Consumers are worried about health risks related to agricultural products, and, in particular, to the nitrate content, pesticide residues, contaminants, etc. in fresh vegetables. They are also concerned about the adverse effects on the environment of high nutrient inputs and the growing lack of concern for nature and landscape. There is a growing public demand for production methods, which have an 'ecology content'. The dilemma is that, simultaneously, consumers are also demanding high quality products, and not only consumers. Government authorities, in their policies and efforts, are addressing exactly the same issues, and, finally, retailers and other market parties are increasingly searching for 'certified environmentally friendly products'.
Farmers are thus no longer being asked to produce cheap food in large quantities, but are currently being challenged to be responsible managers of rural areas, of their green space. At the same time, they are also required to produce high- quality (even speciality) products. The repercussions of these demands are influencing the entire depth and scale of farm management.
There is an urgent need for new multi-objective farming systems that integrate into the old objectives 'new' aims such as product quality coupled with quality in production methods, quality in the a-biotic environment, higher landscape and nature values, and agronomic sustainability.
For this to take place, the old one-sided (mainly agrochemical-based) methods have to be reconsidered, redesigned, and replaced by new multi-objective methods that are able to meet these new objectives. In redesigning these methods, the key issues of farming are involved, such as crop rotation, crop protection and nutrient management. In addition, new strategies for nature and landscape development are urgently required. All these different aspects need to be integrated in safe, efficient, acceptable and manageable strategies. At the farm level, this can only be done within the context of a farming system.
At present, there are two major visions with respect to integral approaches towards agriculture: integrated and organic farming systems (I/OFS). Integrated production is slowly growing in importance, and integrated labels have been introduced in a number of European regions and countries. The development of these labels is still in progress, but, too often, it is only based on single factor research. A consistent research base on comprehensive farming systems, and on the potential and possibilities for integrated production, is mostly lacking. Switzerland is possibly the only exception. Here, as early as the end of the eighties, large-scale pilot projects were carried out, which resulted in detailed production guidelines.
For organic production, national labels have long been available and have recently been harmonised with the European directive on organic farming (EC 91/2092). The current objectives of organic farming are to use no pesticides or chemical fertilisers at all. The emphasis is on what should not be done, rather than on stressing explicit (positive) objectives for protecting the environment or caring for nature and landscape. Both systems have not yet been fully explored and exploited and need to be developed further before a proper evaluation can be made of their potential contribution to the future of European agriculture.

1.2 VEGINECO: Farming systems research on field grown vegetables

Objectives and research method

Within the framework of the EU FAIR programme, a project was set up to develop integrated and ecological farming systems for outdoor vegetable farming systems. The overall objective of this project was:

' to develop integrated and ecological outdoor horticultural farming systems that are more sustainable in agronomic, environmental, ecological and economic terms, and that ensure high quality products that minimise environmental and health risks, thereby meeting market demands'.

This EU project focused on research into farming systems to develop, test, evaluate and compare prototypes of integrated and ecological vegetable farming systems in four important vegetable-producing regions in Europe, selected to represent different socio/economic, soil and climatic conditions. These regions were: the clay region in the Southwestern area of the Netherlands, Emilia-Romagna in Italy, and the Valencia region in Spain. Additionally in Switzerland, organic and integrated pilot farms were compare and improved.

In this project, the prototyping methodology of designing, testing, improving and disseminating new 'farming systems' (Vereijken 1994, 1995) was applied and improved. It was a combined research/development effort, taking as its starting point a profile of agronomic, environmental and economic demands (objectives) for more sustainable, future-oriented farming systems. The end product was a number of tested prototypes, ready and available for widespread application.

Participants in this farming systems research:

Applied Plant Research (P.P.O., formerly P.A.V.), Lelystad, the Netherlands (project co-ordinator)
PPO has been involved in farming systems research since 1978. For the VEGINECO project, PPO tested integrated and organic vegetable systems in the Southwestern clay region of the Netherlands. The integrated systems consisted of eight variants of integrated vegetable systems in which arable and intensively or extensively grown vegetable crops were combined. The integrated system variants were aimed at direct practical implementation to achieve optimal economic results, whilst the organic system was focused more on experimental freedom to explore the environmental and agronomic potential of the system.

Centro Ricerche Produzioni Vegetali (C.R.P.V.) soc. coop. a.r.l. Cesena, Italy (Emilia-Romagna)
C.R.P.V developed and tested two types of integrated systems and one type of an organic system for this project. All the systems were located in the Emilia-Romagna region. To reflect the situation of small farmers accurately, the organic system and one of the integrated systems were based on fresh vegetables. The other integrated system, aimed at larger farms, focused on integrating arable and horticultural activities.

Instituto Valenciano de Investigaciones Agrarias (IVIA), Moncada (Valencia), Spain
I.V.I.A. developed and tested five integrated systems and one organic system for this project, based on the small-scale production of fresh vegetables. To form a representative sample, the integrated systems included enterprises spread over the entire Valencia region. The location (Paiporta) and rotation system of the organic system was identical to one of the integrated systems.

Eidg. Forschungsanstalt fur Obst-, Wein- und Gartenbau, Wädenswil (F.A.W.), Switzerland
F.A.W. performed 'on-farm research' at 14 private pilot farms scattered over the country – seven integrated farms and seven organic farms. By monitoring the practices and results at these selected farms, a clear picture emerged of their differences. This made it possible to target specific elements in need of further development and to introduce improvements in these areas into farm practice.

VEGINECO publications
This VEGINECO method manual is one of a series of publications resulting from the VEGINECO project. VEGINECO specialises in producing tested and improved multi-objective farming methods for key farming practices – e.g. crop rotation, fertilisation and crop protection – to facilitate the integration of potentially conflicting objectives like economy and ecology. In addition to improving 'old' practices, new methods have been developed to integrate environmental concerns in the field of nature and landscape management with current farming practices. A manual deals with each method in depth. An extensive description of prototyping methodology is included in the manual on crop rotation. In addition to these methodological manuals, other publications include workshop proceedings and a final report on the VEGINECO project. The workshop proceedings focus on project results in general and their implications for policy and certification. The final project report concentrates on the results of the prototyping methodology, in terms of application and development, and how well the tested systems performed.
This report describes the process of developing a methodology for ecological infrastructure management. A prototyping methodology for determining the quantity and quality of nature on farms is presented and tested in different systems within the participating countries.

1.3 Prototyping methodology

For the development of these sustainable vegetable-farming systems, a standardised methodology called "prototyping" was used. The methodology is a combined research/development effort beginning with a profile of agronomic, environmental and economic demands (objectives) for more sustainable, future-oriented farming and ending with tested, ready-to-use prototypes, designed for widespread use. The prototyping methodology was examined for arable farming in a four-year European Union Concerted Action (Vereijken, 1994 and 1995). For vegetable farming, however, this type of research is limited. The methodology of prototyping is still young, dynamic and developing. However, it can be described as an innovative process in 4 steps: analysis and diagnosis, design, testing and improving and dissemination (Figure 1.1) .

The process of prototyping starts with a regionally based *analysis and diagnostic* phase that includes the following aspects: sectorial statistics, farm structure, agro-ecological state-of-the-art, ecological–environmental impact, the socio-economic situation, trends in structural changes and current political conditions.

Based on an analysis of shortcomings in current farming methods and of future perspectives, the *design phase* starts by establishing a hierarchy of objectives for all-round sustainable farming systems. In the VEGINECO prototyping practice, these rather abstract objectives are translated into five directional themes: quality production, clean environment, attractive landscape and diversified nature, the sustainable management of resources, and farm continuity.

In order to quantify the objectives of a theme, each one is fixed within a number of farm-level parameters (Annex 2). Each parameter is given a target value so that a well-defined, documented and clear framework can be established to design, test and improve farming systems. The target levels are future oriented and are derived from legislation, scientific evidence or expert knowledge.

The next step is to design a suitable set of farming methods (methods are defined here as coherent strategies on the major aspects of farming). In most cases, these methods need further development if they are to realise their objectives (Annex 3).

To create a basic framework for interpreting the results, the next step in the methodology is to design a theoretical prototype to link the parameters with the methods. It then becomes possible to check the links. The last part of the theoretical exercise ends with detailed cropping programmes, allowing for adjustments that might be necessary for specific crops, weather and soil conditions.

The next phase is *testing and improving* the farming system that has been designed. For the test phase to be successful, a farming system has to be laid out in time and space. Important here is the choice, not only of a multi-functional crop rotation, but also of the agro-ecological identity of the farm.

When the prototype shows stable results at the level of the parameter targets, the next logical step is *dissemination*. The perspectives of a new prototype can only be evaluated in practice. Management is the key factor for the success and feasibility of these new approaches. Therefore a region-specific prototype, developed on experimental farms, is first tested on a small number of pilot farms. This is considered an indispensable step before new prototypes are introduced on a large scale.

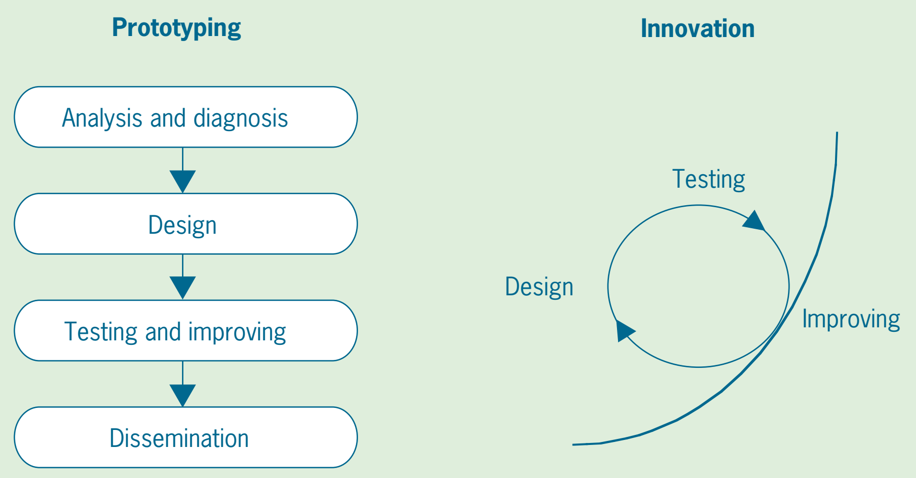

Figure 1.1 Prototyping methodology and the innovation cycle

2 Ecological Infrastructure Management

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Ecological Infrastructure Management (EIM) can be defined as the management of non-productive, linear or non-linear elements on a farm that are suitable habitat for flora and fauna. An example of an element on a farm is a ditch including the sides or a wooded bank. By managing the existing elements in an appropriate manner and creating new elements, an ecological network can be created on a farm, which can be linked to the surrounding landscape. This prevents isolation and creates a network at a landscape level.

In this chapter, first a short analysis and diagnoses is made of the current situation of nature, landscape, policies and legislation in Europe. Next, the opinions on Ecological Infrastructure Management of the researchers and farmers are presented. In the last part of this chapter, the theoretical background of Ecological Infrastructure Management is described.

2.1 Current situation in Europe

2.1.1 Nature and Landscape

In recent decades, both the quantity and quality of nature has dramatically decreased in Europe. The characteristics of the landscape are becoming increasingly similar and biodiversity is still decreasing. Intensification of agriculture, the disappearances of traditional management methods and increasing urbanisation have resulted in the removal of natural elements from the landscape and in the decrease of the quality of the remaining landscape elements. Although differences exist in the speed and intensity of these processes among countries, examples can be found everywhere.

Currently, the image of farmers is under pressure because they are held responsible for the decline of nature and landscape characteristics in rural areas. The result of this is interference from people outside of the farming community in the development of rural areas. At the same time, farmers also see the decline and feel the responsibility for nature and landscape in rural areas. They know it is important to have a good relationship with the local population and they are willing to search for possibilities to work on the quality of nature and landscape at a farm level. Managing non-productive elements on farms in order to develop an ecological infrastructure contributes to the restoration of the rural landscape. To protect nature and landscape elements, the European Union has developed policy and legislation, which will be briefly discussed below.

2.1.2 Policy and legislation

For nature conservation in Europe, legal instruments and policy frameworks have been developed. Most of them focus on the conservation of biological and landscape diversity. An example is the decision to promote closer co-operation and activities between countries to protect wild flora and fauna and their natural habitat (Bern Convention, 1982 (82/72)). Another example is the decision to promote co-operation to preserve and manage endangered migratory species (Bonn Convention, 1982 (82/461)). Several directives to protect nature have been developed, for instance, the directives to protect water quality in order to support fish life (EC 78/659) and the directive to prohibit commercial import of seal products (EC 83/129). The following are two directives important for agriculture.

Birds Directive (EC 79/409)
EU member states have strict legal obligations to maintain populations of native wild birds at levels corresponding to ecological requirements, to regulate trade in birds, to limit hunting to species able to survive exploitation, and to prohibit certain methods of capture and killing. Member states have to take special measures to conserve the habitat of certain listed and threatened species through the designation of Special Protected Areas (SPAs).

Habitats Directive (EC 92/43)
Conservation of fauna, flora and natural habitats of EU importance. The fundamental purpose of this directive is to establish a network of protected areas throughout the EU designed to maintain both the distribution and the abundance of threatened species and habitats (terrestrial and marine). The network of Special Areas of Conservation (SAC) is called Natura 2000 and will include Special Protected Areas of the Birds Directive.

The *EU policy on rural development (EC 99/1257)* promotes preservation of nature and landscape in rural areas. It includes special environmental measures, known as agri-environmental measures. These provide funding for those who are committed to progressive agricultural practices. Support can be granted to farmers who, for at least five years, use agricultural production methods that are designed to protect the environment and maintain the countryside (agri-environment). This support promotes farming methods that are compatible with the protection of the environment, environmental planning in farming practice, the conservation of farmed environments of high natural value and the upkeep of the landscape.

As a result of Agenda 2000, the reform of the common agricultural policy, member states must set up environmental requirements they consider to be appropriate according to the common rules in direct support schemes in agricultural markets. Funding to farmers may be dependent on compliance with those requirements.

This is called *cross compliance* and this can contribute considerably to cleaner agriculture in the future because farmers are forced to meet the environmental requirements before they receive the subsidies. The restoration of rural areas and implementation of environmental measures are to a large extent stimulated by national and international policy and legislation, but are also result of farmers' changing attitudes. As the attitude of farmers concerning nature and landscape changes, and agricultural policies promote cleaner production methods, the environment is no longer seen as a "feature". The environment becomes an essential part of agricultural and rural development and of the farmers' social and professional lives. Farmers, as the first link in the production chain, have a responsibility for the sound management of environmental resources and that responsibility must be recognised.

In addition to the EU policy and legislation described above, every country has its own policies and legislation concerning nature and landscape. The specific policies and legislation for the countries participating in VEGINECO are described in Chapters 3-6 because this information is important in improving the ecological infrastructure of a system. Actions taken at a farm level have to be in accordance with specific policies and legislation.

2.2 Opinions on EIM

The motivation of both researchers and farmers for working on an ecological infrastructure may differ considerably between countries. Therefore, both researchers' and farmers' opinions on EIM were examined in two separate surveys. The surveys can be found in Annex 4.

2.2.1 Researchers' opinions

Researchers from each country participating in VEGINECO set objectives for ecological infrastructure management by giving marks from 1 to 5, 1 being the most important objective. If an additional objective was stated, marks were given from 1 to 6. The results are shown in Table 2.1.

The results show that within the researchers' scores there is almost no difference between integrated and organic farming. In general, the researches' most important objectives were to increase the population of natural predators and increase biodiversity.

There are some differences between the researchers from the participating countries in ordering the objectives. Increasing the natural predators' populations is the most important objective for the Italian and Spanish researchers compared to the Dutch and Swiss researchers, who chose the increase in biodiversity as the most important objective. This seems to follow the political goals in these countries. For the Dutch researchers, the role of ecological infrastructure management in connecting nature areas is another important objective. The Swiss researchers stated the increase of the farmer's income as another objective because Swiss farmers receive subsidies for working on ecological infrastructure.

Table 2.1 The results of the survey among researchers (1 = most important, 5 = least important)

Objective	NL INT	NL ORG	I INT1	I INT2	I ORG	CH INT 1	CH ORG 3	ES INT 2 ES INT 3	ES ORG
Increasing biodiversity	1	1	3	2	1-2	1	1	3	2
Attractiveness to the community	3	3	1	3	3	5	5	5	5
Reducing losses (nutrients, drift pesticides)	4	4	4	5	4	4	4	4	4
Increase natural predators' populations	3	3	1-2	1	1	2	2	1	1
Improving/maintaining physical conditions (erosion, wind break)	4	4	5	4	5	3	3	2	3
Other …									
Increasing the farmer's income						6	6		
Connecting nature areas	2	2							

Table 2.2 Results of the survey among farmers: Advantages of introducing natural elements, only farmers who thought it important arranged the advantages

	NL		I	CH		ES
	INT	ORG		INT	ORG	
Number of surveys	16	69	16	7	7	13
Is it important to introduce natural elements?	Yes 56%	Yes 86%	Yes 62%	Yes 43%	Yes 86%	Yes 15%
Advantages						
- Subsidy	5	5	1	2	5	1
- Natural predators	6	3	2	5	2	3
- Biodiversity	3	2	3	2	1	6
- Preventing erosion	4	6	5	1	2	4
- Better image	2	4	4	2	4	5
- Windbreak*			6			2
- Attractive landscape**	1	1				
- Increase in visitors***				6	5	
Stated by the farmers						
- Increase of nutritional quality of meadow					x	
- Increase of nesting sites for birds					x	
- Lower competition in Swiss market					x	
- Personal pleasure	x	x				
- Part of organic farming		x				

* Not asked in the Dutch and Swiss survey (stated by one Swiss farmer however)
** Only asked in the Dutch survey
*** Only asked in the Swiss survey

2.2.2 Farmers' opinions

Farmers from each participating country completed the survey. The farmers arranged advantages and disadvantages of ecological infrastructure management by giving marks (1 = most important advantage/disadvantage). For every additional objective that was stated, the ranking range was increased by one. In the Netherlands and Switzerland, a distinction was made between organic and integrated farmers. The results are given in Tables 2.2 and 2.3.
In the Swiss survey, the lists of given advantages/disadvantages and the method to arrange the list were different than the lists used by the other countries. Despite the differences, the answers of the Swiss farmers have been converted and put in the Tables 2.2 and 2.3, in order to compare and survey. The results of the original Swiss survey are given in Annex 5.

Taking into account only the advantages given in the survey for all countries, increasing biodiversity was stated as the most important reason to introduce natural elements. There were many differences between countries. In Italy and Spain, the most important reason to introduce natural elements was funding. In Switzerland, it was biodiversity and preventing erosion. In the Netherlands, an attractive landscape was very important. Another interesting result is the difference between integrated and organic farmers. Natural predators and biodiversity are more important to organic farmers, whereas preventing erosion and a better image seems to be more important to integrated farmers.
The most important disadvantages, in the opinion of the farmers, are the loss of productive area and barriers for the operation of machinery. Swiss farmers did not state loss of income because they receive subsidies for the introduction of natural elements. Possible hosts for diseases are not seen as a great disadvantage.

The results per country concerning the disadvantages are very different. The same holds true for the results of integrated and organic farmers. Weeds, for example, are not seen as a great disadvantage in Spain, but the integrated farmers in the Netherlands think weeds are the biggest disadvantage if natural elements are introduced.

Table 2.3 Results of the survey among farmers: Disadvantages of introducing natural elements, all farmers who filled in the survey arranged the disadvantages

	NL		I	CH		ES
	INT	ORG		INT	ORG	
Number of surveys	16	69	16	7	7	13
Disadvantages						
- Loss of income*	2	3	4			3
- Weeds	1	4	2	4	2	5
- Loss of productive area	5	1	3	1	2	1
- Possible hosts for diseases	4	5	5	7	5	4
- Barriers for operation of machinery*	3	2	1			2
- Limitation of free management**				1	5	
- Time for management**	x	x		3	4	
- Increase in pest pressure**				5	1	
- Increase of damage by hikers**				5	7	
Stated by the farmers						
- Waste disposal of cut grass					x	
- Damage by small game	x					

* Not asked in the Swiss survey

** Only asked in the Swiss survey (however, time for management was stated by almost 20% of the Dutch farmers!)

There are also some striking differences between integrated and organic farmers in Switzerland. Limitation of free management is a very important disadvantage for integrated farmers, whereas the organic farmers experience this as less important. The opposite is true for the increase of pressure from pests: an important disadvantage for organic farmers, but less important for integrated farmers.

Comparison between researchers and farmers

Both researchers and farmers are of the opinion that increasing biodiversity is an important aspect of introducing natural elements. According to the researchers, it does not seem to be important if the introduction takes place on an integrated or organic farm. From the results of the farmers' survey in the Netherlands and Switzerland, where integrated and organic farmers are separated, it appears that the two types of farmers think differently about the introduction of natural elements.

2.3 Theoretical background of EIM

For the introduction and management of natural elements on farms, a methodology is needed that can guide the proposed actions and evaluate the results. A suitable methodology for this might be the prototyping methodology for ecological infrastructure management, which was recently developed by Dutch researchers. This methodology has been developed from the methodology of prototyping described in the manual on prototyping methodology and multifunctional crop rotation (VEG-INECO-report no. 2). This methodology consists of three steps: 1) analysis and diagnosis, 2) design and 3) testing and improving. These steps will be thoroughly explained in the following sections.

2.3.1 Analysis and diagnosis

Regional landscape and policy

National and regional policy has to be analysed thoroughly and taken into consideration before actions can be taken and a plan set up at the farm level. For example, in the Netherlands, 16 million people live and work in a relatively small area and, as a result, pressure on the available land is high. Land is mainly needed for housing, industry, transport, nature, recreational use, and food production. In order to achieve a balance, rural development plans are designed for almost all areas at provincial and community levels. A thorough knowledge of these plans is necessary for determining developmental strategies for individual farms.

In addition to policy, a thorough analysis of the existing landscape in which the farm functions is necessary. Existing biotopes (size, frequency, distribution, and connectivity) and present land use have to be described. A target plan for the local nature and landscape can be developed from these two types of analysis.

Agro-ecological layout and management
A general picture of the agro-ecological layout of a farm and the intended type of management has to be constructed. Therefore, a spatial image of the farm and its immediate surroundings has to be drawn up, indicating productive fields, buildings, roads and various landscape elements. This provides information on the diversity and frequency of the different biotopes, the length of transition zones, the level of buffering of landscape elements, and the connectivity of the ecological infrastructure. To complete the picture, the intended management has to be described, which makes it possible to judge qualitatively the chances of success for biotope-specific vegetation development. The complete overview of the existing agro-ecological layout is the basis for the next step in prototyping: the design.

2.3.2 Design

The design phase consists of the following steps: 1) determine *objectives*, 2) develop a suitable set of *parameters* and their target values and 3) develop *strategies* to reach the target values. These three steps will be described below.

Objectives
From the analysis, several objectives for ecological infrastructure management can be deduced:

- to create an attractive landscape that functions well,
- to increase biodiversity,
- to develop a stable agro-ecological layout,
- to contribute to a clean environment.

People, who work in ecological infrastructure management, have their own reasons to do so. Often knowledge and experience are absent and farmers need assistance or a tool to help them in optimising their ecological infrastructure management. The main goal in evaluating ecological infrastructure management is to develop and introduce an objective, detailed and usable method that takes into account policy, landscape and the farming system.

Parameters
To make objectives more concrete they are divided into three themes: nature and landscape, environment, and agro-ecological layout. Attractiveness of the landscape is not placed in a theme because this factor is difficult to measure (subjectivity). In addition, this factor can only be measured after the ecological infrastructure has been developed.

The three themes have to be converted into a suitable set of parameters in order to measure them. The parameters can be used to determine the target and current values (quantity and quality of ecological elements) for the evaluation of ecological infrastructure management on a farm.

Nine parameters have been chosen, which quantify the categories (Table 2.4). The set of parameters is still in development and is, therefore, not definitive yet. In Table 2.5, the definitions of the parameters are given. The parameter BTS, Biotope Target Species, is not completely developed yet. It has been included in the theme 'agro-ecological layout' because of the functional biodiversity aspect. A suitable biotope for natural predators of pest insects is needed to attract and allow the predators to live in the biotope. Both the predators and the plants that attract them are target species. In this way, the biotope contributes to a stable agro-ecological layout. When the BTS parameter is more developed, it may be placed in a new theme in which the quality of different biotopes in a system is measured. The BTS parameter can be used to evaluate the results of specific management, which are related to the objectives.

The set of nine parameters can be used to evaluate the management of ecological infrastructure on a farm.

Table 2.4 Objectives and themes with related parameters

Objective	Theme	Parameter
To create a landscape that functions well and increase biodiversity	Nature and Landscape	- PWE = Percentage Woody Elements - CoLE = Connectivity Landscape Elements - CiLE = Circuitry Landscape Elements - BTP = Biotopes
To contribute to a clean environment	Environment	- BZI = Buffer Zone Index - BZW = Buffer Zone Width
To develop a stable agro-ecological layout	Agro-ecological layout	- EII = Ecological Infrastructure Index - FSI = Field Size Index - BTS = Biotope Target Species

Table 2.5 Ecological infrastructure parameters and definitions

Parameter		Definition
PWE	Percentage Woody Elements	The presence of woody elements (trees, bushes, hedges, forest) on the farm in relation to the landscape.
CoLE	Connectivity Landscape Elements	The extent to which landscape elements (nodes) are connected with each other by suitable habitat for dispersal (links) of target species.
CiLE	Circuitry Landscape Elements	The extent to which it is possible for target species to move between landscape elements (nodes) through different links.
BTP	Biotopes	The degree in which biotopes, representative of the landscape that the farm is located in, are present on the farm.
BZI	Buffer Zone	Index The degree to which landscape elements (ditches, pools, bushes) are buffered from agricultural practices (pesticide drift, nutrient leaching and disturbance by agricultural traffic).
BZW	Buffer Zone	Width The average width of the buffer zones that are present on the farm.
EII	Ecological Infrastructure Index	Percentage of the farm that is managed as a network of linear- and non-linear biotopes for flora and fauna (including buffer strips).
FSI	Field Size Index	The extent to which the field sizes on the farm deviate from the “optimal” field width for stabilising the agro-ecosystem using functional biodiversity.
BTS	Biotope Target Species	Number of target species present in a biotope.

An extensive description of the parameters, including the manner in which they are calculated and tested, is given in Annex 6.

In evaluating the results of ecological infrastructure management, emphasis is placed on the difference between the current situation and the desired results (deficit). The deficits for the different parameters provide the starting point for the design of the new prototype. A new prototype aims at fulfilling all target values.

Justification of parameters
The methodology was developed in the Netherlands and only tested there up until this time. The set of parameters is, therefore, developed for the Dutch situation and may not be completely suitable for other countries. Differences in policy, legislation and landscape can make it necessary to use different target values or even different parameters for different countries. By testing the methodology in countries participating in VEGINECO, the strengths and weaknesses of the present methodology may become clear.

The parameters proposed for linking the farm to the landscape (PWE, CoLE, CiLE and BTP, see Tables 2.4 and 2.5) have recently been developed and have yet to prove their suitability in different landscapes. PWE was developed to provide a guideline for the number of woody elements on a farm that reflect the landscape surrounding the farm. The same holds true for BTP. CoLE and CiLE were derived from landscape ecology, where connectivity and circuitry are used to describe the functioning of networks (Forman & Godron, 1986). In this methodology, connectivity and circuitry are used to involve farms in creating corridors that connect natural areas. The introduction of specific stepping stones on the farm may improve the connectivity and circuitry of existing networks. Moreover, when new landscape elements are introduced on a farm, the positioning has to be evaluated regarding the connectivity and circuitry in relation with existing networks.

The environmental parameters BZI and BZW are based on pesticide drift reduction studies, which show that four-meter wide buffer zones can reduce drift to zero (Huisman et al., 1997). EII is also used in existing methodologies. FSI was developed to indicate the possibility for stabilising the agro-ecosystem of the specific farm. Expert judgement indicates that the optimal field width for terrestrial predators to reach the centre of the field is 125 meter. BTS is, as described in the previous section, not completely developed yet. It has so far only been developed for the management of grassy vegetation on dikes. Similar methods for other biotopes are now being developed. All parameters (except BTS) describe the quantity of the ecological infrastructure. It is hypothesised that if the target values of these parameters are achieved, the conditions will be present for a certain basic level of quality of nature and landscape in agricultural areas. The ultimate quality achieved depends largely on the management of the different elements. This can be evaluated with the BTS parameter. This could be accomplished by introducing a new theme with parameters, which describe the quality of the different biotopes that occur on a farm.

Relation to other methods
Ecological Infrastructure Management is related to Crop Rotation and Crop Protection. One of the objectives of Crop Rotation is to prevent pests and weeds. One of the objectives of Crop Protection is to minimise the effects of

pesticides on the environment. The EIM-parameters Field Size Index, Buffer Zone Index and Buffer Zone Width can help in preventing pests and weeds, and reducing the use of pesticides. The parameters are, therefore, partially complementary to Crop Rotation and Crop Protection.

The main objective of the EIM-parameter Field Size Index is to create an "optimal" field width for stabilising the agro-ecosystem using functional biodiversity. Herbaceous strips across and around the fields (buffer zones) are good habitats for the natural predators of pest insects. In this way, the smaller fields can help in preventing pests and reducing the use of pesticides. The herbaceous strips can also help to prevent weeds in the fields and, therefore, reduce the use of weed pesticides. The strips have to be permanent and managed in the appropriate manner. If the strips become poor due to removal of the vegetation after mowing, the weeds in the strips will decline and disappear after a few years. This results in a buffer strip without weeds that helps to reduce the amount of weeds in the fields.

Strategies

To reach the target values of the parameters described above, the current ecological values have to be strengthened and protected, incorporated into an ecological infrastructure and embedded in the landscape. Furthermore, the landscape for humans, flora and fauna has to be improved. It may also be necessary to introduce new ecological elements to reach the target values.

To achieve all these goals, different tools can be used. Before using a tool, the impact on landscape and farming system has to be examined because certain actions may have a negative effect on the landscape or the farming system. Political aspects are also important. In rural development plans, for example, preferences for the development of specific landscape elements may have been indicated.

Below the different tools will be explained and discussed. The order in which the tools are used depends on the chosen goals. For example, if the main goal of a farmer is the use of nature to improve functional biodiversity, the farmer will first develop suitable habitats for predators of pest insects as the main priority. It is important to realise that a certain tool and the accompanying measures usually serve more than one goal. The main goal of the farmer in the previous example is to develop suitable habitats for predators of pest insects, but at the same time, these habitats are also useful for buffering of ditches and connecting biotopes.

Optimising present ecological infrastructure

Why It is important to first create a good basis from which the infrastructure can be further enlarged. If this is not done, the infrastructure will grow, but the quality will be poor.

How This can be achieved by introducing the proper management, which is needed to develop the optimal quality for the projected function. The sides of a ditch, for instance, can be turned from monotonous grassy vegetation into a meadow with many species of flowers by mowing and dispersal instead of only mowing. This results in the reduction of undesired plant species (weeds) and allows plants species from areas with poorer conditions to settle in the vegetation.

Reducing agricultural influence

Why This is important because the ecological potential of the elements is allowed to develop fully.

How This can be achieved by buffering the ecologically important elements. Creating buffer strips reduces pesticide drift, nutrient leaching and disturbance caused by agricultural traffic. This leads to integration of nature and agriculture at a landscape level and to separation at a field level. The most important aspect in preventing pesticide drift and nutrient leaching is the width of the buffer strips. Buffer strips can also contribute to reduced weed pressure and the suppression of plagues in terms of functional biodiversity (see use of nature below). This can be achieved by sowing grass mixtures and developing a poor meadow by mowing and dispersal.

Developing potential

Why Developing the potential of a specific site results in farm specific qualities. At a landscape level, this will result in increased heterogeneity and variation. Biodiversity itself is not the objective, but biodiversity in relation to the specific conditions of that particular site.

How On every farm, spots can be found that are of an ecological interest. Most of the time, these spots are less important agriculturally, for example, a wet depression in a field or a corner of a field that is difficult to access with machinery. These spots can be used to develop ecological elements.

Connection with the surrounding landscape

Why Linking the ecological infrastructure on a farm with ecological elements in the surroundings is important because these connections can be used by both flora and fauna to migrate back and forth between the surrounding landscape and the farm. This dispersal is important to maintain healthy populations and also helps to increase the biodiversity on a farm.
If all the farms in an area are connected with the surrounding landscape (also with each

other), it will be possible to create connections between nature reserves. This is important for certain species. Other (larger) species need larger robust corridors for dispersal.

How Different types of connections between the ecological infrastructure on a farm and the surrounding landscape can be created: herbaceous or woody links, but also water links.
Herbaceous links are important for plants and small, terrestrial animals. These can be created by developing strips of meadow with flowers between the ecological infrastructure on the farm and ecological elements surrounding the farm. The buffer strips that reduce the influence of agriculture can be used as basis from which links with the surroundings can be created.
Woody links are important for animals that can fly in particular and can be created by planting trees and/or bushes at a certain distance. If the distance is not too large, the animals can use the woody elements to move between the ecological infrastructure on a farm and the ecological elements in the surroundings.
Water links can be created using ditches or other 'wet' elements such as pools or swampy land. These are important for certain plant species and animals such as amphibians. If the distance between wet elements is not too large, it is possible for both flora and fauna to migrate from one element to another. Wet links are not part of the methodology yet, but will probably be incorporated in the future.

Use of nature

Why Farmers can also use nature in terms of functional biodiversity. Ecological elements have a higher biodiversity than areas that are used for production and can, if they are managed in the correct manner, contain natural predators of pest insects. The predators can suppress the level of pest insects before they grow into a plague. This results in reduced use of pesticides.

How The grassy strips across fields and buffer strips around fields (between the fields and ditches/-woody elements), if they are managed in the correct manner, can contain natural predators of pest insects. For example, a strip of meadow with flowers can be sown to attract hover flies that feed on the flowers and use pest insects for their reproduction. They lay their eggs in certain pest insects and this will eventually kill the pests. Hover flies can therefore be useful in controlling populations of pest insects.

Management

Why If ecological elements are well-managed, they are ecologically more interesting, more biologically diverse, and contain more specific or even endangered species. The correct management is dependent on the intended use of an element. If ecological elements are not well managed, they can even have a negative effect (increased weeds, pest insects).

How Once the use of an ecological element is determined, the necessary management can be carried out. For example, if a buffer strip is only used to prevent pesticide drift, it is important to develop tall vegetation. In terms of management, this means that not mowing or mowing once a year is enough to reach the goal. If the objective of the buffer strip is to be a biotope for predators of pest insects (functional biodiversity), a different type of management is needed to develop a buffer strip that is suitable habitat for predators.

2.3.3 Testing and improving

In order to optimise and evaluate the methodology, it has to be tested in different situations. Whether the proposed set of parameters is the proper set is subject to testing and improvement. The relative value of a parameter is tested, for example, how sensitive, how descriptive, how indicative is the parameter? The parameters as a whole should reflect the desired target image and objectives. The parameters PWE, CoLE, CiLE, BTP and BTS will have different target values in different regions. The validity of the target values has to be tested and improved in different landscapes and with different development policies. Moreover, not all parameters may be useful to the same extent for the different countries. Given the differences in policy, legislation and landscape, it is possible that different parameters and target values are necessary for the different countries.

In the following chapters, the results of managing ecological infrastructure for the different systems in the participating countries are presented. First, the specific policy and legislation for every country is discussed, followed by the evaluation of the ecological infrastructure management in the different systems. The prototyping methodology as described in this chapter was used for the analysis of the different systems' performances. Unfortunately, the parameter BTS (Biotope Target Species) could not be used because it was not completely developed yet.

The results are presented both in a diagram for a quick general overview and in a table with the target values and the achieved values for all parameters. The most important results and possible improvements are discussed briefly.

3 A practical case of EIM in the Southwest of the Netherlands

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3.1 Policy

In the Netherlands over the past decades, quantity and quality of nature have dramatically decreased, and the characteristic Dutch landscapes have become increasingly similar. To improve the functioning of existing nature reserves, the Dutch Government has launched a national Nature Policy Plan. An important aspect of this plan is the establishment of a National Ecological Network (Ecologische Hoofdstructuur: EHS) by creating new corridors and nature development areas that connect the existing nature reserves. The aim is to enlarge the EHS to 0.7 million ha in 2018. This is 16.9% of the total surface area of the Netherlands.

Other important objectives of the policy concerning the maintenance and development of nature are:

- to develop more natural areas, forest and landscape outside of the EHS with the goal of creating natural transition-zones between nature reserves and arable land.
- to involve more individual landowners in nature conservation.
- to pay for results when the quality of nature is improved as opposed to paying a standard amount just for carrying out the prescribed obligations. This objective will be achieved by making funding dependent on the improvement in quality of nature. Concrete objectives must be met.

In order to reach these objectives, the government has increased the budget for nature management. The budget for the most important national programme was € 19 million for the year 2000. This is € 13.3 million for the 'management and development of nature' programme and € 5.7 million for the 'management and development of nature on farms' programme. The total amount was doubled in the year 2001 and will be increased to € 107 million for the year 2018, according to recent plans.

To achieve the objectives, the government created a large set of regulations. These will be discussed in the next section.

3.2 Legislation

A large number of financial assistance programmes concerning ecological infrastructure management are set up in The Netherlands. The programmes are set up at all levels: national, provincial and local council. Most programmes are at a provincial level, and only the national programmes will be discussed here (Table 3.1).

Contracts
Within each programme, different contracts are possible concerning different combinations of natural elements.

Table 3.1 National programmes concerning ecological infrastructure management

Programme	Objectives
Green projects (fiscal)	Stimulation of green projects with low interest loans.
Resolution project contributions to valuable cultural landscapes (regional level)	Maintenance and improvement of natural, landscape and cultural values and the attractiveness to society of the appointed areas. Stimulation of sustainable agriculture and reduction of the friction between agriculture, nature, landscape and recreation.
Regionally-directed environmental policy (regional level)	Sustainable maintenance of areas in the National Ecological Network.
Programme management and development of nature	Farmers can cost-effectively maintain nature and natural elements on their land.
Contribution programme for landscape maintenance	Provision with a financial contribution for the construction of natural elements in the landscape.
Tree fund	Support for the maintenance of monumental trees.
Compensation programme for game animal damage	Restriction of game animal damage.

The most important programme concerning ecological infrastructure management is the ‘Programme management and development of nature’. This is the application of EU rule 2078/92. At the end of 1998, 37 724 ha were managed under this programme. Under this programme, there are two main projects: one for nature in general and one for nature on farms. The project ‘management and development of nature on-farm’ contains four possible financial assistance opportunities:

Subsidy for maintenance
If the goals are reached, 100% of the subsidy is granted. If not, but the correct measures have been taken, a reduction of 15% is applied. The amount of the subsidy depends on the soil type (peat, clay, sand).

Subsidy for implementation
This subsidy can be received for the creating of natural elements. After this period, a subsidy for maintenance can be received.

Subsidy for landscapes
This subsidy can be received for preserving landscape elements (only in reserved areas).

Subsidy for natural handicaps
This subsidy is additional and can be received for not changing parcel structures, soil structures, water levels or existing landscape elements. The farmer can receive this if he or she receives the maintenance subsidy for at least 30% of the parcels.

Financial assistance is only granted in areas that are reserved for the development of nature on farms. This rule applies for each contract, except for quick-growing forests. The provincial government determines the areas. The policy is to choose areas in the vicinity of the EHS. In this way, natural transition-zones between nature reserves and arable land are created.

Application for financial assistance is handled by the National Service for Regulations (Landelijke Service bij Regelingen: LASER) and the Service Rural Area (Dienst Landelijk Gebied: DLG). If the assistance is granted, the funding may be controlled by DLG. If a farmer does not fulfil the requirements, the financial assistance may be withdrawn and payments may be reimbursed.

Within the project ‘management and development of nature on-farm’, contracts for pastures, arable land and landscape maintenance are possible. The most important contracts for arable land are shown in Table 3.2.

Objectives of the programme management and development of nature on farm for the different contracts are:
1. Maintenance of natural handicaps.
2. Prevention of negative influence to nature reserves and natural elements (buffer objective).
3. Maintenance and development of a good biotope for fauna.

For each type of contract, there are specific requirements. For example, the requirements for the ‘fauna in the field’ contract are given in Table 3.3.

Table 3.2 Possible contracts for arable land

Type	Objectives	Length of contract	Subsidy (€ per ha per year)
Fauna strip (suitable habitat for fauna)	3	6 years	Clay: 1 691 – 2 546* Sand: 1 332 – 2 187*
Rotating grain part	1, 2, 3	6 years	427
No chemicals and fertilisers	1, 2, 3	6 years	591
Fauna in the field	3	6 years	586
Flora in the field	1, 2, 3	6 years	577
Flora strip	1, 2, 3	6 years	564
Refugee for fauna	3	6 years	Clay: 445 Sand: 373
Quick-growing deciduous forest		6 years	545
Quick-growing coniferous forest		6 years	545

* In the range that is shown, the lowest values are the basic amounts. Supplements are:
1. € 636 for leaving the strip in the winter until at least March 1st,
2. € 82 for each period (May until November) in which the fauna strip remains in t the same place,
3. € 136 for sowing herbaceous seeds or leaving a fallow bed.

Explanation: The policy for granting subsidies is based upon compensation of the loss of yield due to the decreased surface for crop cultivation. The supplements are a result of this compensation principle. For a fauna strip rotating with grain, the basic amount of subsidy is received. If the fauna strip remains in the same place, another crop will be cultivated next to the strip. It is likely that this crop will yield more in comparison to grain, so the loss of yield will be higher. For this reason, a supplement can be received.

Table 3.3 The requirements for the 'fauna in the field' contract

Requirements
1. The maintenance area is used for arable land. 2. Grain (no maize) is cultivated in the maintenance area every sixth year. 3. At least 20 indigenous plant species are present within a surface area of 25 m^2 in the maintenance area in the sixth year. 4. The maintenance area is at least 0.5 ha. 5. Grain (with exception of maize) is cultivated at least five out of the six years in the maintenance area. 6. Chemical pesticides are forbidden to be used in the years in which grain is cultivated. 7. Spots of *Cirsium arvense, Rumex obtusifolius, Galium aparine* may be chemically controlled. 8. Mechanical weeding and soil cultivation are not allowed from the first of April until the harvest.

The requirements for the different contracts do not indicate any connection with the surrounding landscape. However, concepts are being developed with the aim of integrating the ecological infrastructure on a farm into the surrounding landscape. The main objectives are to connect natural elements on a farm with the surrounding nature and to create a natural landscape. In other words, the characteristics of the farm must fit with the characteristics of the landscape.

3.3 Results

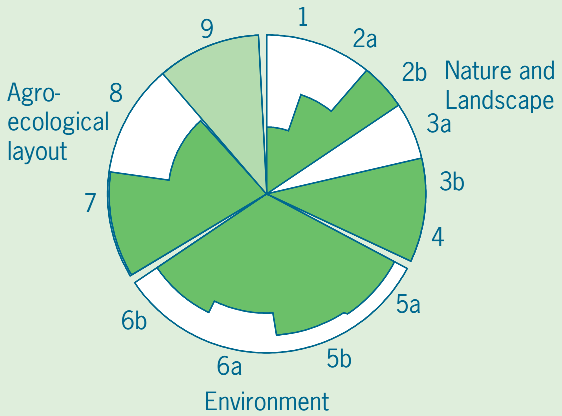
In the Netherlands, the integrated and organic systems at Westmaas (NL INT1, NL INT2 & NL ORG) in the Southwest of the Netherlands were used to evaluate the ecological infrastructure management. A description of the systems is given in Annex 1.

Landscape

The farming system in Westmaas is situated in an area called the Hoeksche Waard polder. Polders are reclaimed land. This is an island that was reclaimed from the sea in the period 1000 until 1600 A.D.. Characteristics of this region are the open landscape and the relative silence in this area, which contrasts with the highly populated city of Rotterdam, located nearby. Many dikes can be seen in the landscape because the land was reclaimed over a long period of time. On these dikes, the houses and farms were built. Between the houses, the dikes were planted with trees. These corridors of dikes lined with houses and trees are an important characteristic in the landscape. Other important landscape elements are the networks of small rivers on the island, which originally were connected with the sea. The largest part of the Hoeksche Waard is used for agriculture.

Rural development plans

The most important objectives stated in rural development plans are the maintenance and reconstruction of important landscape characteristics in the Hoeksche Waard. Emphasis is on the open landscape. To achieve this, the polders need to remain completely open and the pattern of dikes can be maintained by planting trees on these dikes or along the waterways. The old rivers must become visible again in the landscape. Recreation has to be encouraged in this region. Agriculture is important to keep the landscape open.
Figure 3.1 shows an overview of the results of managing ecological infrastructure in the Westmaas system.
The specific target values and the values reached are presented in Table 3.4.



Legenda
1. Percentage woody elements
2a. Connectivity woody elements
2b. Connectivity herbal elements
3a. Circuitry woody elements
3b. Circuitry herbal elements
4. Biotopes
5a. Bufferzone index ditches
5b. Bufferzone index woody elements
6a. Buffer zone width ditches
6b. Buffer zone width woody elements
7. Ecologiscal infrastructure index
8. Field size index
9. Biotope target species

Figure 3.1 Results of managing ecological infrastructure in the farming system in Westmaas in 1999. The outside of the circle represents the specific target value for each parameter. When a segment is filled, the target value has been reached. The light green area (biotope target species) was not measured.

Table 3.4 Parameters with target values, achieved values and results of Westmaas

Parameter	target value	achieved	result
Nature and landscape			
1. Percentage of woody elements	30%	12.5%	42%
2a. Connectivity woody elements	50%	33%	66%
2b. Connectivity herbaceous elements	50%	133%	100%
3a. Circuitry woody elements	100%	0%	0%
3b. Circuitry herbaceous elements	100%	100%	100%
4. Biotopes	3	4	100%
Environment			
5a. Buffer zone index ditches	1	0.91	91%
5b. Buffer zone index woody elements	1	0.89	89%
6a. Buffer zone width next to ditches	4 m	3 m	75%
6b. Buffer zone width next to woody elements	4 m	3.3 m	83%
Agro-ecological layout			
7. Ecological infrastructure index	5%	4.9%	98%
8. Field size index	<125 m	230 m	58%
9. Biotope target species	-	-	-

Figure 3.2 Small woody element (willow) in a buffer strip that functions as a stepping-stone to create connectivity and circuitry

Figure 3.3 Buffer zone next to a ditch, which is being developed into a strip of meadow, one year after sowing grass

The greatest deficits in the system occur within the theme nature and landscape. The percentage of woody elements is too low in relation to the surrounding landscape. The connectivity and especially the circuitry of woody elements are not sufficient, although there are some woody links between biotopes (Figure 3.2). Most ditches and woody elements have buffer zones next to them (Figure 3.3). The target values for the width of the buffer zones are almost reached. There is still a great deficit in the field size index because fields are relatively large (230 m).

To reduce the greatest deficits, it is necessary to plant woody elements and to create smaller fields. When woody elements are planted, regional policy has to be taken into account. For Westmaas, this means that trees have to be planted on dikes or along the waterways to emphasise these patterns. If this is not enough to reach the target value, small bushes can also be planted, but the landscape has to remain open. By planting trees and bushes, the percentage of woody elements increases and also the connectivity and circuitry increases. To make the fields smaller, grassy strips across the fields can be developed. If these strips are managed correctly, they can be developed into strips of meadow, which are a good habitat for predators of pest insects.

4 A practical case of EIM in Emilia-Romagna, Italy

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4.1 Policy

In Italy, there is no policy concerning ecological infrastructure management at national level, only at the regional level. The regional government is stimulating the farmers to apply for financial assistance programmes. During the past three years, the regional governments spent an estimated € 2.8 million per year on the programmes concerning the maintenance of nature and another € 5.5 million per year on the programmes concerning the reduction of the surface area used for arable crops and development of ecosystems. In the future, the level of financial assistance will depend on the content of Agenda 2000.

The concept of land use has been laid down in the Territorial Landscape Regional Plan (Piano Territoriale Paesistico Regionale: P.T.P.R.), which has been in operation since 1993. The P.T.P.R. is an important instrument for appointing priority areas for introduction and maintenance of nature and natural elements on farms. The plan distinguishes 23 types of landscape based on different characteristics, derived from soil maps, maps of land use, morphological maps and maps of geo-environmental risks (1:50 000 and 1:25 000). Each province has to make its own local land use plan (1:10 000). Only a few provinces have done this up until now.

The objectives for land use have been laid down in the Regional Rural Development Plan that represents the application of the EU rule 2078/92. The Regional Rural Development Plan promotes a sustainable development of the environment. This can be an advantage for agricultural and rural development; therefore, it is not only an advantage for the health in general. With this plan, farmers can receive subsidies from the EU from 2000 until 2006. The subsidies are thought to be of great importance for stimulating the farmers to introduce and manage natural elements.

4.2 Legislation

Legislation for managing ecological infrastructure is handled at the regional level. There is no national legislation. Therefore, differences between different regions are possible. In the region of Emilia-Romagna, the 'Agro-environment regional programme' has been in use since 1993. Concerning ecological infrastructure management, this programme has two projects: maintenance of nature and reduction of the surface area used for arable crops to develop ecosystems. The objectives of the programmes are shown in Table 4.1. These objectives are applications of the Regulations EU 92/2078, EU 92/43 and EU 79/409.

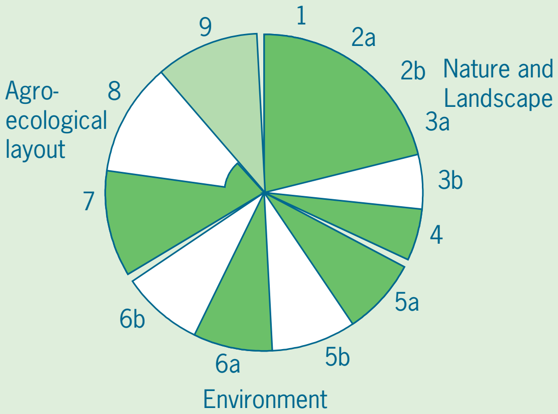
Possible contracts
Within each programme, several contracts can be signed. An overview of the contracts available is given in Annex 5. Farmers can sign a contract if they can prove that they are the manager of the farm, by providing specific documents such as a map of the farm and a plan of action. When a contract is signed, the farmer can decide which type of management and how much surface area will be reserved for nature.

A provincial government inspector checks the farmer's compliance to the requirements. If the farmer does not fulfil the contract properly, the farmer has to change the incorrect practices and the subsidy may be reduced. If the farmer does not change the incorrect practices, the contract may be ended and the farmer could be required to return the financial assistance already received.

Contracts may differ between areas. Certain areas are designated as priorities and the subsidies are higher. Priority is, for instance, given to areas with cultural or historical elements.
Two examples are:
1. The re-establishment of wet zones in areas where there used to be natural marshes.
2. The maintenance of rows of trees that support grapevines at locations where these rows of trees historically occurred.

Table 4.1 Objectives of the programmes concerning ecological infrastructure management

Programme	Objectives
Maintenance of nature	• Maintenance and development of natural elements • Development of cover crops • Husbandry of species at risk of extinction
Reduction of the surface area used for arable crops	• Creation of wet zones and bush-clearing systems • Natural areas • Safeguarding hydrological systems



Legenda
1. Percentage woody elements
2a. Connectivity woody elements
2b. Connectivity herbal elements
3a. Circuitry woody elements
3b. Circuitry herbal elements
4. Biotopes
5a. Bufferzone index ditches
5b. Bufferzone index woody elements
6a. Buffer zone width ditches
6b. Buffer zone width woody elements
7. Ecologiscal infrastructure index
8. Field size index
9. Biotope target species

Figure 4.1 Results of ecological infrastructure management for the Integrated Industrial system in 1999. The outside of the circle represents the specific target values for each parameter. When a segment is filled, the target value is reached. The light green area (biotope target species) was not measured.

4.3 Results

In Italy, two farming systems in the eastern part of the Emilia-Romagna region are evaluated for ecological infrastructure management: the integrated industrial system (I INT1) and the organic system (I ORG). A description of the systems is shown in Annex 1.

4.3.1 Integrated industry system

Figure 4.1 shows an overview of the results of the ecological infrastructure management in the integrated industrial system. The specific target values and the achieved values are presented in Table 4.2.

The results of the system for the theme nature and landscape are very good. Only one target was not reached (circuitry herbaceous elements). The greatest deficits in the system occur within the theme environment because of the absence of buffer zones next to woody elements. There are buffer zones next to all the ditches and they all reach the target of 4 m. The field sizes are large in this system with the average field size of 313 m. This results in a great deficiency in this parameter.

To reduce or even remove the deficits in the system, it is necessary to create circuitry with herbaceous elements and to create four-meter wide buffers next to woody elements. Also the field size has to be decreased. Creating a network of four-meter wide herbaceous buffer strips next to woody elements, across fields and between

Table 4.2 Parameters with target values, achieved values and results of the integrated system

Parameter	target value	achieved	result
Nature and landscape			
1. Percentage of woody elements	14%	40%	100%
2a. Connectivity woody elements	25%	25%	100%
2b. Connectivity herbaceous elements	25%	100%	100%
3a. Circuitry woody elements	14%	100%	100%
3b. Circuitry herbaceous elements	14%	0%	0%
4. Biotopes	2	4	100%
Environment			
5a. Buffer zone index ditches	1	1	100%
5b. Buffer zone index woody elements	1	0	0%
6a. Buffer zone width next to ditches	4 m	4 m	100%
6b. Buffer zone width next to woody elements	4 m	0 m	0%
Agro-ecological layout			
7. Ecological infrastructure index	5%	12%	100%
8. Field size index	<125 m	313 m	25%
9. Biotope target species	-	-	-

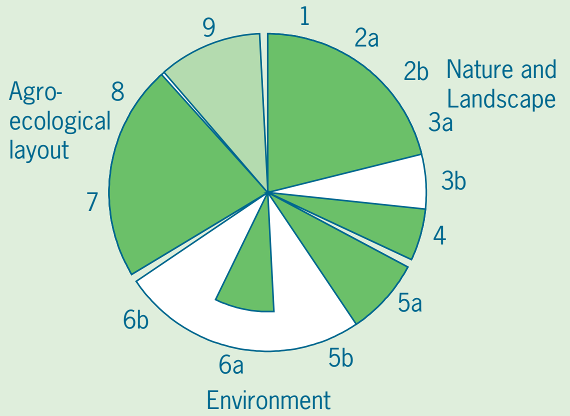


Figure 4.2 Results of ecological infrastructure management for the organic farming system in 1999. The outside of the circle represents the specific target values for each parameter. When a segment is filled, the target value is reached. The light green area (biotope target species) was not measured.

biotopes can solve all of these deficits. The best way to achieve this is sowing four-meter wide grassy strips, followed by the proper management to make the strips ecologically more interesting.

4.3.2 Organic system

Figure 4.2 shows an overview of the results of the ecological infrastructure management in the organic system. The specific target values and the achieved values are presented in Table 4.3.

The results obtained in this farming system are very similar to the results obtained in the integrated industrial system.

There are two differences:

1. The buffer zones next to the ditches are one meter smaller, explaining the deficiency in parameter 6a.
2. The target value for the field size index is fully reached in this system.

To remove the deficits in the system, it is necessary to create circuitry through herbaceous elements, to create four-meter wide buffer zones next to woody elements and to enlarge the buffer zone width next to ditches by one meter. All these deficits can be removed by developing grassy strips. To buffer woody elements and to create circuitry between biotopes, four-meter wide strips have to be created. Next to ditches only one additional meter has to be created. By managing the strips well, they can be made ecologically more interesting.

Table 4.3 Parameters with target values, achieved values and results for the organic system

Parameter	target value	achieved	result
Nature and Landscape			
1. Percentage of woody elements	0%	100%	100%
2a. Connectivity woody elements	33%	100%	100%
2b. Connectivity herbaceous elements	33%	50%	100%
3a. Circuitry woody elements	33%	100%	100%
3b. Circuitry herbaceous elements	33%	0%	0%
4. Biotopes	2	4	100%
Environment			
5a. Buffer zone index ditches	1	1	100%
5b. Buffer zone index woody elements	1	0	0%
6a. Buffer zone width next to ditches	4 m	3 m	75%
6b. Buffer zone width next to woody elements	4 m	0 m	0%
Agro-ecological layout			
7. Ecological infrastructure index	5%	7.6%	100%
8. Field size index	<125 m	<125 m	100%
9. Biotope target species	-	-	-

5. A practical case of EIM in the Valencian Community, Spain

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5.1 Policy

The Spanish policy on nature is the Conservation of Natural Spaces and Wild Flora and Fauna. There are four different types of protected areas: parks, nature reserves, natural monuments and protected landscapes. In Spain, there are 560 protected areas with a surface area of 3 159 641 ha (about 6.2% of the total surface area). In the Valencia region, there are 13 protected areas with a surface area of 38 420 ha (1.6% of the total area).

Other protected areas are combined with international regulations, these are:
- Special Zones for the Protection of Birds (European Union)
- Marsh Lands of Special Interest (Ramsar Agreement)
- Reserves of the Biosphere (UNESCO)
- Network Natura 2000 (European Union)

The level of detail in the plans on land use is at the regional level, the scale of the maps is 1:10 000. The plans are thought to be a good starting point for general nature management, but they are insufficient for nature management at the farm level.

The main national and regional policy on rural development is based on the frame of farming methods compatible with the environment (EC directive 2078/92).

5.2 Legislation

The Spanish rule Real Decreto 4/2001 regulates the subsidies for agricultural production methods to protect the environment. The promoted activities that are related to ecological infrastructure management are:
1. extensification of the farming system,
2. protection of flora and fauna in humid zones,
3. protection of landscapes,
4. development of natural elements and cover crops,
5. measures to prevent (spreading of) fire.

Contacts
Researchers are interested in projects concerning ecological infrastructure management. They have several ideas for possible contracts in the future (Table 5.1):
- For every arable area that is changed into a natural area in the Valencia region, a farmer must be able to receive subsidy, regardless of the type of area.
- Farmers must be able to influence some aspects of the project, for example, the surface area that is reserved for nature, the species of plants, and management.
- Organic farmers could be monitored by the Ecological Agricultural Committee, which has the responsibility to check if production follows the rules of the European Union. Integrated farms could be monitored by the farming advisors of co-operatives (ADV technicians) and members of the Agricultural Extension Service.

5.3 Results

In Spain, two systems in the Valencian Community have been evaluated for ecological infrastructure management: the integrated system in Benicarlo (ES INT2) and the integrated and organic system in Paiporta (ES INT3 & ES ORG). A description of the systems is given in Annex 1.

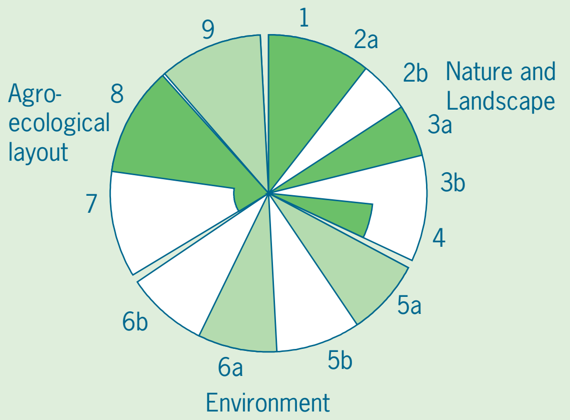
5.3.1 Benicarlo

Figure 5.1 shows an overview of the results of ecological infrastructure management in the integrated system in Benicarlo followed by Table 5.2 with the specific target values and achieved values.

In the integrated system in Benicarlo, deficits are present for connectivity and circuitry of herbaceous elements and

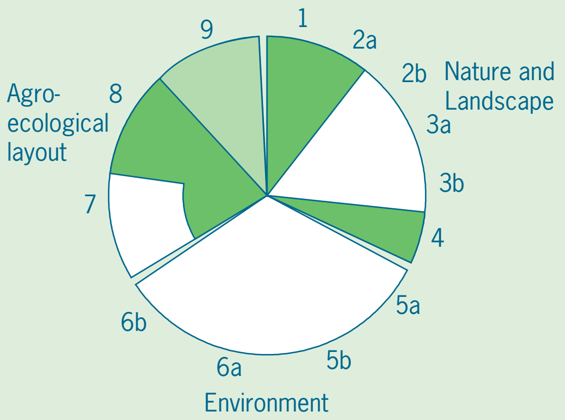
Table 5.1 Researchers' ideas for possible contracts concerning ecological infrastructure management

Contract	Requirements	Length of the contract	Subsidy € per ha per year
Strips of flowerbeds at the borders of a field	To establish a strip of flowering plants and perennial grasses in which pesticides and herbicides are not used. The width of the strip is at least one meter.	At least four years	250
Crop rotation	To sow plants for green manure at least once every four years, without the use of fertilisers or pesticides.	At least four years	150
Hedges	To establish hedges of shrubs or trees. The width of a hedge is at least 1 m. Uncultivated strips are not feasible in the economic point of view.	At least six years	250



Legenda
1. Percentage woody elements
2a. Connectivity woody elements
2b. Connectivity herbal elements
3a. Circuitry woody elements
3b. Circuitry herbal elements
4. Biotopes
5a. Bufferzone index ditches
5b. Bufferzone index woody elements
6a. Buffer zone width ditches
6b. Buffer zone width woody elements
7. Ecologiscal infrastructure index
8. Field size index
9. Biotope target species

Figure 5.1 Results of ecological infrastructure management for the integrated system in Benicarlo in 1999. The outside of the circle represents the specific target values for each parameter. When a segment is filled, the target value is reached. The light green areas were not measured. Buffer zone index ditches and buffer zone width ditches could not be measured because there are no ditches on the farm.



Legenda
1. Percentage woody elements
2a. Connectivity woody elements
2b. Connectivity herbal elements
3a. Circuitry woody elements
3b. Circuitry herbal elements
4. Biotopes
5a. Bufferzone index ditches
5b. Bufferzone index woody elements
6a. Buffer zone width ditches
6b. Buffer zone width woody elements
7. Ecologiscal infrastructure index
8. Field size index
9. Biotope target species

Figure 5.2 Results of ecological infrastructure management for the integrated and organic system in Paiporta. The outside of the circle represents the specific target values for each parameter. When a segment is filled, the target value is reached. The light green area (biotope target species) was not measured.

Table 5.2 Parameters with target values, achieved values and results of the system in Benicarlo

Parameter	target value	achieved	result
Nature and landscape			
1. Percentage of woody elements	44%	45%	100%
2a. Connectivity woody elements	28%	100%	100%
2b. Connectivity herbaceous elements	28%	0%	0%
3a. Circuitry woody elements	20%	100%	100%
3b. Circuitry herbaceous elements	20%	0%	0%
4. Biotopes	3	2	66%
Environment			
5a. Buffer zone index ditches*	x	x	x
5b. Buffer zone index woody elements	1	0	0%
6a. Buffer zone width next to ditches*	x	x	x
6b. Buffer zone width next to woody elements	4 m	0 m	0%
Agro-ecological layout			
7. Ecological infrastructure index	5%	1.1%	22%
8. Field size index	<125 m	<125 m	100%
9. Biotope target species	-	-	-

* There are no ditches on the farm.

Table 5.3 Parameters with target values, achieved values and results of the system in Paiporta

Parameter	target value	achieved	result
Nature and landscape			
1. Percentage of woody elements	0%	28%	100%
2a. Connectivity woody elements	50%	50%	100%
2b. Connectivity herbaceous elements	50%	0%	0%
3a. Circuitry woody elements	100%	0%	0%
3b. Circuitry herbaceous elements	100%	0%	0%
4. Biotopes	2	4	100%
Environment			
5a. Buffer zone index ditches	1.34	0	0%
5b. Buffer zone index woody elements	1.63	0	0%
6a. Buffer zone width next to ditches	4 m	0 m	0%
6b. Buffer zone width next to woody elements	4 m	0 m	0%
Agro-ecological layout			
7. Ecological infrastructure index	5%	2.63%	53%
8. Field size index	<125 m	<125 m	100%
9. Biotope target species	-	-	-

for the entire environment section (buffer zone index and buffer zone width). Also the ecological infrastructure index has a large deficit. The reasons for these deficits are the absence of buffer zones in the system. The parameters for ditches could not be measured because there are no ditches on the farm so this parameter is not applicable. The targets for percentage, connectivity and circuitry of woody elements, and for the parameter field size index are easily reached because this system is relatively small and surrounded by hedges.
The best way to remove the deficits in the system is sowing four-meter wide, grassy strips next to the woody elements on the farm and between the biotopes. This will result in sufficient buffering of the woody elements, connectivity and circuitry with herbaceous elements and an increase of the ecological infrastructure index. If the grassy strips are well managed, they will become ecologically more interesting.

5.3.2 Paiporta

Figure 5.2 shows an overview of the results of ecological infrastructure management in the integrated system in Paiporta followed by Table 5.3 with the specific target values and achieved values.

In this system, most deficits are present in the themes nature and landscape and environment. Most deficits are the result of the absence of buffer zones. If four-meter wide buffer zones were present, the category environment would be filled and the connectivity and circuitry of herbaceous elements and the ecological infrastructure index would also increase. The same holds true for the Paiporta system as well as for the Benicarlo system: introduction of buffer zones by sowing grassy strips followed by good management will result in most targets being reached.

6 A practical case of EIM in Switzerland

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This chapter is extensive because a comparison is made between the evaluation of ecological infrastructure management in the "VEGINECO method" and the evaluation done with the "Swiss method". The comparison is made between two pilot farms: one with connected fields adjacent to the farm building and one with small fields scattered over a larger area.

6.1 Policy

The landscape concept of the Swiss government promotes the sustainable development of landscape in Switzerland. The main objectives are:

- conservation of nature and landscape for now and for the generations to come,
- respect for nature and landscape,
- conservation and promotion of landscapes as environments in which humans, animals and plants can live,

Table 6.1 Types of ecological infrastructure additional subsidised by the Swiss government since 1999

Type	Requirements	Length of contract	Subsidy in € per year
Extensive meadow	First cut not before June 15, removal of grass compulsory, pasture in autumn allowed, neither fertilisation nor pesticide applications except the treatment of single plants, minimum of five are per plot.	at least 6 years at one site	279 – 929 per ha*
Less intensive meadow	Requirements such as extensive meadow, fertilisation after the first cut allowed, in maximum 30 kg N per ha and year as manure, compost or slurry, minimum of five are per plot.	at least 6 years at one site	186 – 403 per ha*
Bedding areas	First cut after September 1, cutting once per year maximum or once in three years minimum, removal of grass compulsory, neither fertilisation nor pesticide input, minimum of five are per plot	at least 6 years at one site	279 – 929 per ha*
Flowerbed strip at crop border (Ackerschonstreifen)	Extensive cultivation of a crop border without weed and pest control except treatments of single plants, no N supply, threshing at maturity, width of the strip 3-12 m.	2 years at one site at least	620 per ha
'Coloured fallow beds' instead of crop (Buntbrache)	Sown meadows with flowers instead of crop, only with registered seed mixture, no fertilisation, no pesticide applications except the treatment of single plants, in the first year cut for cleaning allowed, from the second year on cutting of 50% of the coloured fallow between October 1 and March 15 allowed, at least 3 m wide.	at least 2 years and maximum 6 years at one site	1 859 per ha
'Rotation fallow' instead of crop (Rotationsbrache)	Sown flowering meadows instead of the crop, only with registered seeds mixture, no fertilisation, no pesticide input except the treatment of single plants, cutting allowed between October 1 and March 15, at least 20 acres and 6 m wide.	at least 1.5 years and maximum 2.5 years at one site	1 549 per ha
Field fruit trees	Density of trees less than in orchards, height of the first main branches at least 1.2 m for stone fruits and 1.6 m for pome, at least 20 trees per farm.	-	9 per tree
Hedges, groves	Low or high hedges, hedges of trees, groves, screens or tilled slopes, with buffer strips on both sides of at least 3 m wide, cut buffer strips not before June 15, removal of grass, at least 5 acres .	at least 6 years	279 – 929 per ha*

* dependent on the cultivation zone defined by altitude, topography, precipitation, and distance to the next village

- sustainable development of landscape as native place, cultural estate, economic and recreational area.

The specific objectives for agriculture concerning nature on farms are:
- using ecologically harmless farming methods,
- 65 000 ha of arable land should be converted into ecological infrastructure to conserve the native biodiversity,
- promotion of ecological infrastructure especially in areas with high ecological value,
- support of traditional crops and traditional ecological farming methods.

Objectives combined with land consolidation:
- conservation of ecological infrastructure to conserve biodiversity and environment,
- support of the development of site-specific cultivation.

The Swiss regional governments (cantons) created landscape development concepts that stress sustainable development. To achieve the objectives, pilot projects have been started. The Swiss government supports these concepts with legislation, information and subsidies.

The Swiss government increased the subsidy from € 335 million in 1996 to € 462 million in 1998. In 1999, the governments of the cantons Bern and Aargau each spent € 1.9 million on subsidies for ecological infrastructure in agriculture.

The Swiss government tries to improve the extensiveness in the most intensively used areas (the flat areas). For this reason, farmers in these areas can receive the highest amounts of subsidy. For example, subsidy for flowerbed strips can only be received in intensively used, flat areas. The regional governments (cantons) also encourage the farmers to farm less intensively by means of subsidies. Possible projects differ between different regions.

6.2 Legislation

In January 1999, new legislation became operational with the possibility of direct subsidies for Swiss farmers. The Swiss government supports farming systems that comply with the ecological requirements, up to € 744 per ha. The amount depends on the size of the farm, the farmer's income and properties. According to these requirements, 3.5 – 7.0% of the farm surface area has to be reserved for nature, 3.5% for vegetable crops and 7% for arable crops. Fruit trees can be counted also as ecological infrastructure. One tree is equivalent to one are. The number of trees that can be counted is limited to half of the target area.

Additional ecological subsidies can be received for selected types of natural systems. Sixteen types of natural infrastructure have been described (Table 6.1). A farmer can sign a contract concerning the maintenance of a particular type, so the different types of natural infrastructure reflect the contracts that are available. The maximum amount of subsidy is granted to 50% of the surface area of the farm.

Some requirements in the contract can be changed after consultation, for example, the date for cutting extensive meadows, with the aim to decrease the amount of nutrients in the soil.

Monitoring is executed by private, professional organisations under federal inspection. They monitor 30% of the integrated and organic farms every year. Starters and farmers who did not fulfil the requirements in the previous year are inspected too.

6.3 Results

6.3.1 Introduction

A member of the Swiss team (FAW) spent four days at the research station in Lelystad (Netherlands) to work on ecological infrastructure management. During this time, the VEGINECO evaluation method with its parameters and target values was explained and discussed, and first steps to adapt it to a Swiss pilot farm (Wauwiler Moos) were made. This farm was selected because all of the fields are connected and adjacent to the farm building, which is very similar to Dutch farms. Next another Swiss pilot farm (in Attiswil) was evaluated. It represents a typical Swiss farm where the fields are small, not connected and dispersed over a larger area.

6.3.2 General situation at Swiss pilot farms

Development of ecological infrastructure (1997-2000)

All integrated and organic pilot farms fulfilled the Swiss requirements of direct payments in 1997, 1998, 1999 and 2000 (Table 6.2). The size of the ecological infrastructure area showed a greater variation in 1999 due to the new legislation and the restructuring of vegetable farms (e.g. pilot farm 7). In 1999, pilot farm 7 had the smallest area of ecological compensation of 3.9%. This was the only time a farm did not achieve the VEGINECO target of 5%. Pilot farm 10 had the largest area of ecological compensation in 1999 with 36.7% of the farm surface area. In 2000, the farm with the smallest area of ecological compensation was pilot farm 3 and the farm with the largest area was, as in the years before, pilot farm 10. The average of the ecological infrastructure area of the pilot farms increased in total from 11.4% in 1997, 11.5% in 1998 and 11.8% in 1999 to 12% in 2000. The comparison of the means for both farming systems shows that the majority of the organic pilot farms have a larger area of ecological

Table 6.2 Ecological infrastructure areas per pilot farm (% of the farm) in 1997, 1998, 1999 and 2000. The Swiss target value was 5% in 1997 and 1998. The target value in 1999 and 2000 is shown between brackets because it varies. The VEGINECO target value is 5%.

Pilot farm, label	1997	1998	1999	2000
1. integrated	5.4	5.3	6.2 (3.8)	5.2 (3.8)
2. integrated	5.7	7.1	6.1 (4.3)	8.7 (4.3)
3. integrated	5.5	5.5*	6.1 (3.5)	5.0 (3.9)
4. integrated	6.8	6.3	5.5 (4.5)	6.1 (4.4)
5. iintegrated	5.5	7.6	7.4 (6.3)	7.0 (6.2)
6. integrated	10.4	10.4	8.8 (6.7)	8.9 (6.8)
7. integrated	6.7	6.8	3.9 (3.5)	5.8 (4.0)
average integrated	**6.6**	**7.0**	**6.3 (4.7)**	**6.7 (4.8)**
8. organic	22.0	16.7	24.1 (5.8)	23.0 (5.5)
9. organic	7.0	5.4	7.9 (6.7)	8.2 (6.7)
10. organic	23.4	27.4	36.7 (6.3)	37.2 (6.0)
11. organic	23.1	20.0*	9.0 (4.3)	11.9 (4.7)
12. organic	12.0	11.2	8.2 (4.1)	8.2 (4.1)
13. organic	20.4	17.3	16.8 (5.6)	15.5 (5.8)
14. organic	6.3	14.0*	17.9 (3.5)	-
average organic	**16.3**	**16.0**	**17.2 (5.2)**	**17.3 (5.5)**

* Assessed

compensation than the integrated pilot farms in the four years presented.

Figure 6.1 Extensive meadows „Reckenacker 19" on pilot farm 6

Main types of ecological infrastructure

The main types of ecological infrastructure did not change in this period (1997-2000). The most important type has been extensive meadow (Table 6.3). Apart from the extensive meadows, standard field fruit trees and hedges are found on the majority of the Swiss pilot farms. Less intensive meadows, bedding areas, rotation or coloured fallows, native site-specific trees and natural field paths are less important. Ponds or ditches, gravel areas and flowerbed strips in addition to the crops are rarely found as ecological infrastructure.

Quality of ecological infrastructure: investigation of extensive meadows

Extensive meadow is the most important type of ecological infrastructure in Swiss pilot farms. In 1998, only 8% of all of the agricultural area in Switzerland was area of ecological compensation. 85% of this area was extensive meadows or less intensive meadows (Walter, 2000). Therefore, it is interesting to do a more detailed examination of the type extensive meadow.
The requirements for ecological

Table 6.3a Inventory of ecological infrastructure at Swiss pilot farms in 1999 (ares/type)

pilot farm, label	Ecological infrastructure					
	extensive meadows or pastures*	less intensive meadows	bedding areas	Flowerbed strips (crop border)	gravel areas	rotation or coloured fallows*
1. integrated	78.8		-	-	-	-
2. integrated	19.0	12.0	20.0	-	6.0	-
3. integrated	-	-	75.0	-	-	-
4. integrated	145.0	-	-	-	-	-
5. integrated	38.0	-	-	-	-	-
6. integrated	83.6	-	-	-	-	-
7. integrated	14.0	-	-	-	-	-
8. organic	153.0	100.0	-	-	-	-
9. organic	667.5	56.5	74.8	-	-	38.0
10. organic	147.0	85.0	-	-	-	59.0
11. organic	40.0	-	-	8.0	-	20.0
12. organic	158.0	-	-	-	-	-
13. organic	-	127.0	-	-	-	-
14. organic	178.0	-	-	-	-	-
% of total area	**54.9%**	**11.5%**	**5.1%**	**0.2%**	**0.2%**	**3.5%**

* in the Swiss requirements each is defined as a special type

Table 6.3 b Inventory of ecological infrastructure at Swiss pilot farms in 1999 (are/type)

pilot farm, label	Ecological infrastructure				
	standard field fruit trees*	native site specific trees*	hedges	ponds, ditches	natural field paths
1. integrated	65.0	-	-	-	-
2. integrated	-	-	-	11.0	8.0
3. integrated	-	-	-	-	-
4. integrated	-	-	-	-	-
5. integrated	2.0	-	-	-	-
6. integrated	59.0	-	12.0	-	-
7. integrated	-	-	9.0	-	10.0
8. organic	33.0	3.0	19.0	-	10.0
9. organic	20.0	38.0	234.8	60.7	-
10. organic	28.5	-	11.0	-	-
11. organic	24.0	1.0	10.0	-	3.0
12. organic	39.0	-	-	-	-
13. organic	-	-	99.0	-	-
14. organic	6.0	-	-	-	-
% of total area	**8.3%**	**1.3%**	**11.9%**	**2.2%**	**0.9%**

* One tree is equivalent to one are, only the number of trees counted as ecological infrastructure is given

infrastructure in Switzerland include the following for extensive meadows: first cut not before June 15th, removal of grass is compulsory, pasture in the autumn is allowed, neither fertilisers nor pesticides are allowed except for the treatment of individual plants.
Seven extensive meadows on integrated and organic farms were investigated in early spring, late spring and summer 1999. The surroundings and structural elements as well as the biodiversity were assessed with the use of an official Swiss key from “service romand de vulgarisation agricole” and “Landwirtschaftliche Beratungszentrale Lindau” (Charollais et al., 1997).

Criteria of evaluation

Surroundings and structural elements:

- distance to the next natural habitat,
- presence or absence of damp or sandy places, hilltops, and hollows,
- number of structural elements such as single trees or bushes, ditches or waterways, heaps of stone or branches, pieces of dead wood, dead trees or tree stumps, and old uncut grass.

Biodiversity:

- colours in the meadow two weeks before cutting,
- plant density in the meadow two weeks before cutting,
- number of plant species in typical 25 m^2,
- presence or absence of the following plant species: *Dactylis glomerata, Avena elatior, Bromus erectus, Briza media, Cyperaceae, Juncaceae, Plantago lanceolata, Bellis perennis, Chrysanthemum leucanthemum, Primula veris, Primula elatior, Lotus corniculatus, Trifolium pratensis, Knautia arvensis, Lychnis flos-cuculi, Orchidaceae, Salvia pratensis,*
- colour of the butterflies,
- presence or absence of grasshoppers,
- presence or absence of crickets,
- presence or absence of snails or their empty shells in the meadow,
- presence or absence of anthills,
- presence or absence of the following groups of animals: bees or syrphids, slowworms, *Triodes apiarius* or *Trichus fasciatus, Cercopis vulnerata, Zygaena filipendulae.*

Definition of the categories

Surroundings and structural elements:

- low value: the area offers no favourable conditions for the development of great biodiversity,
- high value: the area offers good conditions for flora and fauna that can be optimised by adequate management.

Biodiversity:

- low-medium value: the biodiversity in the meadow is low-medium. Adequate management can improve it,
- medium-high value: the biodiversity in the meadow is medium-high,
- high value: the biodiversity is high. The meadow serves fundamentally for conservation of biodiversity.

Results of the investigation

The results of the investigation are summarised in Table 6.4. Only two extensive meadows of integrated farm 1 were low quality concerning surroundings and structural elements. They were located beside a main road close to a village. Nevertheless, these meadows reached the average value for biodiversity: medium-high. The meadow of pilot farm 5 had low-medium biodiversity. The farmer bought this plot in 1998 and started to cultivate it as an extensive meadow. It was unknown how intensively this meadow was previously used. It was most likely a pasture for cattle. The extensive meadow on pilot farm 5 is the newest among the investigated plots, which are three years old or more. The time factor is critical for biodiversity and could have caused this low value. However, the

Table 6.4 Quality of extensive meadows at Swiss pilot farms in 1999

pilot farm, label	extensive meadow: parcel number or name	value of the surroundings and the structural elements*	value of the biodiversity°
1. integrated	137	low	medium-high
1. integrated	138	low	medium-high
2. integrated	Bellechasse	high	medium-high
4. integrated	C6	high	medium-high
5. integrated	Lamontagne	high	low-medium
6. integrated	16	high	medium-high
6. integrated	Reckenacker 19	high	high
Average integrated	**-**	**low-high**	**medium-high**
8. organic	Reservoir	high	medium-high
8. organic	Hinteregg	high	medium-high
9. organic	13	high	medium-high
9. organic	23	high	medium-high
10. organic	Middes 1	high	medium-high
10. organic	Middes 6	high	medium-high
12. organic	SchA3	high	medium-high
Average organic	**-**	**high**	**medium-high**

* three categories: low, medium, high
° four categories: low, low-medium, medium-high, high

majority of the extensive meadows offered good conditions for flora and fauna and reached a medium-high value for biodiversity. The differences among the parcels of integrated farms were higher than among that of organic farms. The most valuable meadow "Reckenacker 19" (Figure 6.1) was found on an integrated farm.

6.3.3 Results of Wauwiler Moos (farm with adjacent fields)

Description of different aspects of the landscape in the Wauwiler Moos region
(Anonymous, 1993)

Location of the landscape
The region Wauwiler Moos is situated in the central part of Switzerland near the Lake of Lucerne. The plain of Wauwil is a typical and almost intact landscape made by a glacier with moraine, little lakes and swampy areas. The villages in this region have characteristic centres and fruit trees in the surrounding areas. Most of the villages are situated at the border of the plain, but some extend their areas in the direction of the centre. In addition, there are prehistoric settlements, which are of archaeological interest. The natural character of the region is disturbed by geometrical structures such as hedgerows (windbreak). Some of these made of non-native, site-specific trees such as poplars or spruces.

Description of the agriculture
Most of the area is arable land except the reservations and wildlife reserves. Most parts of the swampy areas were drained and are now used for agriculture. The ditches were used for drainage. However, most of the drained soil is not very suitable for agriculture and therefore a crop rotation with a high percentage of meadow is promoted.

Description of the biotopes
The wildlife reserve for birds in the centre of the region is particularly interesting. This open landscape is an important biotope for certain animals such as hares and pewit to live and reproduce in. In spring and autumn, moist areas are important places for waders (limikolen) to rest and feed, other places are of importance for some rare amphibians to spawn. Some swampy areas are under the protection of the Swiss government; others are disturbed by intensive agriculture nearby. The intensive agriculture and the increase in recreational activities in this area also disturb the connectivity of the swampy biotopes.

Recreational activities
Wauwiler Moos is an open recreational area, but more or less monotonous. Many roads (mainly dirt roads) cross this area and this leads to a lot of traffic. Dog owners come by car to walk their dogs in this area. A small area is set aside for people flying model aeroplanes.

Rural development plans for the Wauwiler Moos region
(Anonymous, 1993)

Plans for landscape development
The characteristically open landscape needs to be preserved. To reach this aim, regional and cantonal guidelines will be established. The growth of the villages into the

Figure 6.2 Aerial photo of the Wauwiler Moos region (Courtesy of Bundesamt fuer Landestopographie, Switzerland: Luftaufnahme der Eidg. Vermessungsdirektion vom 22.3.2000, Fluglinie 011 194, Bild-Nr. 549, Luftbildarchiv LT/KSL)

protected areas will be prevented, however, the traditional village centres and the old farms should be preserved. The grit and sand working will only be possible in the area of the moraines. Larger equipment will not be allowed.

Plans for agricultural development

The agriculture in this area needs to be preserved and promoted. A management concept adapted for the special situation in this area will be established and further developed. The farmers will be consulted by specialists to increase their ecological farming. Also the ecological infrastructure needs to be increased. For certain parts of the region, there will be a restriction for arable use and fertilisation.

Plans for biotope development

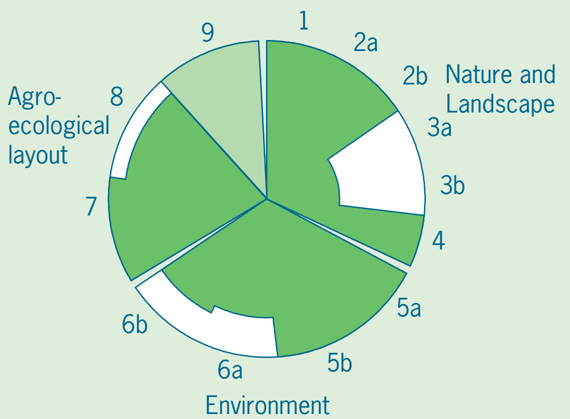
The existing wildlife reserves will be protected and improved. For waterways and moist areas, buffer zones and, at suitable places, new reservations will be created. At least 10-12% of the whole area should become part of the ecological infrastructure. Existing natural elements will be preserved and completed. To improve the habitats of hares, pewits, larks and quails, the Swiss ornithological station in Sempach has a special project in this area (creating a mosaic of natural elements) (Birrer & Graf 1996).

Plans for recreational development

The Wauwiler Moos region should be preserved as a quiet area for recreational activities such as walking and cycling. Traffic will be prohibited in this area, except on some main roads. Paths will be marked for walking and cycling. Dogs have to walk on a leash. The possibility for using this area for environmental education has to be tested.

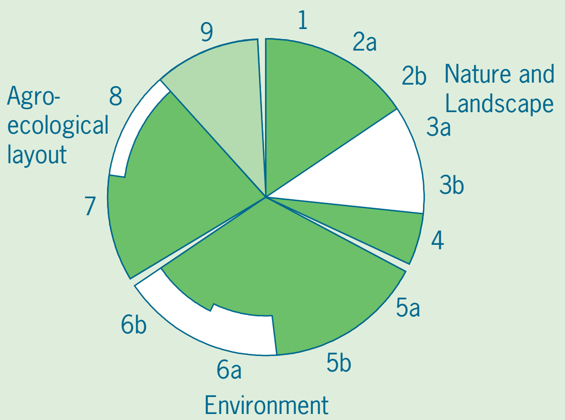
Background of the Wauwiler Moos farm

This farm is one of the biggest farms in the area of Lucerne. It is owned by the Canton Lucerne and is connected to a prison. The farm started organic production in 1996. In addition to 40 species of vegetables, the farm also produces arable crops, fruits and animal products. The total area of the farm is about 150 ha: 12 ha of field grown vegetables, 0.3 ha of vegetables in greenhouses, 90 ha of grassland, 45 ha of arable crops, 1 ha of orchards and 12 ha of ecological infrastructure (= 8.15% of the total area). All fields are connected and adjacent to the farm building. The main vegetable crops are carrots, lettuce, cabbage,



Legenda
1. Percentage woody elements
2a. Connectivity woody elements
2b. Connectivity herbal elements
3a. Circuitry woody elements
3b. Circuitry herbal elements
4. Biotopes
5a. Bufferzone index ditches
5b. Bufferzone index woody elements
6a. Buffer zone width ditches
6b. Buffer zone width woody elements
7. Ecologiscal infrastructure index
8. Field size index
9. Biotope target species

Figure 6.3 Results of ecological infrastructure management for the Wauwiler Moos farm in 2000. The circle represents the results of the VEGINECO method of calculation. For the parameters connectivity and circuitry, the existing nodes were taken into account. When a segment is filled, the target value is reached. The light green area was not measured.



Legenda
1. Percentage woody elements
2a. Connectivity woody elements
2b. Connectivity herbal elements
3a. Circuitry woody elements
3b. Circuitry herbal elements
4. Biotopes
5a. Bufferzone index ditches
5b. Bufferzone index woody elements
6a. Buffer zone width ditches
6b. Buffer zone width woody elements
7. Ecologiscal infrastructure index
8. Field size index
9. Biotope target species

Figure 6.4 Results of ecological infrastructure management for the Wauwiler Moos farm in 2000. The circle represents the results of the VEGINECO method of calculation. For the parameters connectivity and circuitry, the existing biotopes were taken into account. When a segment is filled, the target value is reached. The light green area was not measured.

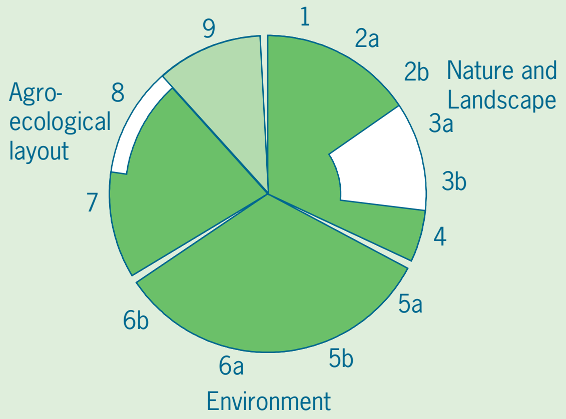
Table 6.5 Parameters with target values, achieved values and results of Wauwiler Moos (VEGINECO method)

Parameter	target value	achieved	result
Nature and landscape			
Percentage of woody elements	9%	23%	100%
Connectivity woody elements (nodes)	33%	50%	100%
Connectivity herbaceous elements (nodes)	33%	50%	100%
Connectivity woody elements (biotopes)	*33%*	*66%*	*100%*
Connectivity herbaceous elements (biotopes)	*33%*	*66%*	*100%*
Circuitry woody elements (nodes)	>30%	14%	46%
Circuitry herbaceous elements (nodes)	>30%	14%	46%
Circuitry woody elements (biotopes)	>30%	0%	0%
Circuitry herbaceous elements (biotopes)	>30%	0%	0%
Representative biotopes	4	8	100%
Environment			
Length of buffer zones/ length of ditches	1.48	1.48	100%
Length of buffer zones/ length of woody elements	1.57	1.57	100%
Buffer zone width next to ditches	4 m	3 m	75%
Buffer zone width next to woody elements	4 m	3.2 m	80%
Agro-ecological layout			
Ecological infrastructure index	5%	8.15%	100%
Optimal field width	125 m	139 m	90%
Biotope target species	-	-	-

Table 6.6 Parameters with target values, achieved values and results for Wauwiler Moos (Swiss method), values in bold deviate from the VEGINECO method

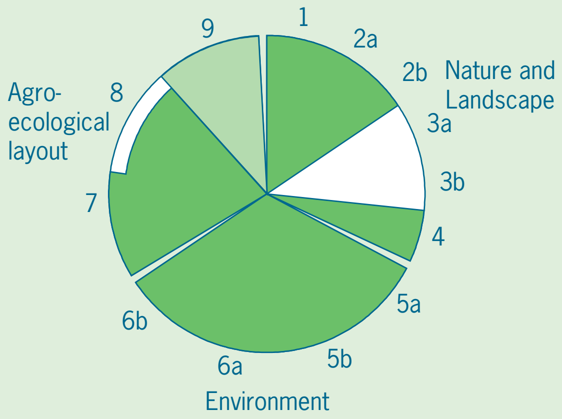
Parameter	target value	achieved	result
Nature and landscape			
Percentage of woody elements	**5%***	23%	100%
Connectivity woody elements (nodes)	33%	50%	100%
Connectivity herbaceous elements (nodes)	33%	50%	100%
Connectivity woody elements (biotopes)	33%	66%	100%
Connectivity herbaceous elements (biotopes)	33%	66%	100%
Circuitry woody elements (nodes)	>30%	14%	46%
Circuitry herbaceous elements (nodes)	>30%	14%	46%
Circuitry woody elements (biotopes)	>30%	0%	0%
Circuitry herbaceous elements (biotopes)	>30%	0%	0%
Representative biotopes	4	8	100%
Environment			
Length of buffer zones/ length of ditches	1.48	1.48	100%
Length of buffer zones/ length of woody elements	1.57	1.57	100%
Buffer zone width next to ditches	**>3 m**	3 m	**100%**
Buffer zone width next to woody elements	**>3 m**	3.2 m	**100%**
Agro-ecological layout			
Ecological infrastructure index	**6.7%**	8.15%	100%
Optimal field width	125 m	139 m	90%
Biotope target species	-	-	-

*map of 1931 (map of 1987: 7%)



Legenda
1. Percentage woody elements
2a. Connectivity woody elements
2b. Connectivity herbal elements
3a. Circuitry woody elements
3b. Circuitry herbal elements
4. Biotopes
5a. Bufferzone index ditches
5b. Bufferzone index woody elements
6a. Buffer zone width ditches
6b. Buffer zone width woody elements
7. Ecologiscal infrastructure index
8. Field size index
9. Biotope target species

Figure 6.5 Results of ecological infrastructure management for the Wauwiler Moos farm in 2000. The circle represents the results of the Swiss method of calculation. For the parameters connectivity and circuitry, the existing nodes were taken into account. When a segment is filled, the target value is reached. The light green area was not measured.



Legenda
1. Percentage woody elements
2a. Connectivity woody elements
2b. Connectivity herbal elements
3a. Circuitry woody elements
3b. Circuitry herbal elements
4. Biotopes
5a. Bufferzone index ditches
5b. Bufferzone index woody elements
6a. Buffer zone width ditches
6b. Buffer zone width woody elements
7. Ecologiscal infrastructure index
8. Field size index
9. Biotope target species

Figure 6.6 Results of ecological infrastructure management for the Wauwiler Moos farm in 2000. The circle represents the results of the Swiss method of calculation. For the parameters connectivity and circuitry, the existing biotopes were taken into account. When a segment is filled, the target value is reached. The light green area was not measured.

cauliflower, broccoli, leeks, pumpkins, zucchini and fennel grown in the fields, and corn, tomatoes and cucumbers grown in the greenhouse.

Parameters, targets and results (VEGINECO method)

Most of the targets (following the VEGINECO method) were reached on the Wauwiler Moos farm (Table 6.5). There are two possibilities of calculating the parameters connectivity and circuitry: either nodes (Figure 6.3) or biotopes (Figure 6.4) are taken into account. Both possibilities are shown in Table 6.5 because they give different results. However, both parameters of circuitry can be improved. The width of the buffer zones and the optimal field width, the greatest deficit, could be improved as well.

Parameters, targets and results (adjusted to Swiss situation)

Following the Swiss methods, most targets were reached on the Wauwiler Moos farm (Table 6.6) as well. The results are similar to Table 6.5. The change of the target value for the parameter buffer zone width caused a result of 100%. Figure 6.5 and 6.6 show an overview of the results.

Differences between VEGINECO and Swiss method at Wauwiler Moos

Percentage of woody elements:

The rural development plans for the Wauwiler Moos region make it necessary to place the screen for determining the target value on the map to represent the characteristic landscape and not place it with the farm in the centre. Information about the characteristic landscape is partly taken from maps from the first half of the 20th century. For this reason, a map of 1931 is used to determine the Swiss target value. However, considering the rural development plans, the 23% achieved dramatically exceeds the target of 5%, so that the result should not be 100% but less. The calculation of the result should be done in a different way.

Buffer zone width:

Concerning the Swiss legislation of buffer zones, the width should be at least three meters. In Switzerland, only meadow strips are called buffer zones.

Ecological infrastructure index:

The Swiss legislation of direct subsidies for Swiss farmers requires 3.5-7% of the farm surface area to be reserved for nature: 3.5% for vegetable crops and 7% for arable crops. Therefore every farm has its own target value.

In Switzerland, the buffer zones and ecological infrastructure index parameters are part of the requirements for direct payments. Therefore, they are less important to calculate in Switzerland. The optimal field width and the nature and landscape parameters are more important, but the nature and landscape parameters are only possible to calculate for farms with non-adjacent fields.

Possible improvements on the Wauwiler Moos farm

The largest deficits in both ways of evaluating are in circuitry and in optimal field width.

The circuitry of herbaceous and woody elements concerning the biotopes can easily be improved by adding one more connections. The target value will be 100%.

To reach the target of circuitry concerning the nodes, two more connections are necessary. Considering the rural development plans for this region (preserving an open landscape), these connections should be herbaceous strips and not hedge rows.

The size of the fields could be reduced (smaller fields), but this has to be arranged with the farmer and should be adequate for the type of machinery used.

6.3.4 Results of Attiswil (farm with non-adjacent fields)

Description of different aspects of the Attiswil landscape

(Wetzel, 2000)

Location of the landscape

The village of Attiswil is situated in the western part of Switzerland close to the Jura Mountains. The southern part of the village extends almost to the Aare River; the northern part extends to the first hills of the Jura. The centre of the village is very beautiful and its rustic character has been preserved.

The landscape around Attiswil can be divided in three parts:

- *Attiswil Fields:* situated in the southern part in the Aare river plains.
- *Attiswil Slope:* situated at the bottom of the first Jura hills.
- *Jura Forests:* large forests in the upper northern part.

Description of the agriculture

Mainly in the southern part (Attiswil fields), there is intensive agriculture with cereals as the main crops. There are only a few groves and single trees. On some plain fields at the slope, there is agriculture as well, but also an increasing number of orchards. The rest of this part and also the clearings of the Jura forests are used as pasture land.

Description of the biotopes

- *Attiswil Fields:* There are only a few hedgerows, groves and some orchards at the farms. There are a few small rivers, which have buffer zones on both sides. Natural elements are rare. Special species of animals are larks and rabbits.
- *Attiswil Slope:* The small rivers in this part are buffered as well. There are a lot of woody elements such as hedgerows and orchards. Concerning the herbaceous elements, there are dry and wet areas as well. Most of the forests edges are structured. Special species of animals are woodpeckers, screech owls, jays and rabbits.
- *Jura Forest:* In addition to the forests, there are also meadows (wet or dry areas) and other woody elements such as individual trees or rows of cherry trees. Special species of animals or plants are woodpeckers, rabbits and orchids.

Recreational activities

Mainly the northern part of Attiswil has an important function as a recreational area. Many different landscape elements make up this area. There is even a small restaurant.

Rural development plans for Attiswil

(Wetzel, 2000)

Plans for landscape development

The existing natural elements in this area should be preserved and supported in an appropriate manner. Existing natural elements could be improved by enlarging their size with buffer zones, for example. This would reduce side effects of intensive agriculture and different biotopes with varied structures could be created. If biotopes do not occur in this area, new and suitable biotopes could be created. All existing biotopes and natural elements should be connected with hedgerows or meadow strips in order to form ecological corridors.

Plans for agriculture development

Mainly in the Attiswil fields, there is intensive agriculture with large fields. Wild flower strips and flowerbed strips at crop borders are planned to reduce the field size. Hedgerows and single trees are planned to support the connectivity of the biotopes.

Plans for biotope development

- *Attiswil Fields:* See above. Target species in the development plans are hare and lark.
- *Attiswil Slope:* Existing field fruit trees should be protected and supported; especially old trees should be preserved. New orchards should be promoted. Meadows in orchards and in special areas (dry or wet) should be used extensively. Again, the connectivity of the biotopes should be improved with hedgerows and tree rows. The target species in the development plans is woodpecker.
- *Jura Forests:* Habitats for rabbits and orchids in this area should be preserved with extensive use of

meadows. The edges of the forests should be improved by combination with extensive meadows. The target species in development plans are orchids.

Plans for recreational development
The beauty of the landscape mainly in the northern part of Attiswil should be preserved for recreational activities in this area.

Background of the Attiswil farm
This is a small agricultural farm with 20 head of cattle. The farm surface area is about 22 ha: 5 ha arable crops, 14 ha grassland, 1 ha field grown vegetables, 0.01 ha vegetables in greenhouses and 1.5 ha ecological infrastructure with 90 field fruit trees (= 8.9% ecological infrastructure). The average field size is about 0.04 ha for the fields for growing vegetables and 1 ha for the rest. It has been an integrated production farm since 1995 with the main vegetable crops of carrots, lettuce, pumpkins, corn and Brussels sprouts. Only the fields for growing vegetables are connected and adjacent to the farm buildings. The rest of the fields are dispersed over all three parts of Attiswil.

Parameters, targets and results (VEGINECO method)
From the theme nature and landscape, only the biotopes parameters could be calculated. The percentage of woody elements, connectivity and circuitry parameters could not be calculated because of the dispersion and small size of the fields. The rural development plans and the dispersed fields made it impossible to place a screen for determining the target value on the map with the farm in the centre. Therefore, the percentage of woody elements parameter could not be established. The connectivity and circuitry parameters can only be used on a landscape level and not on a farm level for farms with small, dispersed fields. The optimal field width parameter expresses the possibility for stabilising the agro-ecosystem on the farm. The optimal field size parameter of 125 m is needed for predators to reach the centre of the field so only the fields with vegetables growing are taken into account for calculating this parameter. Figure 6.8 shows an overview of the results. Most of the possible targets (following the VEGINECO method) were reached on the pilot farm in Attiswil (Table 6.7). Only the buffer zone width has to be improved.

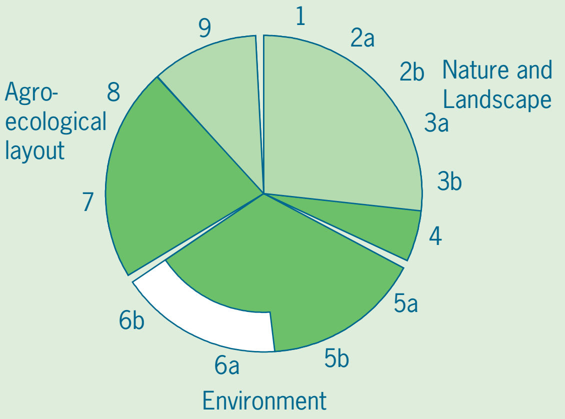
Figure 6.7 Map of the rural development plans for Attiswil (Courtesy of J. Wetzel and the Attiswill community)

Parameters, targets and results (adjusted to the Swiss situation)
The nature and landscape parameters are divided in the three parts of Attiswil because the landscape is very different and so are the parameters (percentage of woody elements) (Table 6.8). The connectivity and circuitry parameters are not calculated because the rural development plans call for ecological corridors in each of the parts to connect the existing natural elements. Some fields on the farm are part of the planned corridor and should follow the planned guidelines. Concerning the themes environment and agro-ecological layout, there is no subdivision of the parameters because they are independent of the landscape. Figure 6.9 shows an overview of the results.

Table 6.7 Parameters and target values Attiswil (VEGINECO method)

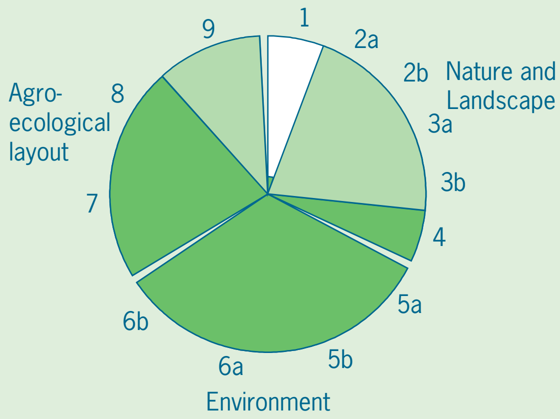
Parameter	target value	achieved	result
Nature and landscape			
Percentage of woody elements	-	-	-
Connectivity woody elements	-	-	-
Connectivity herbaceous elements	-	-	-
Circuitry woody elements	-	-	-
Circuitry herbaceous elements	-	-	-
Representative biotopes	3	4	100%
Environment			
Length of buffer zones/ length of ditches	1	1	100%
Length of buffer zones/ length of woody elements	1	1	100%
Buffer zone width next to ditches	4 m	3 m	75%
Buffer zone width next to woody elements	4 m	3 m	75%
Agro-ecological layout			
Ecological infrastructure index	5%	8.9%	100%
Optimal field width*	125 m	<125 m	100%
Biotope target species	-	-	-

* Field size only of vegetable growing fields



Legenda
1. Percentage woody elements
2a. Connectivity woody elements
2b. Connectivity herbal elements
3a. Circuitry woody elements
3b. Circuitry herbal elements
4. Biotopes
5a. Bufferzone index ditches
5b. Bufferzone index woody elements
6a. Buffer zone width ditches
6b. Buffer zone width woody elements
7. Ecologiscal infrastructure index
8. Field size index
9. Biotope target species

Figure 6.8 Results of ecological infrastructure management for the Attiswil farm in 2000. The circle represents the results of the VEGINECO method of calculation. When a segment is filled, the target value is reached. The light green areas were not measured.



Legenda
1. Percentage woody elements
2a. Connectivity woody elements
2b. Connectivity herbal elements
3a. Circuitry woody elements
3b. Circuitry herbal elements
4. Biotopes
5a. Bufferzone index ditches
5b. Bufferzone index woody elements
6a. Buffer zone width ditches
6b. Buffer zone width woody elements
7. Ecologiscal infrastructure index
8. Field size index
9. Biotope target species

Figure 6.9 Results of ecological infrastructure management for the Attiswil farm in 2000. The circle represents the results of the Swiss method of calculation. The percentage of woody elements is only shown for the Attiswil Fields because the results of the Attiswil Slope and Jura Forests are lower (see Table 6.8). The light green areas were not measured.

Table 6.8 Parameters and target values for Attiswil (Swiss method), values in bold deviate from the VEGINECO method

Parameter	target value	achieved	result
Nature and landscape			
Percentage of woody elements (Attiswil Fields)	**18%**	**2%**	**11%**
Percentage of woody elements (Attiswil Slope)	**48%**	**1.5%**	**3%**
Percentage of woody elements (Jura Forests)	**82%**	**1%**	**1%**
Connectivity woody elements	-	-	-
Connectivity herbaceous elements	-	-	-
Circuitry woody elements	-	-	-
Circuitry herbaceous elements	-	-	-
Representative biotopes (Attiswil Fields)	**3**	**4**	100%
Representative biotopes (Attiswil Slope)	**4**	**4**	100%
Representative biotopes (Jura Forests)	**4**	**4**	100%
Environment			
Length of buffer zones/ length of ditches	1	1	100%
Length of buffer zones/ length of woody elements	1	1	100%
Buffer zone width next to ditches	**≥3 m**	3 m	**100%**
Buffer zone width next to woody elements	**≥3 m**	3 m	**100%**
Agro-ecological layout			
Ecological infrastructure index	**6.8%**	8.9%	100%
Optimal field width*	125 m	<125 m	100%
Biotope target species	-	-	-

* Field size only of vegetable growing fields

Following the Swiss method, most targets were reached on the Attiswil farm. The calculation of the percentage of woody elements parameter in the three parts of Attiswil was a first attempt to adjust this parameter to the Swiss situation. The small, dispersed fields made it impossible to use this parameter to show how many woody elements on a farm reflect the landscape the farm is situated in. To improve the amount of the woody elements in the Attiswil area, the rural development plans call for the planting of hedgerows, field fruit trees and single trees in the Attiswil fields and slope.

Possible improvements on the Attiswil farm

There are only deficits in the category nature and landscape. This is caused by the dispersion and size of the fields. For this reason, it is important to evaluate the parameters (except biotopes) not at the farm level, but at the landscape level. The existing rural development plans, which are very detailed and up-to-date, should be fulfilled for the fields that are involved.

6.3.5 Discussion

Adapting the parameters and target values used in the method for ecological infrastructure management developed in the Netherlands is only possible in a limited way, especially for farms with non-adjacent fields. The parameters of the theme nature and landscape (except biotopes) are very dependent on the rural development plans, especially for the target species. In some cases, it is not efficient to create connectivity and circuitry. In other cases, it is almost not possible. Birds, for example, which breed in hedges, can be very endangered if all the nodes or biotopes are connected because foxes or martens use the landscape elements to find their prey easily. The creation of connectivity and circuitry is only efficient if the target species are also considered. In the Wauwiler Moos region, one of the target species is the pewit, which requires an open landscape. Therefore, the connections could not be achieved with hedgerows. For these farms, where the calculation of the parameters of the theme nature and landscape is possible and efficient, aerial photos (Figure 6.2) and existing rural development plans (Figure 6.7) are very helpful.

The principle of using target species (as in the rural development plans for Attiswil and Wauwiler Moos) is very useful in evaluating the results of the rural development plans. For both communities, rural development plans are available that contain target species for their regions. Furthermore, these plans are very detailed and they are related to the different types of landscape and not only the area of the community. In Switzerland, different types of landscape are very close together. Therefore, it is very important to consider these rural development plans for every nature activity on a farm (e.g. planning, evaluating). The Swiss government promotes these plans to be implemented in cantons and communities (Bundesamt für Umwelt, Wald und Landschaft (BUWAL), 1999).
In Wauwiler Moos, the rural development plan (passed in 1993) contains a detailed concept for the implementa-

tion. However, implementation is voluntary and therefore a slow process. In Attiswil, the rural development plan and the detailed concept (with timetable) for the implementation was granted by the community of Attiswil during Summer 2000.
The evaluation method for ecological infrastructure management developed in the Netherlands was adapted to two Swiss pilot farms, one farm with adjacent fields and one farm with non-adjacent fields.
For the farm with adjacent fields (Wauwiler Moos), the adaptation of the parameters and target values was possible. Considering the Swiss situation (different types of landscape very close together), the VEGINECO evaluation method had to be changed to a Swiss evaluation method (change the target values for the buffer zone width).
For the farm with non-adjacent fields (Attiswil), only the adaptation of the parameters and target values for the themes environment and agro-ecological layout was possible. Again the VEGINECO evaluation method had to be changed to evaluate the Swiss situation.
In Switzerland, the government promotes rural development plans in communities or cantons. These are very detailed and adapted to each community's or canton's situation. Most of the time farms are involved in the implementation of these plans and should follow their guidelines. However, the evaluation method could give valuable additional information.

6.3.6 Summary

Within the scope of the EU-project VEGINECO, two Swiss pilot farms, one with adjacent fields and one with non-adjacent fields, were evaluated concerning ecological infrastructure management. The evaluation method was developed in the Netherlands and was tested during the project. If the calculation of the parameters and target values, following the VEGINECO method, were not possible, the parameters and target values were adjusted to the Swiss situation.
For the farm with adjacent fields (Wauwiler Moos), most of the parameters could be calculated with the VEGINECO method. Only the percentage of woody elements parameter had to be changed and only the target values for buffer zone width and ecological infrastructure index had to be adjusted to the Swiss situation.
For the farm with non-adjacent fields (Attiswil), most of the parameters could be calculated with the Dutch method, except the parameters of the theme nature and landscape. Parameters such as connectivity and circuitry could not be evaluated because the fields are dispersed over a large area. The target values for buffer zone width and ecological infrastructure index had to be adjusted to the Swiss situation as well.
Most of the target values calculated with the VEGINECO method as well as in the Swiss method were achieved at both farms.

7 Discussion and conclusions

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The methodology of prototyping ecological infrastructure management was originally developed for the Dutch situation. In the VEGINECO project, two goals for ecological infrastructure management were included:

1. By introducing the prototyping method, attention was requested about this specific topic in the participating countries.
2. In this way, the method could be tested and evaluated under other conditions than in the Netherlands.

The results are presented in this report. The following conclusions can be drawn.

7.1 Methodology

In general, we can conclude that the methodology can be used for the different systems in the different countries. It provides a quick scan of the different systems' performances regarding ecological infrastructure management. However, the methodology has to be adapted to the different systems in some aspects.
For example, in a farming system with dispersed fields as tested in Switzerland, problems with the calculation of some of the parameters occurred. It is not possible to create connectivity and circuitry between nodes (suitable habitats) with woody and herbaceous elements because the areas between the fields are not included. The parameters that have been developed can therefore not be used at a farm level. Connectivity and circuitry can only be achieved when the areas between the fields are included. This means that connectivity and circuitry can only be achieved on a landscape level instead of a farm level. This can be done relatively easily if a rural development plan has been set up, although it demands consultation and co-operation with other landowners.

The methodology also has to be adapted when a farm is small like those found in Italy and Spain, where many farms cover only a few hectares. Within a farm, it is then difficult to create connectivity or circuitry. In this case, the parameters should be tested for a few farms together, which again results in an approach at a landscape level.

The VEGINECO method as used in the project only tests the quantity and location of the ecological infrastructure on a farm. The biotope target species parameter, which should give an indication of quality, was not developed yet and could not be tested.
One of the objectives of ecological infrastructure management is diversified nature with increased biodiversity. This is also the general perception of both farmers and researchers. A very important strategy to reach the objectives is optimising the present ecological infrastructure. It is therefore necessary to take the quality of nature on a farm into account and expand the methodology with parameters on quality.

The target values used in the methodology are focused on the future and are derived from legislation, scientific evidence or expert knowledge. Every country that is a EU member has its own national or regional legislation in addition to the EU legislation, which means it may be necessary to change the target values. The differences between legislation in countries have to be taken into account. The same holds true for non-EU members. In Switzerland, for instance, the target values for buffer zone width and ecological infrastructure index deviate from the target values derived from the Dutch situation. The target value for buffer zones is, considering Swiss legislation, one meter smaller than the target value derived from the Dutch situation. The target value for ecological infrastructure index on the other hand, is in Switzerland variable and depends on the type of crop that is cultivated. In most of the cases, the Swiss target value is higher.
It is possible to use the prototyping methodology in every country because it is flexible. The target values can be adapted to the country-specific demands. By doing this, there will be no conflict with national or regional legislation.
Depending on the specific needs for a farm, it is also possible to work with the target values derived from the methodology, if these are higher than the target values considering national or regional legislation. Obtaining the target values will be more difficult, but it will also result in a better ecological infrastructure when it is completed.

7.2 Results per country

Considering the results of the different countries for ecological infrastructure management, there are some striking differences. In the Netherlands, most deficits are present within the theme 'Nature and Landscape', whereas in Italy and Spain most deficits occur within the theme 'Environment'. In Switzerland, most of the targets are reached, only the parameter 'Circuitry' on the farm with adjacent fields shows relatively large deficits, both for the original methodology and the Swiss adaptations.
The deficits within the theme 'Nature and Landscape' in the Netherlands are the result of the changing land use over the past decades. In the past century, agriculture in the Netherlands has become more and more intensive. Fields are made larger at the expense of trees and ditches, which make up the largest part of the ecological infrastructure on farms. This has resulted in an increasing similarity in the landscape characteristics and a decrease in biodiversity.
In Italy and Spain, the deficits within the theme

'Environment' are caused by the absence of buffer zones. In Italy, it involves the lack of buffer zones next to woody elements and in Spain it involves the lack of buffer zones next to both woody elements and ditches.
The deficits of the parameter 'Circuitry' in Switzerland are due to the lack of links between suitable habitats.

7.3 Conclusions

The developed methodology works satisfactorily for most situations. It brings attention to factors, which at present may not be focused on in a country, but may nonetheless be important in the future. In applying the methodology in other countries, two issues have to be taken into account:

- Small farms or scattered fields have to be evaluated over a larger area to calculate connectivity and circuitry.
- When there is a contradiction with local or national legislation, the target value in principle can be adjusted to the legislation's policies.

Despite the fact that the methodology works quite satisfactorily for different situations, it needs to be improved before it can be used on a large scale. The development of parameters that describe the quality of the ecological infrastructure and the management utilised to improve this, is the first step that needs to be taken. Since this is beyond the scope of this project, this may be the focus of a new project on ecological infrastructure management on farms in different countries. The results presented in this report could be fundamental for such a project in the future.

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VEGINECO publication list

VEGINECO project reports

1. VEGINECO Final Report
W. Sukkel and A. Garcia (Eds.)
VEGINECO Report 1. 2002. Applied Plant Research. Lelystad.

2. Manual on Prototyping Methodology and Multifunctional Crop Rotation
J.J. de Haan and A. Garcia (Eds.)
VEGINECO Report 2. 2002. Applied Plant Research. Lelystad.

3. Integrated and Ecological Nutrient Management
J.J. de Haan (Ed.)
VEGINECO Report 3. 2002. Applied Plant Research. Lelystad.

4. Integrated and Ecological Crop Protection
W. Sukkel and A. Garcia (Eds.)
VEGINECO Report 4. 2002. Applied Plant Research. Lelystad.

5. Ecological Infrastructure Management
G.K. Hopster and A.J. Visser (Eds.)
VEGINECO Report 5. 2002. Applied Plant Research. Lelystad.

6. Proceedings of the VEGINECO workshop, 20-21 June 2001, Amsterdam
W. Sukkel and J.J. de Haan (Eds.)
VEGINECO Report 6. 2002. Applied Plant Research. Lelystad.

Other project-wide VEGINECO publications

Wijnands, F.G. and W. Sukkel. 2000. Prototyping organic vegetable farming systems under different European conditions. In Proceedings 13th IFOAM Scientific Conference, 28-31 August Basel. vdf Hochschulverlag. Zürich. pag. 202-205.

In addition, every partner has published many publications in national and regional agricultural journals. For a complete overview, contact the concerning partner.

Annex 1. Short description of the systems

Southwest region of the Netherlands

Regional Context

In the Netherlands, approximately 70 000 hectares of more than 50 different types of vegetables are grown (including onion and peas). The farms are be divided in two groups: 1) the very specialised, small farms that grow mainly fresh market vegetables (19 000 ha, 4 200 farms, average size 4.5 ha) and 2) the larger farms with arable activities (more industrial processing crops, 25 000 hectares of vegetables, 4 900 farms, 25-75 hectares per farm). Arable farms are increasingly including vegetables in their crop rotations. In addition, farm size and specialisation is growing and land lease and exchange is becoming more important. The most important crops in terms of area and financial turnover are onions, carrots, chicory, leek, asparagus, Brussels sprouts, cauliflower, cabbage, lettuce, beans and peas.

Site information

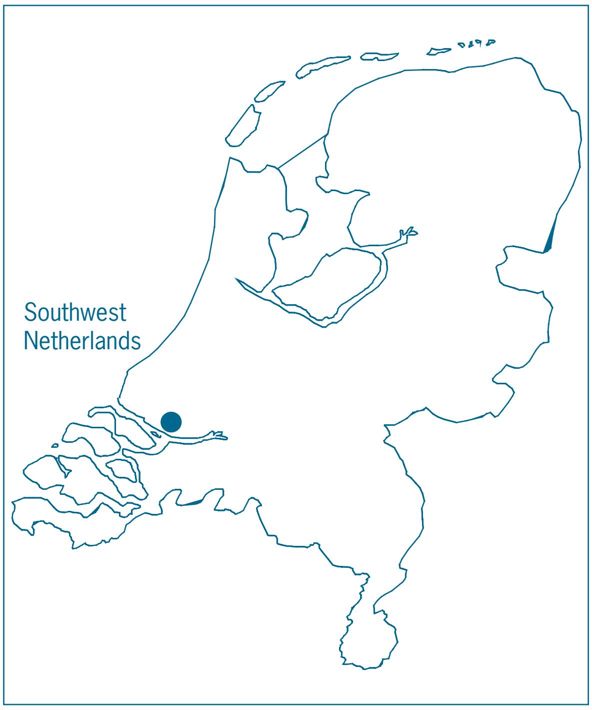
Soil characteristics	Integrated	Organic
main soil type	marine clay	marine clay
clay (%)	33	33
organic matter (%)	2.4	2.2
pH (KCl)	7.5	7.2

Climatic information	
annual average precipitation	760 mm
annual average sunshine	1 450 hours
annual average radiation	380 kJ cm^{-2}
annual average temperature	9.9 °C
average latitude	51 °N.
average altitude	0.8 m above sea level

Tested systems

In the Netherlands, two integrated and one organic systems were tested on an experimental location in the Southwest region of the Netherlands. A combination of vegetables and arable crops were chosen in all systems, this represented the developments in the region. The labour demand differed between the two integrated systems. The system with Brussels sprouts (NL INT1) as the main crop was designed as a labour extensive system. The other system, with iceberg lettuce (NL INT2) as main crop, was designed as labour intensive.

Location



Rotations

Integrated fresh market Brussels Sprouts (labour extensive) (NL INT1)	Integrated fresh market Iceberg Lettuce (labour intensive) (NL INT2)	Organic fresh market system (NL ORG)
1. potatoes	1. potatoes	1. iceberg lettuce
2. Brussels sprouts	2. fennel / celeriac / cauliflower	2. cereal / clover
3. winter wheat / spring barley	3. winter wheat / spring barley	3. Brussels sprouts
4. fennel / celeriac / iceberg lettuce	4. iceberg lettuce	4. fennel
		5. cereal / clover
		6. potato

Emilia-Romagna, Italy

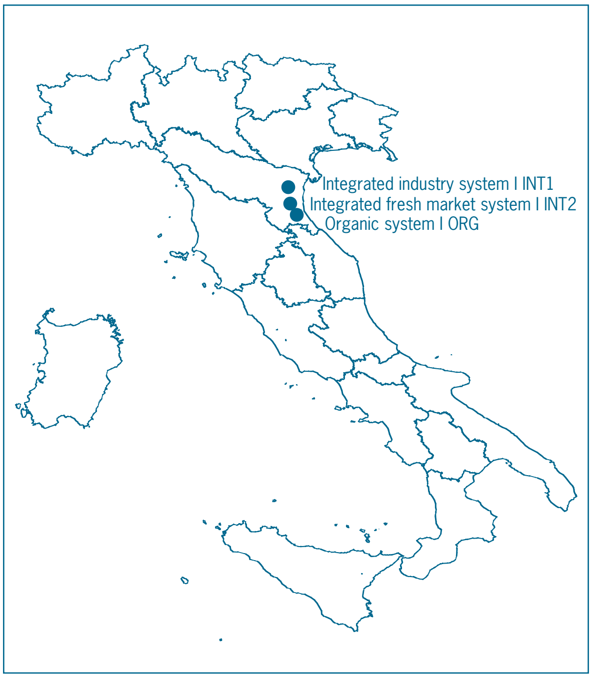
Regional context

In Emilia-Romagna, Italy, there are almost 4 000 specialised farms and 35 000 non-specialised farms in vegetable farming. Some 54 000 hectares are cultivated with vegetables at medium and large sized farms (5-20 ha). The main crops grown on large farms for industrial processing are tomatoes, green beans, (water)melons and onions. These farms have a high level of mechanisation. At small farms (2-5 ha), the main crops are grown for the fresh market (lettuce, fennel, spinach, celery, potatoes, melons and cauliflower). These small farms have a low level of mechanisation. Since 1993, integrated vegetable farming have produced crops under Quality Control (QC) labels.

Tested systems

In Emilia-Romagna, two integrated and one organic systems were tested in the eastern part of the region in Ravenna (I INT1) and Cesena (I INT2 and I ORG). I INT1 is focussed on industrial vegetable crops in combination with arable crops while I INT2 and I ORG are focussed on fresh market vegetables.

Location



Site information

Soil characteristics	I INT1	I INT2	I ORG
soil type	silt loam	silt clay	silt clay loam
% clay	20	42	35
% silt	63	47	53
% sand	17	12	12
% organic matter	1.2	1.8	2.7
pH (H_2O)	7.8	7.7	8.0
Climatic information	RAVENNA (I INT1)		CESENA (I INT2 and I ORG)
annual average precipitation	581 mm ('88-'94)		591 mm ('92-'94)
annual average sunshine	4.139 hour		4.139 hour
annual average radiation	439 kJ cm^{-2}		541 kJ cm^{-2}
annual average temperature	13.1 °C		13.9 °C
average latitude	44-45 °N.		44 °N.
average altitude	5 m above sea level		16 m above sea level

Rotation

Integrated industry system (I INT1)	Integrated fresh market system (I INT2)	Organic fresh market system (I ORG)
1. spinach tomato	1. lettuce spr./sum./aut. catch crop	1. green beans fennel
2. wheat green beans	2. green beans	2. melon
3. sugar beet catch crop	3. strawberry celery + catch crop	3. catch crop
4. melon	4. melon	4. strawberry lettuce summer + autumn

Valencian Community, Spain

Regional context

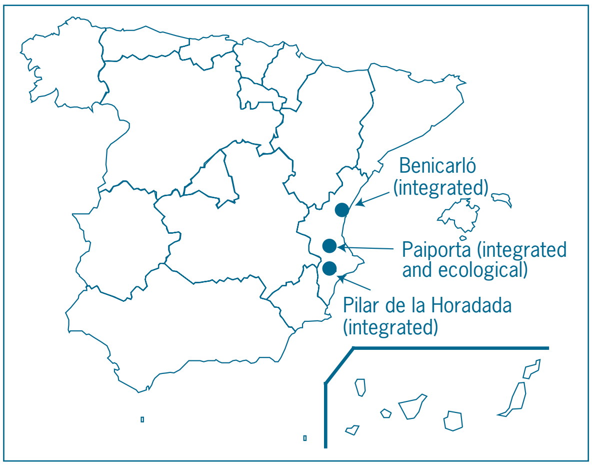
In Valencia Region, Spain, an area of about 44 000 hectares are grown each year with more than 30 vegetable crops (including potato). The most important crops are tomato, onions, potato, artichoke, watermelon and cauliflower. Most of the vegetables are grown for fresh market production. The farms are small (more than 50% of the farms have a surface area less than three ha, and about 20% of the farms have a surface area less than one ha). Levels of mechanisation are generally low. Irrigation is necessary because of the dry conditions and low natural rainfall. Crops can be grown all year round.

In Spain, the area cultivated for organic farming was about 150 000 hectares (less than 1% of the agricultural area). In Valencia, the area with organic farming is about 3 000 ha, with about 3% area for vegetable crops.

Tested systems

In the Valencian region, three integrated and one organic systems were tested at different locations. The three integrated systems are representative for their area: Pilar de Horada (ES INT1 in the south of the Valencian Region, Benicarlo (ES INT2) in the north and Paiporta (ES INT3) in the centre. The organic system (ES ORG) is located at the same experimental farm as ES INT3. ES INT1 and ES INT2 are located at private farms, ES INT3 and ES ORG are located at an experimental station.

Location



Site information

Geodesic	co-ordinates	ES INT1	ES INT2	ES INT3 and ES ORG
Situation	Latitude	37° 51' N.	40° 23' N.	39° 28' N.
	Longitude	0° 43' W.	4° 4' E.	0° 25' W.
	Altitude	<50 m above sea level	17 m above sea level	52 m above sea level
Province		Alicante	Castellón	Valencia
Town		Pilar de la Horadada	Benicarló	Paiporta

Soil characteristics		ES INT1	ES INT2	ES INT3 and ES ORG
Soil texture	Sand (%)	23	27	34
	Loam (%)	44	47	49
	Clay (%)	33	26	27
Organic Matter (%)		2.3	2.5	1.8
pH (soil/H_2O 1/5)		8.4	8.1	8.5

Climatic characteristics	Mean temperatures	ES INT1	ES INT2	ES INT3 and ES ORG
Temperature	Max (°C)	26.2	20.7	21.9
	Min (°C)	11.1	10.7	13.2
	Mean (°C)	18.2	16.5	16.7
Average rainfall (mm)		292	482	481

Rotation

Pilar de la Horada integrated (ES INT1) private farm	Benicarlo integrated (ES INT2) private farm	Paiporta integrated (ES INT3) & organic (ES ORG) experimental station
1. vetch-oats	1. seed artichoke	1. artichoke
pepper + little gem	tomato	green bean
2. little gem	2. green bean	2. onion + watermelon,
sweet corn + broccoli	lettuce	cauliflower
3. lettuce	3. lettuce	3. potato
onion	watermelon	fennel
4. celery	4. cauliflower	4. oats
watermelon	vetch-barley + artichoke	seed artichoke

Switzerland

Regional aspects

In Switzerland, an area of 7 700 hectares is grown with open field-grown vegetables and 3 800 hectares with vegetables for industry. In total, it concerns 1 400 farms. Most of the farms grow many different crops. The most important crops are lettuces, cauliflower, carrot, onion, leek, fennel and celeriac. 40% of the national demand for vegetables is imported. Integrated crop production and organic farming is of increasing importance in Switzerland (production under label guidelines). The government intends to convert 90% of the farms to integrated or organic farming within the next ten years. At present, more than 75% of vegetable farms already met the requirements for integrated crop production. An increasing number of farms (5% to 20%) will convert to organic production in the near future. Practical difficulties on organic and integrated vegetable farms mainly concern the following topics: (1) availability of nitrogen, (2) weed control and (3) pests and diseases (Gysi et al., 1996).

Tested systems

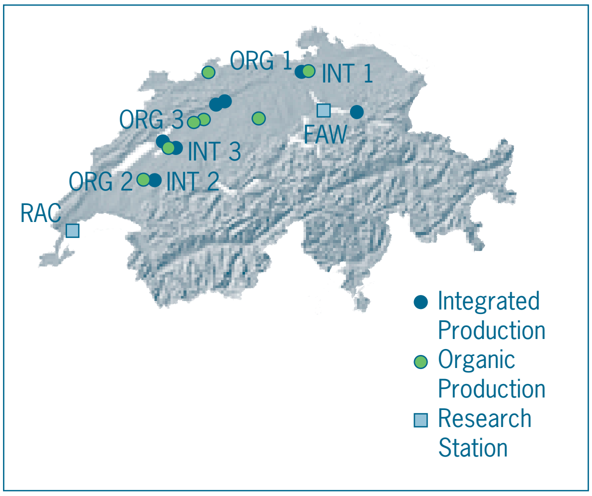
Three integrated and three organic pilot farms were tested:
INT1/ORG1: wholesale distributors, Zurich
INT2/ORG2: direct sale, French-Swiss
INT3/ORG3: retailers / wholesalers, Seeland

Main crops and rotation

Main crops
- head lettuce
- cauliflower
- carrots
- leek
- onions

Rotation length
- short: 3-4 years
- long with arable crops: 6-12 years

Location



Site information

Pedeological information	Bern/Biel		Zürich	
soil type	histosol[2]	eutric cambisol[2]	eutric cambisol[2]	gleyic/calcaric cambisol[2]
clay (%)		1-10/26-54[1]	15-20[2]	30-40[2]
sand (%)		71-94/16-55[1]	40-85[2]	10-70[2]
silt (%		6-19/20-44[1]	0-50[2]	0-50[2]
organic matter (%)	> 30[1]	1-26[1]	2-5[2]	2-5[2]

Climatic information[3]	Bern/Biel	Zürich
annual average precipitation	1 088 mm (Biel)	1 005 mm (Reckenholz)
annual average sunshine	1 681 hour (Liebefeld 95)	1 501 hour (Reckenholz 95)
annual average radiation	4 325 MJ m^{-2} (Liebefeld 95)	3 858 MJ m^{-2} (Reckenholz 95)
annual average temperature	8.5 °C (Biel)	7.8 °C (Reckenholz)
average latitude	47° 00' N.	47° 30' N.
average altitude	440 m above sea level	450 m above sea level

References:
[1] Organische Böden des schweizerischen Mittellandes, Presler/Gysi 1989
[2] Bodeneignungskarte der Schweiz 1980
[3] Annalen der Schweizerischen Meteorologischen Anstalt 1995

Annex 2. Definitions of the parameters

Parameters	Definition	Target
Quality production		
1. Quantity of produce (QNP)	The extent to which good regional yield is realised. QNP = realised yield (kg ha^{-1}) divided by good regional yield (kg ha^{-1}).	All crops should have a yield equal to or higher than good regional yields. QNP ≥ 1
2. Quality of produce (QLP)	The extent to which regional good quality is realised. QLP = realised amount in quality class 1 divided by regional good amount of quality class 1.	All crops should have a quality equal to or higher than regional good quality. QLP ≥ 1
3. NO_3^- content of crop produce (NCONT)	The nitrate content in leafy vegetables in mg kg^{-1} fresh matter.	All leafy crops should have a lower NCONT than the national standard. NCONT < x ppm
Clean environment nutrients		
4. Phosphate Annual Balance (PAB) 5. Potash Annual Balance (KAB)	Phosphate and Potash Annual Balances (PAB/KAB) are phosphate (P_2O_5) and potash (K_2O) inputs divided by phosphate and potash off-take with crop produce in one year.	The value of the target is dependent on the value of the soil reserves (PAR/KAR) (see 13,14) • PAB/KAB > 1 when PAR/KAR is below desired range • PAB/KAB = 1 when PAR/KAR is in desired range • PAB/KAB < 1 when PAR/KAR is beyond desired range
6. Nitrogen Available Reserves (NAR)	Mineral Nitrogen Reserves (NAR) in the soil (0-100 cm) at the start of the leaching season (kg ha^{-1}).	The target values are set such that the EU-norm for drinking water (50 mg NO_3^- l^{-1}) should not be exceeded. NAR < x kg ha^{-1} x = 45 kg ha^{-1} on sandy soils x = 70 kg ha^{-1} for clay soils
Clean environment pesticides		
7. Synthetic pesticides input active ingredients (PESTAS-Synth)	Pesticide input of synthetic pesticides in kg ha^{-1} active ingredient per year.	The use of pesticides in kg active ingredient ha^{-1} should be as low as reasonably possible. PESTAS-Synth < x kg a.i. ha^{-1}
8. Copper input active ingredients (PESTAS-Cu)	Copper input in pesticides in kg ha^{-1} per year.	The use of copper in kg ha^{-1} should be as low as reasonably possible. PESTAS-Cu < x kg a.i. ha^{-1}
Environment Exposure to Pesticides 9. EEP-air, 10. EEP-groundwater, 11. EEP-soil	Emission potential of pesticide active ingredients (a.i.) to the environmental compartments: • air (kg ha^{-1}) • groundwater ppb • soil (kg days ha^{-1})	The potential emission of pesticides should be as low as reasonably possible or fulfil legal standards (EU directive on drinking water) • EEP-air < x kg a.i. ha^{-1} • EEP-groundwater < 0.5 ppb in total and 0.1 ppb (EU countries) • EEP-soil < x kg days ha^{-1}

Parameters	Definition	Target
Nature and landscape		
12. Ecological Infrastructure (EI)	EI is the part of the farm laid out and managed as a network of linear and non-linear habitats and corridors for wild flora and fauna, including buffer strips.	Area with ecological infrastructure should be at least 5% of total farm area EI > 5%
Sustainable use of resources		
13. Phosphorus Available Reserves (PAR) 14. Potassium Available Reserves (KAR)	Phosphate and potash plant available reserves in the soil (kg per unit soil).	PAR/KAR should be within a range that is agronomically desired and environmentally acceptable: $x_p < PAR < y_p$ $x_k < KAR < y_k$
15. Organic Matter Annual Balance (OMAB)	OMAB is the proportion between annual input and annual output (respiration, erosion) of effective organic matter.	The target value is dependent on the actual and desired level of the organic matter content: • OMAB > 1 when actual organic matter content is lower than desired level • OMAB = 1 when actual organic matter content is equal to desired level • OMAB < 1 when actual organic matter content is higher than desired level
Energy Input (ENIN)	Input of direct and indirect (fossil) energy in MJ ha^{-1} used for crop cultivation.	No target established
Farm Continuity		
16. Net Surplus (NS)	Difference between total revenues and total costs (including labour) in € per ha.	Gross revenues should be larger than total costs. NS ≥ € 0
Hours hand weeding (HHW)	The amount of hours needed for hand weeding per ha as indicator of the success of the mechanical and/or chemical weed control.	Hours hand weeding should be as low as possible. HHW < x hours ha^{-1}

Annex 3. Short description of the multi-objective farming methods

Multifunctional Crop Rotation (MCR)
MCR is the major method used to preserve soil fertility and crop vitality in biological, physical and chemical terms. It is also used to sustain quality of production with a minimum of inputs (pesticides, manual and machine labour, fertiliser and support energy).

In MCR, crops are selected and put in order to get maximal positive interaction and minimal external effects for all objectives. A well-balanced mix of crops needs to be chosen. Crops are characterised in their potential role according to different characteristics. Crops are divided into main crops (important from a financial perspective), secondary crops and tertiary crops (the defenders, which put the main crops in an optimal position and defend the rotation against pests and diseases). In addition, an optimal agro-ecological layout of the system in time and space needs to be made to ensure a maximum contribution of the MCR in preventing pests and diseases. MCR forms the basis for the other methods.

Integrated/Ecological Nutrient Management (I/ENM)
I/ENM gives directions in supplying nutrients in the correct amounts and forms, and at the correct time to achieve optimal quality of production; minimise losses to the environment; and keep soil reserves of nutrients and organic matter at adequate levels, agronomically as well as environmentally.

Attention is mainly paid to the macronutrients nitrogen, phosphorus and potassium. Nitrogen, a very mobile nutrient, is treated at a crop level. Phosphorus and potassium are treated at a rotation level as these nutrients are less mobile.

To reach these objectives, the nutrient requirements of the rotation are defined first. Secondly, the contribution of non-fertilisation sources is estimated. External, non-fertilisation sources are deposition, irrigation water and fixation. Internal, non-fertilisation sources (only nitrogen) are green manure, catch crops, crop residues and mineralisation from organic matter in the soil. If these sources are known, the need for fertilisers can be determined. Fertiliser input can be minimised by choosing the correct timing, application technique and fertiliser type.

Integrated/Ecological Crop Protection (I/ECP)
I/ECP supports the Multifunctional Crop Rotation and Ecological Infrastructure Management in achieving optimal quality of production by selectively controlling residual and harmful species with minimal exposure of the environment to pesticides.
The general strategy consists of three steps:

1. maximum emphasis on prevention (resistant varieties, cultural practiceds such as adapting the sowing date and row spacing),
2. a correct interpretation of the need of control (guided control systems, thresholds, signalling systems),
3. the use of all available non-chemical control measures (mechanical weed control, genetic, physical and biological control).

Pesticides are then only necessary as additional measures. Methods with minimum use such as seed treatment, and row or spot-wise application are preferred over applying to the entire field. Appropriate dosages and, when possible, a curative approach (field and year specific), further reduces the input. Finally, pesticides should be carefully selected with respect to selectivity and exposure of the environment to pesticides (EEP).

Minimum Soil Cultivation (MSC)
MSC is an additional method to MCR and I/ENM that sustains quality of production by preparing seedbeds, controlling weeds, incorporating crop residues and restoring physical soil fertility reduced by compaction from machines, specifically at harvest. Soil cultivation should be minimal in order to achieve the objectives with respect to energy use; to maintain sufficient soil cover as basis for erosion prevention; shelter for natural enemies; landscape/nature values; and maintenance of an appropriate organic matter annual balance.

Ecological Infrastructure Management (EIM)
EIM supports MCR in achieving optimal quality of production by providing airborne and semi-soil-born beneficials a place to survive unfavourable conditions, and then recover and disperse in the growing season. In addition, EIM should met the nature/landscape objectives.
Operating EIM implies establishing an area of linear and non-linear elements to obtain spatial and temporal continuity in nature area; and establishing buffer strips to protect these natural areas. Finally, establishing a plan for the long term considering the target species/communities and special ecological elements such as ponds and hay stacks.

Farm Structure Optimisation (FSO)
FSO determines the minimum amounts of labour and capital goods needed to achieve the required net surplus (all revenues - total costs, including labour) ≥ 0.
A region-specific, tested prototype that can meet the quantified objectives also needs a farm economic perspective. The existing farm structure might be an important impediment. To study the perspectives of the prototype, FSO has been developed. FSO examines the farm structure needed to describe an agronomically and ecologically optimal prototype as well as the economical aspects.

The bases for these studies are the existing results of the prototype achieved in an experimental setting. The study considers the perspectives for the near future.

The available results, however, are mostly based on an experimental *(sub-optimal)* scale, with the original *(out-dated)* costs for inputs and outputs and the original *(out-dated)* versions of the prototype. However, perspectives of integrated and ecological systems can only be estimated if subsequently:

1. inputs and outputs are technically updated considering the latest version of the prototype and possible non-system specific events or effects,
2. inputs and outputs are economically updated considering current or expected costs.

An optimal farm structure is developed considering the rates of land, labour and capital, to achieve the basic income/profit objective of net surplus ≥ 0.

Annex 4. Surveys

Researchers' survey

Please fill in the next Table for at least two systems. State five objectives and give them a ranking from one to five. 1 = most important objective. If other objectives are important, describe them and give a ranking. If you add one objective, the ranking range is 1 to 6, if you add two objectives; the range is 1 to 7, and so on.

Objective	Ranking System 1	System 2	System 3
Increasing biodiversity			
Attractiveness to the surrounding community			
Reducing losses (nutrients, drift pesticides)			
Increase of natural predators			
Improving/maintaining physical conditions (erosion, windbreak)			
Other……….			

Farmers' survey

Do you think it is important to work on the introduction of nature and/or natural elements on your farm. (e.g. hedges, ponds, buffer zones)?

- ❑ YES
- ❑ NO

Why is it important to you? Give a number to each advantage, the lowest number being the most important.

- ❑ Subsidies
- ❑ Natural predators
- ❑ Biodiversity
- ❑ Preventing erosion
- ❑ Better image
- ❑ Windbreak (not asked in the Netherlands)
- ❑ Attractive landscape (only asked in the Netherlands)
- ❑ Other

What are the disadvantages of the introduction of these elements?

- ❑ Loss of income
- ❑ Weeds
- ❑ Loss of production area
- ❑ Possible hosts for diseases
- ❑ Barriers for machine operations
- ❑ Other

Annex 5. Results of Swiss farmers' survey

Opinion of Swiss pilot farmers concerning ecological infrastructure - results of an survey on 14 Swiss pilot farms in Autumn 1999
64% of the pilot farmers (3 integrated and 6 organic farmers) think that ecological infrastructure on their farm is useful. 36% (1 organic and 4 integrated farmers) accept ecological infrastructure only to get direct subsidies or the certification.

Advantages of the ecological infrastructure
Each farmer had to give three points and had the opportunity to choose three advantages from a prepared list, but other advantages could be added. One integrated farmer chose only one single advantage (see footnote, Table 1).
The majority of all Swiss pilot farmers and all organic farmers are of the opinion that ecological infrastructure promotes biodiversity. Preventing erosion by creating nature on farms is also important for both, integrated and organic farmers. A better image and a higher income are the main advantages from the integrated farmers' point of view.

Disadvantages of ecological infrastructure
Each farmer had to give three points and had the opportunity to choose three disadvantages from a

Table 1 Advantages of the ecological infrastructure - attitudes of Swiss pilot farmers

Advantage	Number of points from integrated farmers	Number of points from organic farmers	Percentage of points from the 14 pilot farmers
Increase biodiversity	4	7	26.2%
Protection against soil erosion	7[1]	4	26.2%
Improving the image of agriculture	4	2	14.3%
Increase income with subsidies	4	-	9.5%
Promotion of benefits	1	3	9.5%
Increase number of visitors/hikers	1	-	2.4%
Decrease in pressure from pests	-	1	2.4%
Other:			
Windbreak	-	1	2.4%
Improve the quality of meadows	-	1	2.4%
Increase the number of nesting sites for birds	-	1	2.4%
Lower competition in the Swiss market	-	1	2.4%

[1] includes three points from one farmer

Table 2 Disadvantages of the ecological infrastructure - attitudes of Swiss pilot farmers

Disadvantage	Number of points from integrated farmers	Number of points from organic farmers	Percentage of points from the 14 pilot farmers
Loss of productive area	6	4	23.8%
Limitation of free management	6	2	19.1%
Time for tending and cutting	4	3	16.7%
Increase in pressure from pests[1]	1	5	14.3%
Increase in weed pressure[2]	2	4	14.3%
Increase in diseases	-	2	4.8%
Increase in damage done by hikers	1	1	4.8%
Other:			
Waste disposal of cut grass	-	1	2.4%

[1] important pests are slugs, wireworms, crane flies, mice, sparrows, and leaf and root aphids
[2] important weeds: thistle and dock; main problems after "coloured fallows"

prepared list or from additional disadvantages.
Loss of productive area and limitation of free management are the main disadvantages of on-farm nature for the integrated farmers and the Swiss pilot farmers in general (Table 2). The majority of the organic farmers think that ecological infrastructure increases pressure from pests.

Further comments from individual farmers

- The requirements concerning ecological infrastructure (area) should not be increased in the future. Ecological infrastructure is only useful on non-arable land.
- Larger connected areas of buffer zones are ecologically more useful than the small ones for individual farms. A group of farmers can rent these ecological infrastructure areas and each farmer is responsible for a special part of the area (for example, "Biotopverbund Grosses Moos" in the Seeland region).
- It is important to include the natural landscape on a farm.

Annex 6. EIM parameters

PWE

Full name	Percentage of Woody Elements
Definition	The presence of woody elements (trees, bushes, hedges, forest) on the farm in relation to the landscape.
Dimension	–
Level	Farm and surroundings (<100 m)
Targets	Dependent on the presence of woody elements at a landscape level. The percentage at a farm level should reflect the percentage at the landscape level.
Countries	CH, I, NL, ES
Calculation	To calculate the percentage at a landscape level, maps (1:25 000) are used, which reflect the desired landscape. These maps can be historical maps or landscape maps in which the desired landscape (obtained from for example rural development plans) can be seen. On these maps, a grid with one hundred 250/250-meter squares (6.25 km^2) is positioned with the farm in the middle of the grid. The presence of larger woody elements (hedges, bushes, forests) in the squares is indicated. The number of squares with these elements present gives the percentage of woody elements at a landscape level. To calculate the percentage at the farm level, maps (1:5 000) representing the current situation are used. On these maps, a grid is placed with 50/50-meter squares in position covering the entire farm and the surroundings within 100 meters. The presence of single trees, bushes and/or forest in the squares is indicated. From this, the percentage of squares with woody elements at a farm level is calculated.
Testing	If PWE farm level < PWE landscape level, planting trees may be considered. Planting of new woody elements and possible locations for planting should be evaluated in connection with the parameters CoLE, CiLE and BTP.

CoLE

Full name	Connectivity of Landscape Elements
Definition	The extent to which landscape elements (nodes) are connected to each other by suitable habitat for dispersal (links) of target species. **Node:** landscape element of sufficient size (>50 m^2) to provide shelter, food and the possibility for reproduction (depending on the species). Size should not be related to animals that need large areas for shelter, food and reproduction since this is not possible to achieve on farms. **Link:** A difference is made between woody links and herbaceous links. Links may be formed with hedges, individual trees and/or small bushes (<50 m^2) for woody landscapes. If between nodes these smaller elements are present and the distance between these elements is less than 100 m, the landscape elements are considered to be linked. Some species depend on tall herbaceous vegetation to move between landscape elements. For these groups, nodes are considered to be linked when gaps in herbaceous vegetation are smaller than 50 m.
Dimension	–
Level	Farm and surroundings (<100 meter)
Targets	Result of formula (see calculation) by filling in the formula with N = number of nodes present and L = $\frac{1}{2}$N. If L ≥ $\frac{1}{2}$N, then the target has already been achieved.
Countries	CH, I, NL, ES
Calculation	CoLE = (L / (3*(N-2))*100%, with L = number of links, N = number of nodes.
Testing	If CoLE < target value, new links between nodes should be created. Creation of new links to reach the target value should be evaluated in connection with the parameters PWE and CiLE.

CiLE	
Full name	Circuitry of Landscape Elements
Definition	The extent to which it is possible for species to move between landscape elements (nodes) through different links. (links and nodes, see also definition of CoLE).
Dimension	–
Level	Farm and surroundings (<100 meter)
Targets	Result of formula (see calculation) by filling in the formula with N = number of nodes present and L = N. If L ≥ N, the target has already been achieved.
Countries	CH, I, NL, ES
Calculation	CiLE = ((L - N) +1) / (2N - 5) * 100%, with L = number of links, N = number of nodes.
Testing	If CiLE < target value, new links between nodes should be created. Creation of new links to reach the target value should be evaluated in connection with the parameter PWE and CoLE.

BTP	
Full name	Biotopes
Definition	The degree in which biotopes, representative of the surrounding landscape, are present on the farm. Examples of biotopes are forests (bushes), arable land, lakes (pools), meadows, and heath lands.
Dimension	–
Level	Farm and surroundings (<100 meter)
Targets	50% of existing biotopes in the 6.25 km^2 (a grid of 2.5/2.5 km with the farm in the middle) surrounding the farm must be present on the farm or in the direct surroundings (<100 m): BTP ≥ 50%.
Countries	CH, I, NL, ES
Calculation	BTP = (number biotopes on the farm / number of biotopes in landscape) * 100%
Testing	If BTP < 50%, new biotopes should be created on the farm. The choice for a new biotope depends on several aspects: • the level of abundance of a certain biotope which is needed for appropriate function. • the manner that the farm is situated in relationship to other similar biotopes in the surrounding area. • the potential of the farm (soil type) and farming system. In rural development plans, preferences may have been included for the development of specific biotopes. These should be taken in consideration as well.

BZI	
Full name	Buffer Zone Index
Definition	The degree to which landscape elements (ditches, pools, bushes) are buffered from agricultural practices (pesticide drift, nutrient leaching and disturbance from agricultural traffic). The minimum size for a buffer zone is 0.5 meter.
Dimension	–
Level	Farm
Targets	All landscape elements should have buffer zones next to them. For landscape elements on the border of the farm, the index is 1 and for internal landscape elements the index is 2. Therefore, at a farm level, the target for BZI may vary between 1 and 2 depending on where the landscape elements are situated. 1 ≤ BZI ≤ 2
Countries	CH, I, NL, ES
Calculation	BZI = B / ((Li * 2) + Le), with B = total length of buffer zones, Li = total length of landscape elements situated within the farm and Le = total length of landscape elements on the border of the farm. For non-linear landscape elements, the outline of the element should be used as the length.
Testing	If BZI < target value (1-2), buffer zones should be created if they are absent.

BZW	
Full name	Buffer Zone Width
Definition	The average width of the buffer zones on the farm
Dimension	meter
Level	Farm
Targets	BZW = 4 meter
Countries	CH, I, NL, ES
Calculation	BZW = (Wa * La + Wb * Lb + Wc * Lc+ ...) / (La + Lb + Lc + ...), with Wa, Wb, Wc = Width of buffer zone a, b, c and La, Lb, Lc = Length of buffer zone a, b, c. For the calculation, buffer zones wider than 4 m are fixed at 4 m
Testing	If BZW < 4, buffer zones that are < 4 m should be enlarged to 4 m

EII	
Full name	Ecological Infrastructure Index
Definition	Percentage of the farm that is managed as a network of linear and non-linear biotopes for flora and fauna (including buffer strips).
Dimension	–
Level	Farm
Targets	EII ≥ 5%
Countries	CH, I, NL, ES
Calculation	
Testing	If EII < 5%, additional area should be added to the network. Which type of ecological infrastructure and where to create it is driven by the performance of all the other parameters of ecological infrastructure management.
FSI	
Full name	Field Size Index
Definition	The extent to which the field sizes on the farm deviate from the “optimal” field width for stabilising the agro-ecosystem using functional biodiversity. The optimal field width for stabilising the agro-ecosystem is ≤ 125 m based on the radius of action of the most important terrestrial species of predators.
Dimension	meter
Level	Field and farm
Targets	FSI = 0 (no deviation from the optimal field size)
Countries	CH, I, NL, ES
Calculation	FSI = (A1 * (W1-125)/At), with A1 = area of the farm with fields wider than 125 m, W1 = average width of fields wider than 125 m and At = total area of the farm Every 25 units deviation corresponds with a 10% deficit.
Testing	On the part of the farm where the deviation originates from, the field size should be reduced. Reduction of the field size creates habitat for terrestrial predators (herbaceous strips across the field).

BTS (This parameter is not completely developed yet)	
Full name	Biotope target species
Definition	Number of target species present in a biotope
Dimension	–
Level	Farm
Targets	–
Countries	CH, I, NL, ES
Calculation	The idea is to monitor chosen target species and use the presence of these species in the vegetation as an indicator that a certain level of quality has been reached in a succession stage.
Testing	For each biotope, 20 target species are chosen, which can be divided into four groups that correspond to a specific stage in the succession of the vegetation. The presence of certain target species defines a stage and thus reflects the quality of a biotope.

Annex 7. Possible contracts concerning EIM in Italy

Regulation	Contract	Requirements	Length of contract	Subsidy € per year
Maintenance and/or introduction of natural elements	Rows of trees to support grapevines Single trees or rows of trees Hedges Brushwood with a minimum surface of 0.5 ha Retting-pits (only in flat areas, these were used to ret hemp) Artificial ponds (in hills and mountains) Ponds with natural sources	• The farmer has to reserve a minimum surface area for natural elements (5% natural elements in a flat area, 10% in a hilly area and 15% in a mountainous area) • Only indigenous trees can be planted • On each side of a natural row of plants or trees, there has to be an uncultivated strip of land. • The width of this strip has to be at least 1.5 m. In hedges the plants have to be at a minimum distance of 1.5 m from each other. • The distance between different rows has to be at least 3m. A hedge must contain at least five different plant species. In brushwood the maximum distance between trees is 3 m. • It is forbidden to use fertilisers or pesticides in the uncultivated strips. • If trees die, the farmer has to replace them with new ones of approximately the same age. • Mowing is allowed from the 1st of August until the 20th of February. • Around retting-pits and ponds, there must be uncultivated strips of at least 3 meters (buffer zones). The farmer has to maintain a water level of at least 50cm. in the pits and ponds during the entire year.	5 years	Flat area: € 0.1 per m^2. Hilly area: € 0.05 per m^2 Maximum area = 10% (flat) or 20% (hilly) of the total farm surface
Reduction of the surface area used for arable crops and development of ecosystems	Establishing and maintaining natural ecosystems Establishing specific areas in which water quality is improved by decreasing pollution Improving the ecological system in the specific areas Re-establishing wet zones Establishing of expansion basins along the rivers to protect the land from being flooded	The minimum surface of natural land is 1ha.	20 years	The subsidy used to be - € 724.5 per ha for priority flat areas, - € 483 per ha for other flat areas, - € 483 per ha for all hilly and mountainous priority areas. In the year 2000, the subsidy will depend on Agenda 2000.

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