# Voluntary Agreements and the Environmental Efficiency of Participating Farms

**Article** · February 2002

Source: RePEc



Jutta Roosen
Technical University of Munich

# Voluntary Agreements and the Environmental Efficiency of Participating Farms

Jutta Roosen
E-mail: Roosen@ecru.ucl.ac.be

Andrea Ordonez
E-mail: Ordonez@ecru.ucl.ac.be

**Paper prepared for presentation at the X[th] EAAE Congress**
**'Exploring Diversity in the European Agri-Food System',**
**Zaragoza (Spain), 28-31 August 2002**

# Voluntary Agreements and the Environmental Efficiency of Participating Farms

**by**

*Jutta Roosen* [1]
Assistant Professor
Unit of Agricultural Economics and Center for Operations Research and Econometrics (CORE)
University of Louvain
Address: Place Croix du Sud 2/15, B 1348 Louvain-la-Neuve Belgium
Phone: +32 10 47 87 07 and Fax +32 10 47 36 75
E-mail: Roosen@ecru.ucl.ac.be

and

*Andrea Ordóñez*
Research Assistant
Unit of Agricultural Economics
University of Louvain
Address: Place Croix du Sud 2/15, B 1348 Louvain-la-Neuve Belgium
Phone: +32 10 47 87 07 and Fax +32 10 47 36 75
E-mail: Ordonez@ecru.ucl.ac.be

[1] Roosen is the corresponding author.

We thank, without implications, Denis Devos for effective research assistance and Thierri Walot, Lionel Delvaux and Manuel Grosjean for their helpful comments on environmental farm indicators. This project was supported by a research grant of the Walloon Agricultural Directorate General, Belgium, whose support is gratefully acknowledged.

**Voluntary Agreements and the Environmental Efficiency of Participating Farms**


## Abstract

Voluntary environmental agreements have been popular with government agencies in several countries. However, many questions remain about their efficiency as a regulatory tool. Recent analyses suggest that they are more effective than conventional regulatory or economic approaches when dealing with diffuse pollution and when innovation processes at the source are necessary to define effective regulation. This paper applies an activity-based framework to assess the contribution of such a voluntary agreement to the environmental performance of farms participating in a whole farm plan in the Southern part of Belgium. Using a cross-section of 52 farms, our results show that farms entering into environmental agreements are environmentally more efficient than non-participating farms in terms of the preservation and provision of landscape features. However, their environmental efficiency with regard to the reduction of non-desirable outputs, such as organic nitrogen, is mostly determined by technical efficiency and not by participation in the whole farm plan.



***Keywords***: Agri-environmental indicators, Data envelopment analysis, Environmental efficiency, Voluntary agreements, Whole farm plan

***JEL Codes***: C14, Q12, Q2

## Voluntary Agreements and the Environmental Efficiency of Participating Farms

### 1. Introduction

Governments have become increasingly interested and involved in voluntary environmental agreements regulating different sectors of the economy. The Fifth European Program of Action adopted in 1992 proposed this new approach to environmental policy and by 1996, more than 300 voluntary agreements (VAs) have been created in the European Union (Aggeri, 1999). Governments' interest in this approach is justified by its potential to reduce the increasing administrative costs of direct regulation, by the political difficulties in introducing taxes and permit systems, and by the support VAs receive from industry groups (Carraro and Lévêque, 1999).

A large number of voluntary programs can also be found in agriculture. These programs seek to reduce negative externalities, such as nitrate and pesticide leaching into groundwater, as well as to pose incentives to maintain and improve the provision of public goods, such as ecologically important landscape elements. Voluntary approaches have been deemed appropriate for the regulation of environmental impacts of agriculture because of the nonpoint source character of many pollution problems. In addition, agriculture has a long history of public support in the development and diffusion of new technologies as documented by the important role that governments attribute to agricultural programs and extension services.

The growing interest in voluntary agreements calls for an assessment of their efficiency in improving environmental impacts. Hanley et al. (1999) point to the need to develop methods evaluating the environmental achievements of stewardship programs. This exercise may be simple when program objectives are uni-dimensional, for example when protecting a single endangered species. However, many environmental programs in agriculture are not only concerned with one precise environmental variable but tackle several issues at once. This makes it difficult to measure their success in achieving their multiple objectives.

Some papers have assessed the success of agri-environmental programs by analyzing the adoption of environmentally sound production practices (e.g., Lichtenberg et al., 1993). However, little research has been done in order to assess the achievement of general environmental performance objectives. Environmental performance and efficiency of a given production activity may be measured by agri-environmental farm indicators (see for example OECD, 2001) or by activity-based analysis, i.e., data envelope analysis (DEA). The latter approach allows to overcome problems associated with the aggregation of several environmental indicators (Tyteca, 1997). It takes into account the technical efficiency of resource use and can be extended to account for the production of weakly disposable outputs and non-market amenities.

The objective of this paper is to analyze the environmental performance and efficiency of farms participating in a voluntary public scheme encouraging environmentally friendly agricultural practices. Showing that a VA improves the environmental performance and efficiency of participating farms is certainly not sufficient to prove its overall economic efficiency. This would require a more detailed analysis of costs and benefits. However, observable improvements in the environmental performance of participating farms are a necessary condition for any effective environmental policy tool.

The VA of our choice is the whole farm plan (WFP) that has been proposed to farmers in Wallonia, Belgium, since the introduction of the agri-environmental stewardship programs according to EU regulation 2078/92 in 1994. Using a collection of agri-environmental indicators and DEA, we compare a sample composed of farms having established a plan to a sample of farms not having subscribed to the program.

The remainder of the paper is structured as follows. First we give an overview of the literature on voluntary environmental agreements. We introduce, in section 3, the WFP implemented in southern Belgium. Then we introduce the methods and the data collection procedure. Results are discussed in section 5. The paper concludes with a discussion of the implications of our findings.

## 2. Voluntary Agreements

The term "voluntary agreements" refers to a multitude of environmental policy approaches. In this section we review the main features of the literature on VAs.

### *2.1. Definition and types*

VAs are hybrids between traditional "Command and Control" policies and horizontal non-regulatory measures, and have been linked to other instruments such as legislation, taxes, and subsidies (European Commission, 1997). In voluntary approaches, firms commit to improve their environmental performance exceeding legal requirements. VAs can be classified into four categories (Carraro and Lévêque, 1999). *Unilateral commitments* are environmental improvement programs set up by firms and communicated to their members (employees, shareholders, clients, etc.), whereas *negotiated agreements* provide contracts between public authorities and firms that prescribe a target and a time limit to accomplish it. *Covenants* negotiate agreements establishing rules of implementation to meet targets. This type of VA has different purposes, ranging from studying a particular issue to reaching a specific environmental goal through binding or voluntary agreements (e.g., the Dutch energy efficiency covenants). Lastly, *public voluntary schemes* are general frameworks and standards voluntarily adopted by individual firms. These types of agreements define compliance conditions and monitoring and evaluation criteria. In response, participating firms receive economic benefits in form of R&D subsidies, technical assistance, and certified environmental reputation, such as in the Eco-Management and Auditing Scheme (EMAS) implemented in the EU since 1993. The whole farm plan studied in this paper is of this public voluntary scheme type.

### *2.2. Efficiency of voluntary agreements*

In response to the rising interest in VAs by public decision-makers and industry, economists have become increasingly involved in the analysis of VAs. At first sight, it seems puzzling that public decision makers are willing to form VAs with polluting firms because such arrangements may give considerable negotiating power to the firms or to the industry to be regulated. But moral hazard prevailing in environmental regulation might be better dealt with on a "cooperative" basis and transaction and monitoring cost could substantially be reduced. Indeed, public decision makers preserve their negotiation power by credible legislative threats of stricter mandatory regulation in the case that the environmental goals fixed in VAs are not achieved (Segerson and Miceli, 1998).

The environmental efficiency of VAs is much debated. They may improve a firm's public image and leave more flexibility to firms in achieving environmental goals and thus provide cost reduction possibilities with respect to compliance, administrative, and transaction costs (Börkey et al., 1999). Despite this flexibility and the resulting cost reductions, VAs may not be efficient in achieving an environmental standard for two reasons: Firms have the possibility to disrespect their commitments and firms may declare an easy target to reach (Carraro & Lévêque, 1999). As a result, VAs may lead to a watering down of environmental standards and monitoring and enforcement mechanisms may not be reliable. In badly designed VAs, free-rider problems may prevail, such that the agreements lack credibility in public opinion and are not be accepted by non-government organisations (Lévêque, 1997). Binding agreements provide more guaranties for reaching environmental standards (Lefèvre, 2000). The success of non-binding agreements depends then on the simultaneous existence of a credible threat of stricter legislation and correct incentives encouraging firms to participate.

VAs will be efficient in defining an appropriate environmental quality standard if these non-binding programs are used as a complement to other regulatory tools rather than as a substitute of them. A good example is the Danish scheme on greenhouse gas emissions reduction that includes a financial support in form of investment grants and $CO_2$ rebates (Lefèvre, 2000). According to Aggeri (1999), VAs also represent an appropriate way for developing and monitoring innovation.

In particular, Aggeri (1999) considers that the use of VAs can be justified in cases of nonpoint source pollution, where a large number of heterogeneous actors is involved, the number of transformation stages is significant, and the level of uncertainty is high. In these cases, strong coordination mechanisms are required in setting quantitative objectives and in designating responsibilities, know-how transfer rules, and monitoring schemes. VAs can provide such mechanisms, even if they provide lower incentives for abatement than other economic instruments.

*2.3. VA as a stimulus for innovation*

VAs can reduce compliance and transaction costs by allowing polluters flexibility in the choice of technology through which environmental performance targets are met. In several cases, this flexibility may stimulate innovation. By being first in adopting and developing new technologies, firms participating in VAs can push for tightened regulation that increases their compliance cost by less than its competitors' costs. The 'environmental' innovators may hence improve their strategic position in the industry (Salop and Scheffman, 1983, Videras and Alberini, 2000).

It has been observed that innovation at the source is an important process for improving environmental conditions. For example in the last decades in the Netherlands, agriculture has rapidly progressed and has frequently resorted to innovations (David et al., 2000). The Dutch government has contributed to this success by investing in research, education, and extension, but it has also understood that delegating more authority and responsibility to firms reduces public expenses and increases the environmental involvement of firms.

## 3. The Walloon Whole Farm Plan

The agricultural administration of the Walloon region has proposed an environmental whole farm plan (WFP) to farmers since 1994. This plan is part of the environmental stewardship programs introduced in Belgium according to the EU regulation 2078/92. In transposing this regulation, the Walloon region distinguishes between the region as a whole and areas of particular environmental statute, such as those facing difficulties of meeting the objectives set out in the EU nitrate directive (91/676/CEE) and those being protected under the statute of a natural park. There are six horizontal agri-environmental programs that are accessible to farmers independent of location and five vertical programs only accessible in the environmentally sensitive areas. The latter encourage reduction of inputs in cereal and maize production, plantation of winter green cover crops, very extensive pasture management, and the protection of wetlands. The horizontal programs proposed without area restriction and thus applicable to the whole region support extensive pasture management, extensive field margins, the maintenance of hedges, fruit trees, and wetlands, and the reduction of livestock densities. During the period from March 1999 to December 2000, vertically restricted programs could be adopted outside the sensitive zones if farmers agreed to subscribe to at least three programs and if they subscribed at the same time to an environmental whole farm management plan.[1]

The WFP consists of a description of the farm and its production activities, and examines the farm's environmental approach in seven categories: (1) the application of the good agricultural practice; (2) application of new and improved cultural practices; (3) control of technical material (pesticide sprayer, effluent applicators, etc.); (4) pest management; (5) plant nutrition management; (6) effluent storage; and ( 7) nature protection and landscape integration. The plan is prepared in collaboration between the farmer and the regional administration and the assessment of current farm practices leads to the definition of short-term (1 year), medium-term (5 years), and long-term objectives. Progress towards these objectives is to be reviewed regularly (annually) and objectives can be adapted to take changes into account. The WFP consists of a five-year contract. This is consistent with the commitment period of the other agri-environmental programs that farmers can subscribe to.

The focus of the whole farm plan lies explicitly in improving the overall environmental approach of the participating farm. As it was mandatory for certain stewardship programs, farms particularly interested in these vertical programs have enrolled. For instance, one of the vertical programs subsidizes the plantation of winter cover crops at 100 Euro/ha, and many farmers with large acreage in spring crops (in particular maize, potatoes, and sugar beets) are interested in this program. The establishment of the plan itself or the achievement of the fixed objectives was not an object of remuneration in itself. Participation was hence mostly based on negative incentives, because the plan was necessary to access some of the agri-environmental subsidies (Ervin and Smith, 1996). Positive incentives, for example related to training and education, have rarely been a motive to establish the plan. Until the end of 1999, about 4 - 5% of the eligible farms outside the zones of particular environmental statute have subscribed to the WFP.

## 4. The measurement of environmental performance

We employ two approaches to measure the environmental performance of farms. First we use a set of agri-environmental indicators developed by the Walloon administration. The problem with this type of indicators is that it is difficult to globally assess the environmental impacts. Indicators are more or less focused on one particular aspect of environmental protection and one particular aspect is often addressed from different angles by different indicators. For

[1] The stewardship programs have been revised in response to EC 1257/1999 and are now part of the Walloon Rural Development Plan. The whole farm plan is no longer mandatory to qualify for any of the vertical or horizontal stewardship programs.

example, an indicator on nitrogen fertilization per hectare deals with questions of soil and water protection, and is often complemented by indicators analyzing the equilibrium of organic matters on agricultural land or measuring the animal stocking density.

When analyzing the global environmental performance of farms, the indicator method encounters problems when it comes to aggregation issues. How to weigh different indicators in the aggregation and how to account for the technical efficiency of production? Methods, such as *ecopoints* employed in lower Austria to calculate stewardship subsidies (Van Huylenbroeck and Whitby, 1999), are criticized for arbitrarily aggregating different indicators. While problematic, aggregation of indicators is an important issue. Especially if programs and farms are to be evaluated on their environmental contributions to landscape management and pollution reduction, an overall performance indicator is necessary. We thus use in a second instance data envelope analysis (DEA) in order to calculate an overall index of environmental efficiency. DEA or activity analysis allows evaluating the efficiency of farms by calculating weights that compare each individual farm to the entire sample. The envelopment is formed from the input-output data of the sample as its convex, weakly disposable hull of efficient observations.

### *4.1 Agri-environmental indicators*

The agri-environmental indicators evaluated in this study are those developed by the Walloon administration in order to evaluated the environmental performance of farms. Table 1 provides a list of the indicators used. They can be grouped into a set of indicators measuring the adoption of practices aimed at reducing the environmental intensity, and thus improving the degree of soil and water protection, and a second set of indicators evaluating the provision of desirable environmental services, such as landscape amenities. This classification is not unambiguous as some indicators relate to both aspects. The table shows in columns 2-4 a range of benchmark values according to which an indicator is considered signifying low, medium, and high environmental benefits.

### 4.2 *Data envelopment analysis measuring environmental efficiency*

Recent studies have used DEA to evaluate not only technical and economic efficiency but also environmental efficiency. This extension goes back to Färe et al. (1989) who include weakly disposable inputs in the technology. Färe et al. (1996) propose an indicator of the environmental performance that is based on the separability of the distance function.

Tyteca (1997) has used this method to form an indicator of environmental performance for electricity companies using a production technology characterized by a set of inputs, weakly disposable, nondesirable outputs, and strongly disposable, desirable outputs. He proposes three different indicators. The first efficiency measure considers only the reduction in undesirable, not freely disposable inputs. The second evokes a proportional reduction in inputs and undesirable outputs. And the third does no longer consider inputs in the technology description and considers the reduction in nondesirable outputs for a given level of desirable outputs. Ball et al. (1994) and Piot-Lepetit and Le Moing (2000) apply similar methods in the agricultural context.

In our application, we introduce in addition to weakly disposable undesirable outputs also desirable non-market outputs, i.e., amenities. These include the provision of environmental services, such as cultural variety measured by a crop rotation indicator, and space for nature protection such as marginal grassland, marginal arable land, and small landscape elements, e.g., hedges, trees, and wetlands.

We consider a set of k = 1, 2, …, K farms that use N inputs $x^k \in \mathbb{R}_+^N$ and produce M desirable market outputs $y^k \in \mathbb{R}_+^M$, *I* desirable non-market outputs $z^k \in \mathbb{R}_+^I$, and *J* non-desirable output, $w^k \in \mathbb{R}_+^J$. The outputs $y^k$ and $z^k$ are strongly disposable, whereas the $w^k$ are weakly disposable. The indices of efficiency used in our analysis deal only with aspects of technical efficiency and not with allocative efficiency, and thus all variables can be determined in physical or economic units.

To introduce the concept of technical efficiency, we first establish the convex free-disposal hull technology involving only inputs, *x*, and desirable market outputs, *y*. It is formed by the set

$$T = \left\{ (x, y) : x \geq \sum_{k=1}^{K} \lambda^k x^k , \; y \leq \sum_{k=1}^{K} \lambda^k y^k , \; \lambda \in R_+^K \right\}. \qquad (1)$$

For each k = 1, 2, …, K, $\left(x^k, y^k\right) \in T$ , and *T* is convex with inputs and outputs freely disposable. That means that if $(x, -y) \geq \left(x^0, -y^0\right)$ and if $\left(x^0, y^0\right)$ belongs to *T*, so does $(x, y)$.

The key concept in deriving technical efficiency is the input distance function that leads to radial measure of technical efficiency, $\theta_{Tech}$ , measuring the distance between the farm under consideration and the envelope formed as the convex hull of the efficient farms:

$$\theta_{Tech} = \min_{\theta} \left\{ \theta : (\theta\, x^k, y^k) \in T \right\} \; k = 1, \ldots, K \qquad (2)$$

When we account for weakly disposable outputs, *w*, then the new production technology is described by the set

$$T_{Env} = \left\{ (x, y, w) : x \text{ can produce } y \text{ and } w \right\}. \qquad (3)$$

Desirable outputs, *y*, and undesirable outputs, *w*, are distinguished by the property of strong and weak disposability. While *y* is strongly disposable, i.e., if $(x, y, w) \in T_{Env}$ and if $y' \leq y$ , then $(x, y', w) \in T_{Env}$ , *w* is weakly disposable and thus when $(x, y, w) \in S$ and $0 \leq \tau \leq 1$, then $(x, y, \tau\, w) \in T_{Env}$ . A reduction in the weakly disposable output can only be achieved at a cost, either by reducing the desirable output *y* or by increasing input use *x*.

In this framework, Tyteca (1997) proposes three alternative environmental indices. Two of them consider the unilateral reduction in non-desirable outputs and they are distinguished by accounting or not for inputs in the efficiency measure. A third indicator considers the reduction of inputs and undesirable outputs. This index is in particular useful in cases where it is meaningful to consider inputs as valuable resources. In agricultural production, where most inputs, such as land use or energy-intensive mineral fertilizer, represent valuable resources, this latter index seems to be the most appropriate. We thus measure environmental efficiency as

$$\theta_{Env}^k = \inf_{\theta} \left\{ \theta : \left( \theta\, x^k, y^k, \theta\, w^k \right) \in T_{Env} \right\} \qquad (4)$$

Under the assumption that the distance function is separable in the weakly disposable outputs and the technical efficiency score, this index has the convenient property that it can be decomposed into an index of pure input efficiency, $\theta_{Tech}$, and an index capturing the effects of undesirable outputs (Färe et al., 1996).

Finally, we introduce desirable non-market outputs by augmenting the vector of desirable market outputs, *y*, by the vector of desirable non-market outputs, *z*. We define an amenity and environmental efficiency index as

$$\theta_{Amen\,\&\,Env} = \min_{\theta}\left\{\theta : (\theta\, x^k, y^k, z^k, \theta\, w^k) \in T_{Amen\,\&\,Env}\right\}\ k = 1,\ldots,K \qquad (5)$$

where

$$T_{Amen\,\&\,Env} = \left\{(x,y,z,w) : x \geq \sum_{k=1}^{K}\lambda^k x^k,\ \ y \leq \sum_{k=1}^{K}\lambda^k y^k,\right.$$
$$\left. w = \sum_{k=1}^{K}\lambda^k w^k, z \leq \sum_{k=1}^{K}\lambda^k z^k,\ \ \lambda \in R_+^K\right\} \qquad (6)$$

This index can be reduced to a pure amenity index by ignoring the effect on non-desirable outputs. We call this index $\theta_{Amen}$ and calculate it according to

$$\theta_{Amen} = \min_{\theta}\left\{\theta : (\theta\, x^k, y^k, z^k) \in T_{Amen}\right\}\ k = 1,\ldots,K \qquad (7)$$

where

$$T_{Amen\,\&\,Env} = \left\{(x,y,z) : x \geq \sum_{k=1}^{K}\lambda^k x^k,\ \ y \leq \sum_{k=1}^{K}\lambda^k y^k, z \leq \sum_{k=1}^{K}\lambda^k z^k,\ \ \lambda \in R_+^K\right\} \qquad (8)$$

Table 2 defines the variables entering vectors *x*, *y*, *w*, and *z* in the empirical analysis. The desirable market outputs are measured in terms of gross revenue from animal and plant production activities. Inputs are land, labor, the number of large animal units and mineral nitrogen fertilization. The only weakly disposable inputs, *w*, entering the analysis is organic nitrogen, and positive amenity outputs, *z*, account for extensively managed land and the crop rotation index as an indicator of variety.

## 5. Results

A farm survey was implemented in the spring of 2001 in the Condroz region in south-central Belgium. Nine communities were chosen on the basis on similar pedo-climatic conditions. The region is not of any particular environmental statute, and hence, during the period March 1999 – December 2000, farms could only qualify for vertical agri-environmental programs by adopting a whole farm plan for a five-year period. We chose farms having adopted the plan according to the database of the local administration. Non-adopters where chosen from a random sample of 200 farmers obtained from the National Statistics Institute. In total, 28 farms having adopted a WFP and 24 farms that have not adopted a WFP were evaluated.

The area is characterized by silty soils and predominately cultivated by mixed crop and livestock farms. In order to assure the homogeneity of the sample, farms in the process of converting to organic agriculture and those with large pork and broiler production were eliminated from the sample. Some farm characteristics of our sample are presented in table 3. The average farm size in the sample is about 46 ha of arable land, 33 ha of grassland. Livestock rearing includes dairy production and beef production. Farms have on average 103.5 large livestock units (LAU) of which 15 are dairy cows and 47 are suckler cows. Important crops include cereals, fodder maize, sugar beets, and potatoes.

The sample of non-adopters and adopters are fairly homogeneous but with respect to holdings of arable land. Non-adopters cultivate on average 27 ha, while adopters cultivate about 63 ha. This considerable difference can be explained by the interest of farmers with large areas of arable land for some of the vertical agri-environmental programs, such as that subsidizing cover crops during winter fallow.

*5.1 Agri-environmental Indicators*

Table 1 shows the results on evaluated agri-environmental indicators. Indicators on water and soil protection practices show on average a better performance of adopters in comparison to non-adopters. The percentage of mechanically, instead of chemically, weeded row crops is, despite being relatively low for both subsamples, higher for adopters. Also the indicator on integrated pest management is higher for adopters. This indicator is a qualitative measure evaluating on a scale from 1 to 10 the quality of advice farmers seek in making their pest management decisions (pest forecasts, education level of pest management consultants etc.)

The percentage of winter fallow land planted with cover crops is 59% in contrast to non-adopters where no winter cover crops are planted. However, this indicator is to be considered carefully as it does not consider the amount of fallow land during winter. Many of the non-adopters have lower holdings of land in arable crops, so that less land might be bare during winter.

With regard to the management of nitrogen fertilizer, adopters apply less excess fertilizer than non-adopters. The "crop nitrogen fertilizer" index is constructed as a weighted deviation of fertilization from the recommended norm and results on average as 12.8 versus 16.5 for non-adopters. Animal-rearing activity is less tied to land, and the animal density per hectare fodder crops is 3.96 versus 3.16. Nevertheless, the soil equilibrium indicator formed as the ratio of total organic nitrogen available on the farm and total organic nitrogen potentially applicable on the farm, results as 0.67 whereas it is 0.76 for non-adopters. The percentage of riverbanks protected from agricultural run-off by extensive farming practices is 79% for farms with a WFP and 0% for farms without WFP.[2]

As far as nature protection practices are concerned, adopters of the WFP dedicate a lower percentage of their grassland to marginal utilization, 3.2 % versus 7.5 %. Marginal grassland is defined as grassland that the farmer uses in a less intensive way (low fertilization, lower grazing intensity, etc.) either because of its natural location or because of its distance from the farm.

In percentage terms, less land is also dedicated to landscape elements such as hedges and wetlands, 9.99 versus 14.83. However, a larger percentage of arable land is used marginally and cropped less intensively. This might be due to the fact that this indicator accounts for extensively managed field margins. Extensively managed field margins receive currently a premium 36 Euro for an area 200 $m^2$ and many farms having adopted a WFP have enrolled in this agri-environmental program. Calculating the equivalent amount of hectares managed as marginal arable land and grassland or dedicated to landscape elements, adopters manage 13.4 ha as marginal land and non-adopters 9.41 ha. Given the differences in total land holdings

[2] This indicator is statistically not very meaningful as only 11 farms in the sample have creeks crossing or bordering their land. However, it gives some indication that farmers having adopted the WFP are more sensitive to such issues. On the 11 farms where rivers cross or border some of the farm land, five among the eight farms having adopted the WFP protect 100% of the river banks, whereas 0% of river banks are protected on the 3 farms not having adopted the WFP.

this amounts to 13% and 16%, respectively. Finally, no significant differences are detected for the crop rotation indicator and the farm animal diversity indicator.

In conclusion, we can state that farms having adopted a WFP perform better with respect to water and soil protection practices, but that these advances over non-adopters are relatively small. Some nature protection practices are applied on larger shares of land, such as marginal crop land utilization, whereas those dedicated to marginal grassland management and landscape elements are more pronounced on farms not having adopted the WFP. These results are in part due to agronomic differences across the farms in our sample. Farms less interested in some of the vertical agri-environmental programs have not adopted the WFP that was a condition to access these environmental programs. Some of the non-adopters in our sample possess a significant amount of land under extensive management practices whose inclusion in a WFP would benefit the environmental interest.

5.2 *Environmental Efficiency Analysis*

The results of the efficiency analysis are summarized for the entire sample in table 4. Average technical efficiency is 71% and 19% of the farms in the sample are considered as technically efficient. As more outputs are included in the analysis, more farms are used to form the efficiency frontier and thus the efficiency indicators increase on average when taking not freely disposable and amenity outputs into the analysis. The share of farms receiving an efficiency score of 1 increases to 29% for $\theta_{Env}$, 46% for $\theta_{Amen\&Env}$, and 50% for $\theta_{Amen}$. It is thus more interesting to compare the efficiency performance for a given indicator across different groups of farms rather than to compare different efficiency indicators across the entire sample. Table 5 groups the results of the efficiency analysis by farm characteristics.

We are most interested in the comparison of adopters and non-adopters of the WFP. Results are shown in the upper left part of table 5. Farms having adopted a WFP (group 2) perform better according to all efficiency measures. Their average score of technical efficiency is 0.74 versus 0.68 for non-adopters. Looking on the one hand at the environmental efficiency, $\theta_{Env}$, their efficiency taking into account the weakly disposable output of organic nitrogen is at 0.91 seven percentage points higher than for non-adopters. On the other hand $\theta_{Amen}$, the indicator taking into account amenity outputs, adopters outperform non-adopters with 0.78 versus 0.70. Finally, taking both types of environmental outputs into account as in $\theta_{Env\&Amen}$, the average score increases from 0.86 for non-adopters to 0.93 for adopters.

We test for the significance of these differences using an analysis of variance test and the Wilcoxon test. Results of both tests show that the differences among adopters and non-adopters are at most marginally significant. While we reject equality of the means of the distributions according to the analysis of variance for $\theta_{Env}$ and $\theta_{Env\&Amen}$ at the 10% level, we reject it for $\theta_{Amen}$ according to the Wilcoxon test.

Other determinants of efficiency are tested for using alternative groupings. Grouping farms by their intensity measured in gross revenue per hectare shows no clear differences. However, grouping farms by their size measured in land holding shows significant differences for $\theta_{Tech}$ and for $\theta_{Amen}$. Large farms have a significantly higher technical efficiency score and also a significantly higher score when accounting for amenity outputs. Looking at the last comparison, we see that also farms with lower animal stocking density per hectare of land have a higher average $\theta_{Amen}$ score. Both these results indicate that pressure on the provision of marginal land and cultural variety results in particular due to smaller holdings of land, be it absolute as in the comparison according to farm size or relative as is the comparison according to animal stocking.

## 6. Conclusions

The objective of this paper was to test for the contribution of a public voluntary scheme in the reduction of potential negative impacts of agriculture and in the enhancement of agricultural provision of valuable landscape amenities. Our analysis was based on agri-environmental indicators and data envelopment analysis. Our results show that farms having adopted a WFP perform better with respect to water and soil protection practices, but that their improvements over non-adopters are relatively small. Some nature protection practices, such as marginal crop-land utilization, are applied on larger shares of land whereas others, such as those dedicated to marginal grassland management and landscape elements, are more pronounced on farms not having adopted the WFP.

For our sample of farms, farms having adopted the WFP perform better in terms of all efficiency indicators calculated. However, these differences are at best marginally significant for our sample. While these results are not too promising for the evaluation of voluntary agreements, some remarks of caution are in place. While the VA under scrutiny in our analysis is a typical public voluntary scheme, it has some obliging factor in it. Indeed, despite of being accessible to all farms, only those farms interested in adopting vertical agri-environmental programs subscribed to the WFP. Furthermore, our study was applied to farms that have adopted the WFP for at most two years. Given the long-term nature of objectives demanding a change in farmers' attitudes and practices, more conclusive results might be obtained in later years.

One might wonder how differences between farmers with and without WFP have come about. Farms with more environmentally friendly practices might be more attracted to subscribe to agri-environmental programs and some of these differences could have existed before. But also the elaboration of the WFP and the contact with the field agent of the local administration would help to point out existing problems and hint to possible solutions. Lastly, other agri-environmental programs the farmer enrolls in influence some of the indicators. Probably all of these factors play a role in explaining the observed differences and they are not exclusively due to the WFP.

In our view, both the indicator method and DEA provide important information about the state of the environment and about farm practices and should be used as complementary means of analysis. It is obvious that the indicator methods faces important drawbacks when it comes to aggregation issues and it is not a simple task to make sense out of a large number of indicators. Data envelopment analysis overcomes these aggregation problems but faces new ones. Not all types of environmental impacts that can be measured by the indicator method lend themselves easily for being integrated in a production possibility set.

## References

Aggeri, F., 1999. Environmental policies and innovation - A knowledge-based perspective on cooperative approaches. Research policy 28, 699-717.

Ball, V.E., Lovell, C.A.K., Nehring, R.V., Somwaru, A., 1994. Incorporating undesirable outputs into models of production: An application to US agriculture. Cahiers d'économie et sociologie rurales, No 31, 59-74.

Börkey, P., Glachant, M., Lévêque, F., 1999. Voluntary approaches for Environmental policy - An assessment. OECD: Paris.

Carraro, C., Lévêque, F.,1999. Voluntary approaches in environmental policy. Kluwer Academic Publishers: Dordrecht, The Netherlands.

David, C., Bernard, C., Just, F., 2000. Sustainable agriculture in Europe – States of the art and policies in five European countries: Denmark, France, Latvia, Netherlands and Spain. European research project DG XII. Environment and Climate Program. Contract No. ENV4-97-0443 and IC20 CT97-0035.

Ervin, D.E., Smith, K.R., 1996. What it takes to “Get to Yes” for whole farm planning policy. Report, Henry Wallace Institute for Alternative Agriculture, Greenbelt, Maryland.

European Commission DG III.01 – Industry, 1997. Study on voluntary agreements concluded between industry and public authorities in the field of the environment. European Commission: Brussels, Belgium.

Färe, R., Grosskopf, S., Lovell, C.A.K., Pasurka, C., 1989. Multilateral productivity comparisons when some outputs are undesirable: A nonparametric approach. The review of economics and statistics, 71, 90-98.

Färe, R., Grosskopf, S., Tyteca, D., 1996. An activity analysis model of the environmental performance of firms - Application to fossil-fuel-fired electric utilities. Ecological economics, 18, 161-175.

Hanley, N., Whitby, M., Simpson, I., 1999. Assessing the success of agri-environmental policy in the UK. Land use policy 16, 67-80.

Lévêque, F., 1997. Voluntary approaches. Environmental Policy Research Briefs, No. 1.

Lefèvre, P., 2000. Voluntary agreements in EU - Environmental policy - Critical review and perspectives. CAVA Working Paper, no. 2000/2/7.

Lichtenberg, E. Strand, I.E. Jr., Lessley, B.V., 1993. Subsidizing agricultural nonpoint-source pollution control: Targeting cost sharing and technical assistance. In Russell, C.S., Shogren, J.F. (Eds.), Theory, modeling and experience in the management of nonpoint-source pollution. Kluwer Academic Publishers: Dordrecht, The Netherlands.

Ministère de la région Wallonne, 2000. Arrêté du Gouvernment wallon modifiant l’arrêté du Gouvernement wallon du 11 mars 1999 relatif à l’octroi de subventions agri-environnementales. Moniteur Belge, 10.02.2001.

OECD, 2001. Environmental indicators for agriculture: Methods and results. Volume 3. OECD: Paris, France.

Piot-Lepetit, I., Le Moing, M., 2000. Agriculture et environnement: Une évaluation de la performance technique et environnementale d’exploitations laitières. Économie et prévision, 143-144, 201-211.

Salop, S.C., Scheffman, D.T., 1983. Raising rivals' costs. American economic review, 73, 267-271.

Segerson, K., Miceli, T.J., 1999. Voluntary environmental agreements: Good or bad news for environmental protection? Journal of environmental economics and management 36, 109-130.

Tyteca, D., 1997. Linear programming models for measurement of environmental performance of firms - Concepts and empirical results. Journal of productivity analysis, 8, 183-197.

Van Huylenbroeck, G., Whitby, M., 1999. Countryside stewardship: Farmers, policies and markets. Pergamon: Amsterdam, The Netherlands.

Videras, J., Alberini, A, 2000. The appeal of voluntary environmental programs: Which farms participate and why? Contemporary Economic Policy 18(4), 449-461.

**Table 1. Agri-environmental indicateurs**

| | Environmental Benefit Benchmarks | | | Adopters | Non-adopters | Total |
|---|---|---|---|---|---|---|
| | Low | Medium | High | | | |
| **Water and Soil Protection** | | | | | | |
| % of arable acreage weeded mechanically | 2 | 6 | 10 | 2.12 (11.03) | 1.75 (4.96) | 1.98 (9.10) |
| Indicator on integrated pest management | 2 | 6 | 10 | 9.31 (1.81) | 8.03 (2.58) | 8.83 (2.19) |
| % of spring crop acreage covered by winter cover crops | 20 | 60 | 100 | 59.46 (31.52) | 0.00 (0.00) | 35.95 (38.17) |
| Crop Nitrogen Fertilization | 20 | 0 | -20 | 12.83 (50.58) | 16.46 (50.88) | 14.20 (50.14) |
| % of arable acreage receiving organic matter | 10 | 30 | 50 | 36.67 (19.11) | 42.97 (28.03) | 39.05 (22.79) |
| Soil equilibrium | 1.2 | 1.1 | 1 | 0.67 (0.33) | 0.76 (0.28) | 0.71 (0.31) |
| Animal density in large animal units per hectare fodder production | 2.6 | 2 | 1.4 | 3.96 (2.71) | 3.16 (1.15) | 3.58 (2.12) |
| Number of times of liquid manure spreading during winter month | 0.8 | 0.4 | 0 | 0.00 (0.00) | 0.08 (0.29) | 0.07 (0.27) |
| Manure storage capacity in month | 2 | 4 | 6 | 4.88 (3.51) | 4.76 (1.94) | 4.82 (2.70) |
| % of river banks protected by extensive farming practices from | 20 | 60 | 100 | 79.16 (36.46) | 0.00 (0.00) | 57.57 (47.94) |
| **Nature protection practices** | | | | | | |
| % of extensively used grassland | 15 | 20 | 25 | 3.21 (6.25) | 7.47 (9.48) | 5.29 (8.20) |
| % of extensively cultivated crop land | 5 | 15 | 25 | 3.38 (4.66) | 1.36 (3.10) | 2.65 (4.24) |
| Percentage of arable land dedicated to landscape elements | 1 | 3 | 5 | 9.99 (9.56) | 14.83 (18.69) | 12.17 (14.45) |
| Extensively used land in ha equivalents | | | | 13.38 (10.16) | 9.41 (11.94) | 11.54 (11.09) |
| Crop rotation indicator | 3 | 5 | 7 | 5.93 (2.01) | 5.84 (2.72) | 5.90 (2.28) |
| Farm animal diversity | 1 | 3 | 5 | 0.75 (0.75) | 0.75 (0.73) | 0.75 (0.73) |
| Number of observations | | | | 28 | 24 | 52 |

Note: Numbers in parentheses are standard errors.

**Table 2. Indicators entering the efficiency measures**

| Category | Indicator | Mean (Std.Dev.) | Indicators entering the efficiency measures | | | |
|---|---|---|---|---|---|---|
| | | | $\theta_{Tech}$ | $\theta_{Env}$ | $\theta_{Amen}$ | $\theta_{Amen\,\&\,Env}$ |
| Freely disposable outputs ($y$) | Revenue from crops (€) | 39,007 (41,120) | X | X | X | X |
| | Revenue from animals (€) | 74,931 (60,110) | X | X | X | X |
| Inputs ($x$) | Land (ha) | 78.6 (44.4) | X | X | X | X |
| | Number of large animal units (LAU) | 103.5 (67.9) | X | X | X | X |
| | Labor (Person) | 1.6 (0.7) | X | X | X | X |
| | Mineral Nitrogen (kg N) | 8,718.3 (5,863.9) | X | X | X | X |
| Amenities ($z$) | Marginal land (ha) | 11.5 (11.1) | | | X | X |
| | Crop rotation indicator | 5.9 (2.3) | | | X | X |
| Non-freely disposable output ($w$) | Organic Nitrogen (kg N) | 8,572.4 (6,089.4) | | X | | X |

**Table 3. Economic Indicators**

| | Unit | Adopters | Non-adopters | Total |
|---|---|---|---|---|
| Revenue from crops | € | 57,518 (43,450) | 17,410 (25,083) | 39,007 (41,120) |
| Revenue from animals | € | 80,731 (65,767) | 68,164 (53,345) | 74,931 (60,110) |
| Number of large animal units | LAU | 107.6 (70.0) | 99.4 (66.6) | 103.5 (67.9) |
| Grassland | ha | 32.3 (22.5) | 32.9 (19.7) | 32.6 (21.0) |
| Arable land | ha | 62.6 (41.8) | 26.6 (29.2) | 46.0 (40.5) |
| Labor | person | 1.6 (0.7) | 1.5 (0.7) | 1.6 (0.7) |
| Mineral Nitrogen | kg | 11,125.1 (5,449.0) | 5,910.4 (5,109.9) | 8,718.3 (5,863.9) |
| Organic Nitrogen | kg | 9,682.4 (6,872.3) | 7,277.4 (4,850.7) | 8,572.4 (6,089.4) |

Note: Numbers in parentheses are standard errors.

**Table 4. DEA Results**

| | $\theta_{Tech}$ | $\theta_{Env}$ | $\theta_{Amen}$ | $\theta_{Amen\&Env}$ |
|---|---|---|---|---|
| Mean | 0.71 | 0.74 | 0.89 | 0.88 |
| Standard Deviation | 0.21 | 0.21 | 0.16 | 0.16 |
| Minimum | 0.27 | 0.29 | 0.39 | 0.37 |
| Percentage of efficient farms | 0.19 | 0.29 | 0.50 | 0.46 |

**Table 5. Test statistics assessing the relation between efficiency measures and descriptive statistics [a]**

| Group [b] | Whole farm management plan | | | | Intensity | | | |
|---|---|---|---|---|---|---|---|---|
| | $\theta_{Tech}$ | $\theta_{Env}$ | $\theta_{Amen}$ | $\theta_{Amen\&Env}$ | $\theta_{Tech}$ | $\theta_{Env}$ | $\theta_{Amen}$ | $\theta_{Amen\&Env}$ |
| 1 | 0.68 | 0.84 | 0.70 | 0.86 | 0.71 | 0.89 | 0.75 | 0.91 |
| 2 | 0.74 | 0.91 | 0.78 | 0.93 | 0.71 | 0.86 | 0.73 | 0.88 |
| *Analysis of variance* | | | | | | | | |
| F-value | 1.22 | 3.04 | 1.62 | 2.80 | 0.00 | 0.47 | 0.09 | 0.44 |
| P-value | 0.27 | 0.09 | 0.21 | 0.10 | 0.96 | 0.50 | 0.77 | 0.51 |
| Significance [a] | | * | | * | | | | |
| *Wilcoxon-Test* | | | | | | | | |
| Test statistics | -1.08 | -1.18 | -1.28 | -1.16 | -0.31 | 0.01 | 0.14 | 0.02 |
| p-value | 0.14 | 0.12 | 0.10 | 0.12 | 0.38 | 0.50 | 0.45 | 0.49 |
| Significance | | | * | | | | | |

| Group [b] | Acreage | | | | Animal Stocking LAU/ha | | | |
|---|---|---|---|---|---|---|---|---|
| | $\theta_{Tech}$ | $\theta_{Env}$ | $\theta_{Amen}$ | $\theta_{Amen\&Env}$ | $\theta_{Tech}$ | $\theta_{Env}$ | $\theta_{Amen}$ | $\theta_{Amen\&Env}$ |
| 1 | 0.64 | 0.87 | 0.68 | 0.89 | 0.74 | 0.89 | 0.78 | 0.91 |
| 2 | 0.78 | 0.89 | 0.80 | 0.90 | 0.68 | 0.86 | 0.70 | 0.88 |
| *Analysis of variance* | | | | | | | | |
| F-value | 5.78 | 0.18 | 4.19 | 0.12 | 1.31 | 0.34 | 1.99 | 0.33 |
| P-value | 0.02 | 0.67 | 0.05 | 0.73 | 0.26 | 0.56 | 0.17 | 0.57 |
| Significance [a] | ** | | ** | | | | | |
| *Wilcoxon-Test* | | | | | | | | |
| Test statistics | -2.16 | -0.13 | -1.92 | -0.17 | 1.08 | -0.07 | 1.34 | -0.20 |
| p-value | 0.02 | 0.45 | 0.03 | 0.43 | 0.14 | 0.47 | 0.09 | 0.42 |
| Significance | ** | | ** | | | | * | |

[a] One and two asterisks indicate significance at 0.10 and 0.05, respectively.

[b] The groups are defined as follows:

- Whole farm plan: 1: non-adopter (24 farms); 2: adopters (28 farms).
- Intensity: 1: revenue < 75 000 FB/ha (26 farms); 2: revenue > 75 000 FB/ha (26 farms).
- Acreage: 1: < 72.7 ha (26 farms); 2: > 72.7 ha (26 farms).
- Animal Stocking in LAU/ha: 1: < 1.65 LAU/ha land (26 farms); 2: > 1.65 LAU/ha land (26 farms).