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The Nutrient Flow Model for Dutch Agriculture: A Tool for Environmental Policy Evaluation

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The Nutrient Flow Model (NFM) is a micro-simulation model. It describes economic activities and corresponding nutrient flows at farm level for present and future situations in which environmental policy measures are taken. The farm results are aggregated to regional and national levels. The model can be used as an insrument for monitoring and policy evaluation. Technical aspects are incorporated into the model by means of crop growth models and nutrient balances for animals. Economic aspects are partly incorporated and partly added exogenously. The information need for the NFM is rather extensive. Main data sources are the Dutch Agricultural Census and the Dutch Farm Account Data Network. The model tries to combine the detailed approach with respect to production activities and nutrient flows that is often found in models at farm level with the more global approach that is followed in economic models on sector level. The variation in emissions between farms is dealt with explicitly.

This paper presents the general concept of the NFM. It shows that the validation of technical models used in the NFM, on the basis of empirical data, is essential from the point of view of nutrient losses. An example is given of the assessment of the effects of government policies: the obligatory injection of manure may lead to a decrease in ammonia volatilisation but, at the same time, to an increase in nitrate leaching.

The integrated approach of dealing with different nutrients simultaneously, taking into account all inputs and outputs, describing the complete chain of nutrient flows within farms, and modelling the interaction between farms makes the NFM a suitable instrument for the evaluation of environmental policy.

Keywords: nutrient flows, micro simulation, environmental policy evaluation.

1. Introduction

In the Netherlands, environmental policy concerning nutrient losses from agriculture has become more explicit in the last few years. In 1987, maximum application levels for animal manure were introduced. These levels are defined in terms of kg of phosphate

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per hectare. Nowadays, future goals have been set for maximum nitrogen losses by leaching of nitrate and by ammonia volatilisation. Some of these goals are defined in terms of reduction of losses, others in terms of environmental quality. The latter are mostly based on EC standards (C.E.C., 1992). Not only animal manure but all carriers of nutrients (chemical fertilisers, feedstuffs etc.) are taken into account in current policy proposals in the Netherlands. Until now, there has been a strong tendency to use physical standards (amount of nutrients per hectare, application methods and periods of spreading, storage of manure) (Veenendaal and Brouwer, 1991). In the near future, the nature of environmental policy is likely to change from a system with command and control regulation by physical standards into one with financial regulation of the nutrient balance and with levies based on nutrient surpluses. This system will give farmers the opportunity to choose their own way of reducing the environmental effects of agricultural production.

For the preparation and evaluation of environmental policy, it is useful to have an instrument that calculates the environmental effects of different kinds of policies. During the last decade, a number of so-called manure models have been developed in the Netherlands (Wijnands *et al.*, 1988, 1992). At a regional and national level, these models calculate manure and nutrient production and surpluses, ammonia volatilisation, manure transports between regions, and the level of application of manure on different crops. The manure models are fed with data from the yearly Agricultural Census. In addition to many physical quantities, the models calculate the extra costs of specific environmental policies.

In these models manure and nutrient flows are modelled by using fixed coefficients. The effects of a policy which affects (part of) a flow have to be simulated by adapting several coefficients. When many changes in the agricultural production process have to be considered simultaneously, it becomes difficult to make consistent calculations. Furthermore, farm level data, available from the Dutch Farm Account Data Network (FADN), are not used in these models. Data from the FADN can be used to validate the model and to add variation between farms (for example in fertiliser level on grassland) to the model.

To meet these limitations, a micro-simulation model is developed by the Dutch Agricultural Economic Research Institute (LEI-DLO) and the Centre for Agrobiological Research (CABO-DLO). This model is called the Nutrient Flow Model (NFM). This model is used to calculate (1) the quantity, type and location of nutrient losses from agriculture, and (2) both environmental and economic effects of either physical and economic nutrient policies for all farms in the Netherlands. Thus, the NFM can contribute to policy evaluation at both national and regional levels. The calculated regional and local nutrient losses are also available as inputs to environmental models dealing with the distribution of nutrients by air or water. From a methodological point of view, the most interesting feature of this model is the integration of both technical and economic aspects. A pilot model has been constructed for specialised dairy farms on sandy soils in the Province of Gelderland (Van der Veen *et al.*, 1993). The aim of this paper is to describe the way in which the integration of technical and economic aspects has been realised. The construction, validation and results of the model are illustrated by the pilot model.

2. The general concept

The NFM is a micro-simulation model. It describes economic activities and corresponding nutrient flows at farm level in rather a detailed way. The model outcomes

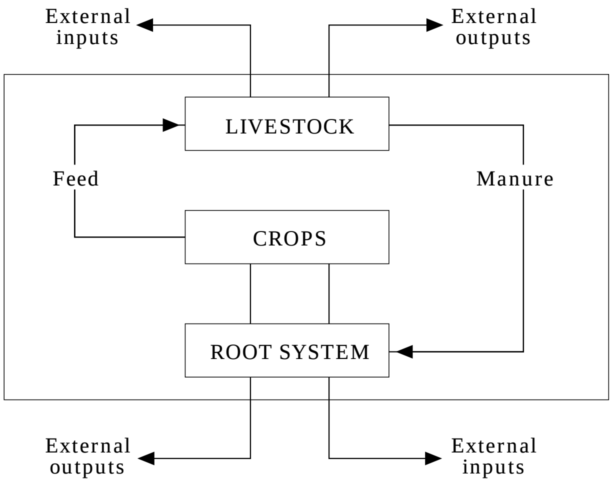

Figure 1. Nutrient flows in an agricultural production system.

at farm level can be aggregated to regional or national levels. This way of modelling clarifies the variation between farms with respect to present emissions and also with respect to changes in emissions and costs as a reaction to governmental restrictions. The level of spatial detail is such that useful inputs for environmental models are generated.

The basis of the NFM is simple. The agricultural system is described by modelling nutrient flows (see Figure 1). On a farm, activities related to animal and crop production take place. Both types of agricultural production use sources of nutrients from outside the farm (external inputs). Nutrients are transported from the farm with the sales of products (arable crops, milk, meat, manure, etc.) and are lost into the non-agricultural environment (external outputs). In addition, internal flows of nutrients exist, in particular on dairy and mixed farms, where crops are used to feed the livestock and manure is used to feed crops (internal inputs and outputs). Storage and release of phosphate and organic nitrogen will also occur. Systems based on the same principle have been used by Berentsen *et al.* (1992), Mandersloot (1992) and Leneman *et al.* (1992).

The first step is to make explicit the boundaries of the agricultural system, by determining which inputs and outputs are internal/external. In the case of the NFM, horizontal boundaries are defined as geographical boundaries of land use. Vertical boundaries are less easy to define, but are considered to be the lower side of the root system of crops and the upper side of animals, stables and so on. Hence, the agricultural system is defined as that part of the environment that can be controlled by the farmer (Ikerd, 1993).

Technical models concerning crop production and animal production have been incorporated as modules in the NFM. They describe the production process, and, in this way, relate nutrient outputs to nutrient inputs. The output consists of crop and animal production (including manure) on the one hand and nutrient losses on the other (Figure 2).

The crop models contain relationships between available nitrogen and uptake of nitrogen by crops, between uptake of nitrogen and dry matter production, and between nitrogen input and different types of losses. These models are based on experimental

INPUTS	OUTPUTS
PURCHASES:	SALES:
— FERTILIZER	— MILK
— MANURE	— LIVESTOCK
— ROUGHAGE	— CROP
— CONCENTRATES	— MANURE
DEPOSITION	LOSSES:
	— DENITRIFICATION
	— VOLATILIZATION
	— NITRATE LEACHING
	NET SOIL STORAGE

Figure 2. The balance of nutrients at farm level.

research (Aarts and Middelkoop, 1990; Middelkoop and Aarts, 1991; van de Ven, 1992). In these relationships, differences in soil type, water supply, period of application of manure and grazing system are taken into account.

With regard to the livestock, the nutrient content of the excreted manure is calculated as the difference between the nutrient content of the production (meat, milk, etc.) and the nutrient content of the feed. Each animal gets a fixed amount of feed. For cows, the feed intake depends on the level of milk yield. The composition of the feed intake of the cattle depends on crop production at farm level. For this agricultural system, a yearly balance of nutrients can be calculated. The balance of nutrients reflects external inputs and outputs, as well as changes of nitrogen storage in the soil (Figure 2). Balances of the cropping system (one for each crop), the livestock system and the soil system are also generated by the model. These balances are the core of the model outcomes.

The NFM uses the level of technical detail that is found in farm level simulation and optimisation models, and tries to incorporate this detail in a sector level model. Because different government measures are related to different nutrients, different types of losses, and to different parts of the production process, it is not easy to assess the economic and environmental impact of a number of measures at sector level without having a good technically-based model. Such a model should describe the production process and nutrient flows in a consistent way. For example, injection of manure reduces ammonia volatilisation but, at the same time, may increase nitrate leaching. Measures with respect to the use of phosphate from animal manure also influence nitrogen use and losses. Lower levels of fertilisation lead to a lower nitrogen content of grassland products, and, in turn, leads to a lower nitrogen content of manure. The NFM tries to model these interactions in a consistent way. Of course, the NFM approach can only be realised when information about technical processes and data on the farm level is available. For Dutch agriculture this is the case.

One of the goals of the NFM is to calculate environmental and economic effects of government policies concerned with the reduction in nutrient losses. If physical regulations or levies are imposed, or some kind of extension policy is carried out, the farmer's response will depend on available technical options and corresponding costs. In economic models describing the behaviour of producers, these options may be evaluated and several strategies or response patterns for different farm types can be distinguished. Outcomes of these models are then translated into data or relationships for the NFM. For instance, if farmers have to reduce ammonia volatilisation by 50%, there are several options (Wijnands *et al.*, 1992). Improved methods of manure application could be introduced. Alternatively, stables and manure storage could be adapted, or the nutrient content of the concentrates could be changed. The optimal adjustment to this specific government measure may differ between farms.

The behaviour of the farmer, his strategies with respect to the use of manure, feeding of animals, utilisation of grassland and so on, are incorporated in the model by means of coefficients, correction factors, best professional judgement and equations that are estimated from sample data. In this way, real farm behaviour is simulated, although the basis of the model consists of technical relationships that are established in experimental research.

3. Data sources of the NFM

The starting point of the calculations at farm level are the composition and the size of the livestock, the cropping pattern and the levels of the variable inputs (fertiliser, purchased feed). These data have to be obtained from sources like the Agricultural Census, or estimated from surveys. The total number of farms in the Netherlands in 1988 was 130 000.

Apart from Census data, some other sources containing information at farm level are used. The milk quotas per farm were obtained from a registration that is kept by the Commodity Dairy Board in the Netherlands and which has been linked to the Census data at farm level. Soil characteristics at farm level were obtained from the National Soil Map which is available in the form of a geographical information system (De Vries and Denneboom, 1991). The location of the Census farms is determined by the postal code that is available from the Census registration. The location is expressed in grid coordinates that correspond to a grid system of 500 $\times$ 500 meters. This information on location is not only useful because of the information on soil characteristics which is used to explain crop growth and to calculate emission levels, but it also allows us to generate model outcomes at a low aggregation level and simplifies using the model outcomes as inputs for models that describe the flows of nutrients in the air, soil, ground water and surface water. These models generally make use of the same grid system.

In addition to the information that is available from the aforementioned sources, the NFM needs to have estimates of the amount of variable inputs: purchases of chemical fertiliser, manure, roughage and concentrates. Very detailed data on these inputs are available from the FADN, a stratified random sample of some 1000 farms representing some 95% of the production and some 65% of the farms.

4. Pilot model: dairy farms in Gelderland

A pilot model has been built for specialised dairy farms (EC farm type 411) on sandy soils in the province of Gelderland (Van der Veen *et al.*, 1993). To capture the variation that is present within agriculture and also to be able to model outcomes at a low level of aggregation, the NFM was applied to all farms that appeared in the yearly Agricultural Census. In total, 14 000 farms were present in the sandy region of Gelderland, 3919 of which were specialised dairy farms. These farms represent about 50% of the total

TABLE 1. Average farm structure for 3919 specialised dairy farms on sandy soil in the Province of Gelderland

Farm characteristics		Average value
Total acreage	(ha)	17·4
Grassland	(ha)	15·0
Maize	(ha)	2·4
Other	(ha)	0·0
Dairy cows		37
Heifers		27
Pigs		32
Poultry		56
Milk quotum	(tons)	204

cultivated area in that region, divided over about forty municipalities. Table 1 presents an overview of the average farm characteristics.

In the FADN of 1988, data for 39 specialised dairy farms are available in Gelderland. However, there are hundreds of comparable farms in similar regions which have also been used as data sources. Sections 5 and 6 deal with the way in which the information from the sample is used to estimate the level of input use for specific farms.

5. Pilot model: construction and validation

The central technical relationships in the model are those of crop growth and livestock feed uptake. Initially, these were estimated on the basis of experimental research. Given the level of fertiliser that was applied and the amount of feed that was purchased, crop growth, manure composition and nutrient losses were calculated. Because there is, in general, a large difference in crop growth and feed uptake relationships between experimental situations and agricultural practice, the relationships had to be adapted in such a way that real farm practice was simulated by the model.

Because it is impossible to check the losses that are calculated by the model with empirical data, another approach was followed for model validation. During construction of the NFM, information from the FADN was used to validate technical relationships in the model. The yield per hectare of arable crops and the corresponding nutrient input level can be derived from the FADN. However, with respect to grass, the main crop on dairy farms, there are no data available on yield levels or for grass uptake by cows. This lack of data has to do with internal flows on the farm that are not completely registered in the FADN. Available statistics are the net purchases of roughage and concentrates. They reflect the difference between crop production and feed consumption by cattle, and therefore comprise results of both the crop part of the model and the livestock part.

A comparison between the net purchase of feed (expressed in energy content) in real farm practice and the net purchase which is calculated by the technical relationships based on experimental research showed that, in 1988, the dairy farms in Gelderland purchased some 55% of the normative feed intake, whereas the experimental research version of the NFM estimated a percentage of only 42%. In addition, the composition of feed intake differed substantially from the FADN estimates. The intake of concentrates was higher than the intake that was calculated from the experimental relationships between feed intake and milk production level.

TABLE 2. Average nitrogen losses (kg/ha) in the non-validated and the validated version of the model

Type of loss	Model version	
	Non-validated	Validated
Nitrate leaching	135	153
Denitrification	56	56
Ammonia volatilisation	120	119
Total losses	311	328

The differences between farm practice and technical model outcomes vary over the years. Naturally, this variation is related to weather conditions. The year 1988 can be considered as an "average" year.

The differences between farm practice and model results can not be corrected in a straightforward way in the NFM because it is not known whether the differences in purchases of feed should be ascribed to a lower grass production level, to higher losses of grass during harvesting, storage and feeding, or to a higher feed intake per animal than is assumed in technical models. None of these three reasons could be confirmed explicitly by experts. The choice was made to correct the experimental research version of the model on all three points (crop growth, crop losses, feed intake). Crop production levels were lowered by 5% for all farms, roughage consumption was raised by 2·5%, the consumption of concentrates by 12% and roughage losses by 20%.

The differences in model outcomes (emissions) between the original technical version of the model and the validated version are shown in Table 2. The effect of the corrections that were made on nutrient losses is most evident for nitrate leaching: after validation, the average leaching of nitrate was 18 kg higher than before. This change is due to the fact that crop production and nitrogen uptake by the crop were reduced, whereas the total supply of available nitrogen to the soil increased. A large part of that difference is caused by leaching to lower parts of the soil.

Consequently, by validating the model using real farm data, the empirical basis for the model has been strengthened. The level of nitrogen losses has become higher. Sensitivity analysis with respect to the correction factors shows that it makes some difference whether the accent with respect to the corrections is on the crop production side or on the feed intake side of the model. However, until now, there has been no information on the exact composition of the differences between model and reality.

Figure 3 gives a graphical presentation of the average nitrate leaching in forty municipalities in Gelderland. Only municipalities with sandy soils are represented on the map.

6. Pilot model: modelling the use of fertiliser on grassland

As mentioned in section 5, input levels should be estimated for each farm in the Census for which the NFM is run. The purchase of chemical fertiliser is estimated from the FADN by:

(a) using the estimated average level of fertilisation for all farms;
(b) establishing a relationship between the use of fertiliser and farm characteristics;

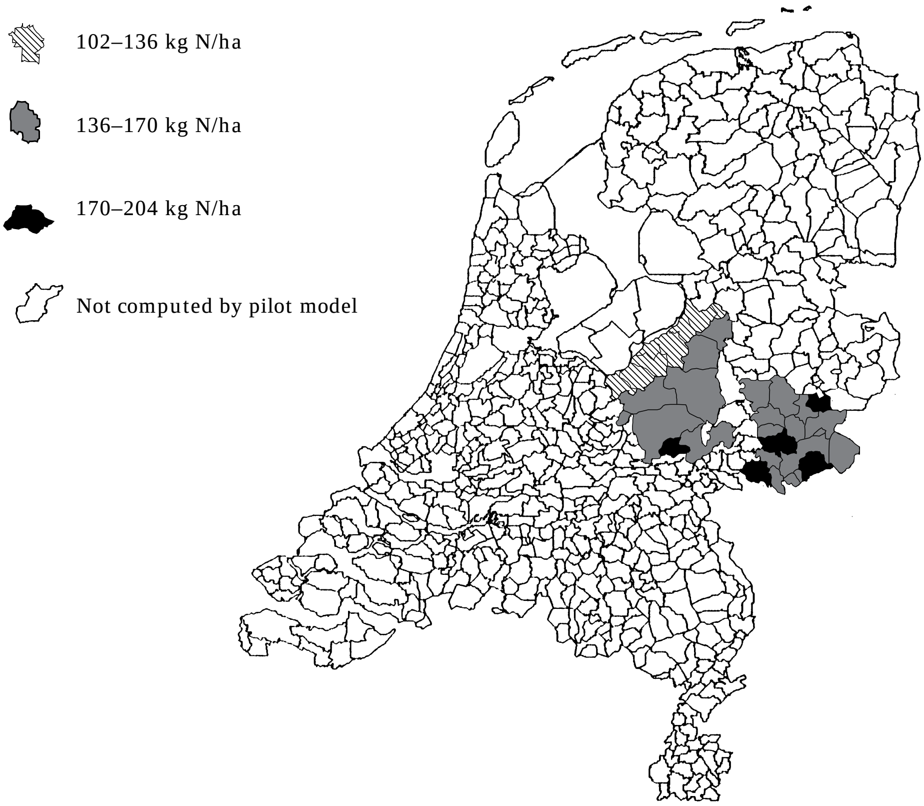

Figure 3. Municipality map of The Netherlands with average nitrate leaching in 40 municipalities on sandy soil in Gelderland (calculated on the basis of specialised dairy farms).

(c) adding a random component to either (a) or (b), in order to capture the original variability that is present at the farms and which cannot be explained by differences in farm characteristics.

Method (c) is called a stochastic approach, while (a) and (b) are deterministic in character.

In the NFM study, these methods have been compared for grassland. First, the average use of fertiliser was determined. Subsequently, the relationship between farm characteristics and fertiliser use was estimated. The use of fertiliser varied from 70–575 kg per hectare. It was expected that the number of dairy cows per hectare or the milk production per hectare would be related to the use of fertiliser per hectare. However, no significant relationship between intensity variables and fertiliser use could be determined. Data that could best be called related were those of fertiliser use and the total number of dairy cows:

Nfert = 97·2 * ln(number of dairy cows) − 26·0
(4·0) ln(number of dairy cows) (0·3)

Nfert = use of fertiliser per hectare (kg N)

$R^2 = 0{\cdot}28$
$N = 39$
t-values between brackets

TABLE 3. Average nitrogen losses (kg N/ha) and standard deviation of losses (in brackets) for three approaches to modelling the use of fertiliser

Type of loss	Method of estimating application level of fertiliser		
	(c) Average	(b) Det. relation	(c) Stochastic
Nitrate leaching	152 (32)	153 (41)	158 (52)
Denitrification	56 (14)	56 (15)	57 (17)
Ammonia volatilisation	119 (45)	119 (46)	118 (46)
Total losses	327	328	333

Although this relationship is hard to explain, it suggests that larger farms use more fertiliser per hectare. Other regions had the same result. The relationship has been used in the NFM, because it seems better than assuming the same average use of fertiliser for all farms.

In the third approach, the estimated equation is used, with a stochastic term added to it. This term is assumed to have a normal distribution with an expectation of 0 and a standard deviation of 80; that is the standard deviation of the residues of the estimated regression line.

In Table 3, the results of the model are shown for all three approaches. The average nutrient loss per hectare for all farms is given, together with its variation.

Table 3 shows that the maximum difference between the average losses of nitrogen in the three approaches is relatively small: 6 kg N/ha. This discrepancy is mainly caused by a difference in nitrate leaching. For nitrate leaching in particular, the standard deviation is higher in the stochastic approach than in the deterministic ones. Because of the non-linearity of the technical relationships describing the losses of nutrients, a higher variability leads to higher losses. Although the differences in results are small in this example, they express that, particularly regarding variable losses, working with average farms can give an underestimation of environmental effects. When the model is used to calculate the effects of a certain policy, this variation is also important: if the use of nitrogen per hectare has to be restricted to 200 kg/ha, it is important to know whether one farm uses 100 kg and the other 300 kg at present, or that both farms already use 200 kg.

7. Pilot model: results of policy evaluation

In addition to giving an accurate and detailed estimate of nutrient losses at a certain point in time, another goal of the NFM is to calculate the effects of policies to reduce nutrient losses. In this section, the environmental and economic effects of a measure to reduce ammonia volatilisation are shown.

The measure comprises the obligatory injection of all manure applications. An assumed side effect is that farmers will react by reducing the use of fertiliser, since the efficiency of nitrogen in injected manure is higher than in surface-applied manure.

The environmental and economic effects of this measure are represented as the

TABLE 4. Average nitrogen losses (kg N/ha), costs and benefits of injection of manure (NLG/ha)

Type of loss	Method of manure spreading	
	Without injection	With injection
Nitrate leaching	153 (41)	164 (38)
Denitrification	56 (15)	58 (14)
Ammonia volatilisation	119 (46)	62 (22)
Total losses	328	284
Increase in costs (NLG/ha):		
— Fertiliser		−46
— Net feed purchase		−6
— Labour and capital		+139
		+87

average nutrient losses per hectare (Table 4). Also the average costs and benefits of the measure are given.

The average ammonia volatilisation is reduced by 48%, from 119 kg N/ha to 62 kg N/ha. However, nitrate leaching increases by 7% or 11 kg N/ha and denitrification by 3% or 2 kg N/ha.

Total costs go up by NLG 87/ha, or about NLG 2 per kg N loss reduction per ha. This increase is mainly caused by extra labour costs. Because the use of fertiliser is decreased, fertiliser costs decrease likewise. As a result of the better efficiency of nitrogen use, crop production has increased and costs for net feed purchases have gone down. The standard deviation is reduced for all types of losses. This is because levels of nitrogen use have become more alike for all farms.

8. Conclusions and discussion

The NFM is a static micro-simulation model. It simulates production activities on the farms that are registered in the Agricultural Census and calculates nutrient losses from the agricultural production system to other parts of the environment. It can be used to describe the present situation, but more importantly to simulate the effects of government policies or technical innovations. Cost calculations are made in terms of additional costs relative to a baserun. The final outcomes of the model are related to the regional and national level.

The strength of the model lies in its integrated approach of nutrient flows: all farm inputs and outputs containing nutrients are included, the total chain of nutrient flows within farms is represented, different nutrients are taken into account simultaneously and interactions between farms are dealt with. This makes the NFM a suitable instrument to evaluate a wide range of policies directed at the reduction of emissions to the environment. It offers the opportunity to evaluate the interaction between different specific policy measures.

The NFM is not unique in its description of the nutrient flows at farm level. Berentsen *et al*. (1992) give an example of a linear programming model with which the effects of different government policies on nutrient flows and losses on a dairy farm are modelled. Wossink *et al.* (1992) present a linear programming model for an arable farm, which incorporates nutrient and pesticide flows. Von Chappuis (1993) describes in detail the nitrogen flow at a livestock farm and focuses on the pollution of drinking water. Compared to these models, the NFM is less detailed.

The NFM, however, is not primarily focused at the farm level, but at the regional, sectoral and national levels. It aggregates the total variety of farms that exist in a certain region instead of following a representative farm approach. In addition, interactions between farms (transport of manure and roughage), and the effect of changing policies on the total manure surplus, on the markets of manure and roughage, are important issues in this respect.

Most studies at sector or regional levels in which economic and environmental aspects are integrated are less detailed with respect to the environment. Becker (1991), for instance, uses an econometric regional supply/demand model which is linked to a nutrient balance model in which, for example, a fixed nutrient content of manure is assumed. Inputs are handled in an aggregated way: variable inputs are feed, energy, manure and fertiliser, among others. The effects of changes in the prices of inputs and outputs are translated into changes in inputs and outputs by using price elastcity. Physical measures and technical solutions for the reduction of nutrient losses can not easily be incorporated into this approach. The division of the total loss over different components is also lacking in this approach.

One of the limitations of the manure models, developed earlier at the Agricultural Economics Research Institute (Wijnands *et al.*, 1988, 1992), is the absence of model results in terms of nutrient losses, except for volatilisation. Another limitation is that the application of manure to crops, crop uptake of nutrients, crop growth, the feeding of the animals and the excretion of animals are not directly linked in the model. For example, a lower level of fertiliser on grassland leads to a lower nutrient content of feed and a lower nutrient content of the manure. These effects had to be modelled indirectly by adapting several model coefficients. When several changes in the agricultural production process have to be considered simultaneously, it becomes difficult to make consistent calculations. A third limitation of the manure models is that they are primarily focused on manure and that chemical fertiliser is dealt with only marginally. A fourth limitation is that the model coefficients are based on technical research, recommended use of fertiliser from extension services and so on, and a thorough validation on the basis of farm level data has not been carried out. Furthermore, the variation in input use, output level and losses between farms is not taken into account. All cows are assumed to excrete a fixed amount of nitrogen, phosphorus and potassium, regardless of the milk production level, the fertiliser level on grassland, etc.

For micro-simulation it is not necessary to make calculations for all farms in the population. The Dutch FADN seems very attractive to be used as the main data base in the Nutrient Flow Model instead of the Census, because it is a representative sample which is linked to the Census via sample weights. The FADN observes farms in great detail. However, it contains too few observations at a local or regional level. In addition, a part of the variability in nutrient losses would be lost. Because this variability in nutrient losses at the local level is an important input for environmental models, the Agricultural Census is used as the database on the farm level.

It is shown that the validation of the technical models with the help of empirical data is essential from the viewpoint of losses. Because one of the goals of the model is to describe present losses of nutrients to the environment, the best parameter for validation would be nutrient loss. However, data on losses for individual farms are not available on a large scale and they cannot always be related to farm characteristics. At this moment, a research project is being carried out in the Netherlands in which the levels of nitrate and phosphate in the ground water are measured at farms that participate in the FADN.

The effects of obligatory injection of manure have been evaluated in this paper. It is assumed that farmers would respond to this by restricting their use of fertiliser. The average losses of nitrogen would be reduced by 13%, caused by a reduction of ammonia volatilisation of 48% and an increase in nitrate leaching and denitrification of 7% and 3%, respectively. This measure thus leads to a limited reduction of losses and also to a reallocation of losses. The costs of this measure are mainly caused by extra labour and machinery costs.

Dynamic aspects such as a farmer's response to government policies and structural impacts of policies have to be derived from other economic models, for instance the European Community Agricultural Model (Veenendaal, 1993). A more direct link between economic models and the NFM is an important aspect for further research.

In the future, the pilot model will be extended to the national level. Then, the model can be validated for more parameters by comparing manure transports and regional roughage balances with statistical sources on a national level. At the moment, a study is being done in which the NFM approach is extended to all sandy soils in the Netherlands (50% of the total land area).

It is also planned to extend the material flow approach to pesticides, energy and heavy metals. This will allow us to deal with interactions between, for instance, nutrient and pesticide policies.

The Dutch government intends to change its environmental policy with respect to the Dutch agricultural sector in the direction of levies on nutrient surpluses. The suitability of the NFM as an instrument for evaluation of this type of policy should be further investigated. The nutrient balance approach, which is the core of the NFM, seems a good starting point.

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