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Mededeling 528

INDICATORS TO MONITOR AGRI-ENVIRONMENTAL POLICY IN THE NETHERLANDS

June 1995

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ABSTRACT

INDICATORS TO MONITOR AGRI-ENVIRONMENTAL POLICY IN THE NETHERLANDS
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The Hague, Agricultural Economics Research Institute (LEI-DLO), 1995
ISBN 90-5242-290-7
Mededeling 528
32 p., tab., fig.

This report reviews the experiences in the Netherlands in the identification and use of agri-environmental indicators. It is largely based on an annual report on agriculture, environment and economics, published by the Agricultural Economics Research Institute (LEI-DLO). Emphasis is placed on indicators related to the use and treatment of energy, nutrients and plant protection products, and to a lesser extent also related to water, heavy metals and waste.

The report includes information on a set of indicators covering targets of environmental policy. It is concluded that monitoring networks, data bases and the organization and management of information collection should be improved or developed. Harmonization of the available data bases and indicators should also be achieved.

Agriculture/Environment/Indicators/Energy/Nutrients/Plant Protection Products/ Monitoring

CIP-DATA KONINKLIJKE BIBLIOTHEEK, DEN HAAG

Brouwer, F.M.

Indicators to monitor agri-environmental policy in the Netherlands / F.M. Brouwer. - The Hague : Agricultural Economics Research Institute (LEI-DLO). - Fig., tab. - (Mededeling / Landbouw-Economisch Instituut (LEI-DLO) ; no. 528)
ISBN 90-5242-290-7
NUGI 835
Subject headings: agriculture and environment.

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FOREWORD

The Organization for Economic Co-operation and Development (OECD) organised a Meeting of Experts on Agri-Environmental Indicators from 8-9 December 1994. A number of OECD Case Study reports were prepared as an input to this Meeting. Documents were submitted for discussion to this Meeting by Australia, Canada, Germany, and the Netherlands. These documents are aimed at examining the experience in the development and use of agri-environmental indicators in the different countries.

The Agricultural Economics Research Institute (LEI-DLO) was commissioned by the Ministry of Agriculture, Nature Management and Fisheries in the Netherlands to prepare a document on agri-environmental indicators in the Netherlands. This support is gratefully acknowledged. The present report provides the basic achievements of the study. It is based on the original document for the OECD (COM/AGR/ENV/EPOC(94)97.

The Director,

The Hague, June 1995

L.C. Zachariasse

1. INTRODUCTION

The OECD-Joint Working Party of the Committee for Agriculture and the Environment Policy Committee (JWP) is developing a set of indicators that would contribute to achieving the following objectives:

- providing information on the current trends and state of the natural environment in agriculture;
- assisting policy makers in the analysis of the environmental impacts of policy decisions and market processes, and monitoring the effectiveness of policies promoting sustainable agriculture.

Several policy documents were published in the Netherlands during the past couple of years, including targets to reduce the pollution of the environment from agriculture. The focus is on policies related to the use of energy, nutrients and plant protection products. Agri-environmental indicators are developed in response to the need to monitor progress on the achievement of environmental targets. Their aim is threefold:

- providing a contribution to monitoring the use of inputs in agriculture and their emissions to the environment. This is to support the evaluation of environmental policy related to the agricultural sector;
- examining response by the agricultural sector to environmental policy. Agriculture should respond to policy to meet standards on environmental quality;
- investigating available options for the agricultural sector to meet environmental targets. Present farming practice shows a wide distribution in using inputs across homogeneous groups of farms.

The main objective of the present report is to review the experiences in the Netherlands in the identification and use of agri-environmental indicators. The objectives of the report in more detail are as follows:

- identification of overall objectives of environmental policy in the Netherlands. This part of the report will primarily summarize the main elements of environmental policy that are important to the agricultural sector. Policy targets are agreed upon for the years 1995, 2000 and 2010. These objectives also stimulated the development and use of a set of agri-environmental indicators that allow for monitoring of policy targets and evaluation of achieved reduction levels. A set of indicators is identified in response to such a need. The context in which the indicators are being developed will be examined (Section 2);
- identification of the framework being used to develop the indicators. A set of indicators that are being developed, will be summarized. This part of the report also includes a review on the progress made so far in establishing the set of indicators and in identifying criteria used to select the set of indicators being used (Section 3);

- summarizing the actual numerical measures and/or numerical derivations used to express each of the indicators chosen. Indicators developed focus among others on usage levels of inputs in physical terms as well as on costs of using inputs, emission levels, farm management characteristics and available options to reduce environmental stress, as well as costs of environmental policy to the agricultural sector (Section 4);
- reviewing of the data collection and management problems that have arisen during the period of developing the indicators and how they have been or are foreseen to be resolved (Section 5).

Some concluding remarks are made in Section 6 of the report. Focus is on the future work programme that is envisaged for the development of agri-environmental indicators in the Netherlands.

The report is based on a review of agri-environmental indicators developed by the Agricultural Economics Research Institute (LEI-DLO), the Central Bureau of Statistics (CBS) and the National Institute of Public Health and Environmental Protection (RIVM).

- LEI-DLO publishes an annual report on agriculture, environment and economics, including a set of agri-environmental indicators. Emphasis in that report is on indicators related to the use and treatment of energy, nutrients and plant protection products, and to a lesser extent also related to water, heavy metals and waste. Linkages among the state of the environment with the economics of farming are made. Main source of information is the LEI Accounting Network (Mulder and Poppe, 1993; Poppe et al., 1994a; 1994b).
- CBS provides annual statistics on costs of environmental policy for agriculture (Pouwelse, 1994). It includes information on investments in environment-friendly equipment as well as on levies paid by the agricultural sector. Compensation of the agricultural sector by subsidies is also considered. Statistics on the use of inputs in agriculture are published on a regular basis as well (e.g. energy and nutrients).
- Long-term reconnaissances of the actual and future state of the environment are published periodically by RIVM (RIVM, 1989; 1991; 1993). These reports examine the impact of policy on the future state of the environment. RIVM is also commissioned to coordinate the publication of so-called environment balances for the Netherlands. These are aimed to present the information that is required to contribute to the monitoring of all environmental policies in the Netherlands. This effort includes agriculture as well. It is to be a joint report of several research institutes and scheduled for publication on an annual basis. The first issue is scheduled for publication in 1995.

The report includes information on a set of indicators covering targets of environmental policy. Monitoring networks, data bases and the organization and management of information collection are to be improved or developed as well. Another aim is the harmonization of the available data bases and indicators .

2. ENVIRONMENTAL POLICY AND AGRICULTURE

2.1 Introduction

Major issues of environmental concern in the Netherlands that (partly) result from agriculture include:

- pollution of groundwater as well as of surface water and coastal waters (eutrophication) from nitrates and phosphate;
- emissions of ammonia and subsequent acidification of water and soils;
- deterioration of soils and water from the use of plant protection products;
- rising levels of carbon dioxide and other greenhouse gases in the atmosphere, and their possible effects on global warming. These emissions result from, among others, energy consumption in agriculture and horticulture (CO_2) as well as from livestock production (e.g. emissions of CH_4);
- desiccation of nature conservation areas in response to high usage of water from groundwater resources, drainage and land consolidation programs.

Environmental policy that is important for the agricultural sector is primarily driven by the issues of environmental concern mentioned before. Three policy documents were published by the end of the 1980s that induced the monitoring of environmental policy for the agricultural sector:

- national Environmental Policy Plan (1989). The overall objective of environmental policy is to aim for a sustainable development of society. The agricultural sector is one of the target groups of policy. Targets are formulated for a large number of environmental issues, to be achieved within a period of 10-20 years. Comparison of the present state with the target levels fixes the required reduction goals. The policy framework is provided by the government, which is translated into objectives and targets for each of the environmental issues and target groups (including the agricultural sector). Progress on environmental policy is reported periodically to Parliament (e.g. VROM, 1994);
- agricultural Structure Memorandum from 1989 (MLNV, 1989). Environmental pressure from agriculture increased in response to the high application levels of animal manure, the emissions of ammonia from livestock and the high use of plant protection products. The three main overall objectives of agricultural policy are to aim for a competitive, safe and sustainable development of the agricultural sector in the Netherlands;

- Third Water Management White Paper (1990). Target pictures are formulated for the Netherlands on desiccation of nature conservation areas in response to the extraction of groundwater, as well as on eutrophication of surface water and coastal waters.

Detailed documents with policy objectives and instruments to reduce deterioration of the environment from agriculture are published as well. These documents focus on the use of nutrients, plant protection products and energy. Objectives are formulated to reduce the emissions of greenhouse gases, the emissions of ammonia and subsequent acidification of soils and water, nutrient loads, diffusion of plant protection products and desiccation of nature conservation areas. Policy objectives are also formulated for the agricultural sector for some of the issues (table 2.1).

Table 2.1 Issues of environmental concern and target levels for 2000

	1985	1990	2000 (target)
Climate change			
- CO_2 (million tonnes)	163	184	173-177
of which agriculture	6	9	.
- CH_4 (million kg)	1,020	1,080	970
of which agriculture	509	520	360
- N_2O (million kg)	62	63	63
of which agriculture	26	25	15
Acidification			
- NH_3 emissions (million kg)	258	216	82
of which agriculture	242	200	70
Nutrients (gross load) a)			
- Phosphor (million kg)	181	155	.
of which agriculture	155	130	.
- Nitrogen (million kg)	1,303	1,066	.
of which agriculture	1,037	849	.
Diffusion			
Plant protection products (million kg)	21	19	9.5
Desiccation of nature conservation areas			
- Area affected by desiccation (index)	100	.	75

a) Load of nutrients to soils and groundwater, not corrected for removal by crops, leaching losses and direct discharge to surface water (Source: RIVM (1993)).

2.2 Energy policy

Environmental policy in the Netherlands related to energy consumption aims at a reduction of the emissions of carbon dioxide of 3-5 per cent during the period 1989/90-2000. Agriculture and horticulture should also contribute to this reduction, but no explicit policy goal is formulated in this respect. The main target in energy policy is to improve the efficiency of energy use, and subsequently contribute to a reduction in the emissions of carbon dioxide. Energy efficiency is the amount of energy required to produce one unit of product. This indicator is therefore affected by a combination of energy consumption and production levels.

About 10 per cent of domestic consumption of natural gas is used by horticulture under glass. This sector also uses more than 90 per cent of the total consumption of natural gas in agriculture. An improvement of energy-efficiency in this sector would therefore contribute substantially to achieving national policy targets. A long-term agreement on energy consumption in horticulture under glass was signed in 1993 between the government and the agribusiness. Energy-efficiency needs to be improved by 50 per cent by the year 2000 compared to the situation in 1980. An improvement of 30 per cent is to be aimed for by the year 2000, compared to the situation in 1989.

2.3 Nutrient policy

The nutrient problem is caused by high usage levels of inorganic fertilizers and (imported) feed, and the subsequent high production levels of animal manure. Groundwater, as well as surface water, is polluted by animal manure and fertilizers from nitrogen and phosphate. The application of animal manure exceeds the amounts taken up by the crops, also taking into account unavoidable losses to the environment. Part of the animal manure from farms with livestock also needs to be applied elsewhere, according to present standards for the application of manure.

The overall objective of nutrient policy is to achieve a balance between production and utilization of minerals, both for nitrogen as well as phosphate. This implies that the total amount of nitrogen and phosphate applied, either from organic or inorganic sources, should not exceed the amount that can be absorbed by the crops, except unavoidable losses. The level of unavoidable loss is to be decided upon by policy. The objective should be reached by the year 2000. These kinds of policy objectives require knowledge on mineral flows at farm level. A so-called mineral balance sheet provides such information.

Policies to reduce the deterioration of the environment caused by animal manure were formulated at the beginning of the 1980s. A three-phase approach to the nutrient problem began in 1986. A phased approach was agreed on to provide sufficient time for the agricultural sector to develop and introduce solutions, in order to bring the deterioration of the environment down to acceptable levels:

- the first phase (1987-1990) was aimed at stabilization of the problem and preventing a further increase in livestock production. Standards for the maximum amount of manure to be applied per hectare were defined under the Soil Protection Act;
- the second phase (1991-1994) is aimed at a gradual reduction of pressure by tightening the standards for the application of animal manure. Manure surpluses as well as the costs of disposal of animal manure increased at farm level. The excretion of minerals from livestock decreased among others in response to adding enzymes to feed. This was achieved by a better digestion of phosphate. The use of organic nitrogen from animal manure improved, since manure needs to be worked into the soil after application and the emissions of ammonia subsequently decreased. The use of fertilizers also shows a decreasing trend;
- the third phase of manure policy starting by 1995 (but likely to be rescheduled for 1996), is aimed at a further reduction of manure and fertilizer application, towards a balanced application of nitrogen and phosphorus by the year 2000. A central role in this stage of nutrient policy is played by the introduction of a mineral accounting system. The system comprises a comprehensive record at farm level of mineral flows regardless of origin (e.g. manure, fertilizers, feed concentrates). Standards on the application of minerals from organic sources are to be replaced by so-called 'loss standards'. They include losses of phosphate and nitrogen that are acceptable from an environmental point of view.

The emissions of ammonia from agriculture need to be reduced by at least 50 per cent by the year 2000 compared to 1980 levels. Policy aims for a 70 per cent reduction during the period 2000-2005, compared to 1980 levels. The target for the year 2015 is an 80 per cent reduction for the country as a whole, according to the *Plan van aanpak beperking ammoniak-emissies van de landbouw (plan to reduce ammonia emission from agriculture)*. A 90 per cent reduction is required in regions that are most vulnerable to acidification (e.g. sandy soils with intensive livestock production). Such a high reduction is to be required in order to diminish deposition such that sustainable standards are met. The emissions of ammonia from agriculture during the reference year (1980) are assessed at 234 million kg NH_3; target levels for the period 2000-2005 and 2010-2015 equal 70 and 45 million kg NH_3.

2.4 Crop protection policy

The use of plant protection products in the Netherlands poses a threat to the environment, including aquatic ecosystems, surface water and groundwater (Faassen, 1994). The objectives of crop protection policy in the Netherlands are formulated in the Multi-Year Crop Protection Plan (LCPP) (MLNV, 1991). The main objective is to bring about a drastic reduction in the dependence on crop protection products in agriculture and horticulture, together with the elimination of negative external effects caused by the use of these products. The use of plant protection products in agriculture and horticulture needs to be reduced by 50 per cent in the year 2000, compared to the average amount of almost 20 million kg during the four annual averages of the period 1984-1988. A 30-35 per cent reduction is to be achieved by the year 1995, compared to the years 1984-1988. Reduction targets are specified by category of plant protection products. Targets are also formulated for the years 1995 and 2000 regarding the reduction of the emissions of plant protection products to the environment, distinguishing between air, groundwater, and surface water.

2.5 Desiccation of nature conservation areas

Groundwater tables lowered during the past couple of decades, among others in response to drainage and land consolidation programmes. The decrease of groundwater tables in regions with major land consolidation programmes was on average some 35 cm. Desiccation of nature conservation areas subsequently increased. Policy presently aims to reduce the size of nature conservation areas affected by desiccation by some 25 per cent in 2000, compared to the situation in 1985. One of the options to achieve this reduction is to reduce the amount of water used by sprinkling systems originating from groundwater resources, and also by using surface water instead of groundwater.

2.6 Monitoring environmental policy

Objectives of environmental policy are formulated for the years 1995, 2000 and 2010. The objectives for the use of nutrients, plant protection products and energy efficiency for the years 1995 and 2000 are part of so-called mid-term reviews. Policy objectives for the year 2010 are based on sustainable levels, and reduction levels for that year may be substantially above those for the year 2000. The emissions of ammonia for example, need to be reduced by at least 50 per cent by the year 2000 compared to 1980 levels. This is considered to be technically and economically feasible. A 90 per cent reduction is assessed to be required in regions that are most vulnerable to acidification. Such a reduction of the emissions of ammonia is considered to be required for achieving sustainable levels. Such a reduction level is aimed for by the year 2010.

Agri-environmental indicators have been developed to monitor the response by the agricultural sector and to examine to what extent policy objectives on environmental stress and/or quality are met.

Monitoring progress of environmental policy in the Netherlands distinguishes between monitoring of (i) policy, (ii) target groups including agriculture, and (iii) environmental quality:

- monitoring of *policy* includes a review of objectives, strategies, instruments and priorities. It also reviews policy measures;
- monitoring of *target groups* focuses on societal activities and their impact on the environment. This type of monitoring also includes environmental pressure from agriculture;
- monitoring of *environmental quality* focuses on the biotic and abiotic environment and their effects on human beings, health, safety and ecosystems.

The context of monitoring progress of environmental policy in the Netherlands is a modified Pressure-State-Response (PSR) framework, identified within the context of OECD as a concept of causality. Pressure on the environment in the context of PSR is treated by the monitoring of the target group. State of the environment under the PSR framework is part of the monitoring of environmental quality, and Response to these changes is part of the monitoring of environmental policy.

Agri-environmental indicators are aimed at serving policymakers, the extension service to farmers, the agribusiness and also at providing research guidance:

- indicators primarily contribute to monitoring the agri-environmental impact of environmental policy. Information is provided by a limited set of indicators that are available over a longer period of time;
- indicators support policy as well as the agribusiness by provision of information on the efforts made by agriculture on adjusting farm practice. Important information in this respect includes the investments made in environment-friendly equipment, and the subsequent costs of meeting environmental standards. Competitiveness of agriculture may be affected in a negative way in case relative cost disadvantages arise (see e.g. Brouwer and Godeschalk, 1993). It is also important to identify response by the agricultural sector, in terms of reduction levels achieved in using inputs in agriculture, and their impact on the environment;
- indicators also provide tools for the extension service to farmers and serve the agribusiness in general. They could support the extension service to farmers, among other things by providing information on the distribution of the inputs used amongst a homogeneous group of farms and on new farm systems. Insight into the efficiency of using inputs, i.e. the amount of input used per unit of output, is also important to the extension service.

The development and use of agri-environmental indicators in the Netherlands will be further discussed in the remaining part of the report. The report will be limited to monitoring of environmental policy related to the agricultural sector, being one of the main target groups for environmental policy in the Netherlands. Neither monitoring of environmental policy in general terms nor that of environmental quality is considered in the remaining part of the report.

3. IDENTIFICATION OF AGRI-ENVIRONMENTAL INDICATORS

3.1 Introduction

Several indicators have been developed during the past couple of years in order to contribute to monitoring and evaluation of agri-environmental policies in the Netherlands. The indicators selected for further investigation in this report are classified according to:

- use of inputs in agriculture at sectoral, regional and farm level. Emissions are identified as well. This type of information provides insights into the use and treatment of inputs across homogeneous groups of activities (i.e. by sector), homogeneous groups of farms (i.e. by farming type) and regions;
- use of inputs related to the output achieved from farming. These kinds of indicators allow to see the use of inputs within the context of key economic indicators of farming (e.g. total costs and family farm income). Indicators of the efficiency of using inputs (inputs used per unit of product produced) and of the productivity of using inputs (netvalue added per unit of input used) are also identified;
- distribution of the use of inputs across homogeneous groups of farms related to key economic indicators of such farms. This is aimed to provide information on the available options regarding farm management and farm structure, for meeting environmental objectives. It might also provide information on which farmers could be affected most by changes in environmental policy.

Emphasis is on indicators related to energy (figure 3.1), nutrients (figure 3.2), plant protection products (figure 3.3) and to a lesser extent on water (figure 3.4). Indicators of energy, nutrients and plant protection products focus on the use of inputs at sectoral, regional and farm level, including the distribution of using inputs across homogeneous groups of farms. The use of inputs is also presented as a percentage of total costs and of family farm income. The efficiency and productivity of using inputs are also examined: efficiency equals the amount of inputs required to produce one unit of output produced, and productivity equals the net value added produced per unit of input required. The distribution of using inputs across homogeneous groups of farms may reflect differences in the cropping plan, livestock production, intensity of farming practice and in farm management characteristics. Indicators of the costs of environmental policy to agricultural sector are also identified (figure 3.5).

3.2 Energy

Indicators of energy primarily focus on consumption levels, as well as on the ratio between energy consumption and the output from farming. Such indicators contribute to monitoring the efficiency of using energy in agriculture (figure 3.1). A distinction is made between four groups of indicators, including energy consumption in agriculture, the use of energy related to output achieved from farming by farming type, the distribution of energy use among groups of farms and the emissions of carbon dioxide from energy consumption.

Energy consumption

1. Energy consumption by energy carrier (natural gas, electricity and diesel) (in energy terms and monetary terms):
   - total by sector and subsector
   - average per farm by farming type
   - average per farm by administrative region (province)
   - total use in agribusiness (total consumption of energy from primary production by sector, as well as from food and processing industry)

Energy consumption related to the output achieved from farming by farming type

2. Energy consumption by energy carrier (in MJ) per unit of output by farming type; costs of energy in relation to net value added and in relation to family farm income per farm by farming type
3. Intensity, efficiency and productivity of energy use by farming type

Distribution of using energy across farms by farming type

4. Distribution of energy consumption among groups of farms (in MJ per unit of output) by farming type

Emissions from energy

5. Emissions of carbon dioxide from agriculture

Figure 3.1 Indicators to monitor agri-environmental policy: energy

3.3 Nutrients

A rather detailed set of indicators has been developed for nutrients (figure 3.2). They contribute to monitoring of nutrient policy in the agricultural sector, including emissions of ammonia from livestock and their effects on acidification as well as the impact of nutrient loads on the environment. It was already mentioned before that the identification of mineral balance sheets is considered an important element in agri-environmental policy. The assessment of mineral surpluses therefore is an important phenomenon within the set of indicators. A mineral balance includes input and output levels of minerals, the difference being the mineral surplus.

Use and treatment of nutrients
1. Nutrients used by mineral (nitrogen, phosphorus and potassium):
   - total use by sector and subsector (in million kg)
   - average use per farm by farming type (in kg)
   - average use per farm by province (in kg)
2. Supply utilization balance (production, import, export and use) of minerals from agriculture at national level (in 1,000 kilogramme N, P and K)
3. Input, output and surplus of minerals (nitrogen, phosphorus and potassium) at national level and by farming type (average per farm and per hectare)
4. Production of animal manure and manure surplus at farm level (in million tons and million kg of nitrogen, phosphorus and potassium) by manure type
5. Emissions of ammonia by manure type and emission type (in million kg of NH_3)

Use of nutrients related to the output achieved from farming by farming type
6. Costs of nutrients per farm and costs of nutrients in relation to net value added and family farm income by farming type
7. Intensity, efficiency and productivity of using nutrients by farming type

Costs of treating animal manure
8. Annual costs per farm of treating manure surpluses (transport and levies) by farming type
9. Annual costs per farm of investments to store animal manure by farming type
10. Net costs of treating manure policy per farm; costs of treating manure policy in relation to total production costs, net value added and family farm income by farming type

Distribution of utilizing nutrients across farms by farming type
11. Distribution of using inorganic fertilizers (kg N, P and K per hectare) by farming type
12. Distribution of nutrients surplus (kg N, P and K per hectare) by farming type

Figure 3.2 Indicators to monitor agri-environmental policy: nutrients

Two approaches are available to quantify a mineral balance: the so-called farm gate balance and the surface balance. The criterion for the identification of the farm gate balance are minerals entering the farm (input factor) or leaving the farm (output factor). The input of nitrogen in that case includes the purchase of fertilizers, organic manure, feedingstuffs and (young) animals. The output of nitrogen includes livestock, livestock products and crop products sold, as well as animal manure that is transported and being treated or applied elsewhere. The surface balance approach includes an assessment of minerals available for plant growth (input to the balance) and the uptake of minerals by crops. The input of minerals originates from fertilizers and animal manure and from deposition of the atmosphere (input components) and the output of minerals originates from harvested crops.

Indicators identified focus on (i) the use and treatment of nutrients in agriculture, including the production of animal manure and the utilization of minerals, (ii) the ratio between the use of nutrients and the output achieved from farming, (iii) the costs of treating animal manure and manure surpluses, and (iv) the distribution of mineral surplus across homogeneous groups of farms. One of the items on the use and treatment of nutrients includes an assessment of the production of animal manure and manure surplus, as well as of emissions of ammonia by manure type. Surplus of animal manure at a farm is defined as the amount of manure produced, that is not allowed to be applied on that farm according to the prevailing law on the application of animal manure. Ammonia emissions are estimated using a model based on relevant farm characteristics.

3.4 Plant protection products

It was already mentioned before that policies on the use of plant protection products aim to reduce usage levels as well as the dependence of agriculture on agrochemicals. Targets are also formulated for a reduction of the emissions of plant protection products to the environment. Indicators identified so far primarily focus on usage levels, on the ratio between the use of plant protection products and output from farming, and on the distribution of usage levels across homogeneous groups of farms (figure 3.3).

Use of (chemical) plant protection products

1. Use of plant protection products by product group (insecticides, fungicides, herbicides, nematicides, growth regulators, additives and other) (in kg of active ingredients):
   - total by sector and subsector (million kg)
   - average per farm by farming type (kg per hectare)
   - average by crop (kg per hectare)
   - average per farm by administrative region (province) (kg per hectare)

Use of (chemical) plant protection products related to the output from farming

2. Costs of plant protection products per farm and costs of using plant protection products in relation to net value added and family farm income by farming type
3. Intensity, efficiency, and productivity of using plant protection products by farming type

Distribution of using (chemical) plant protection products across farms by farming type

4. Distribution of using plant protection products among groups of farms by farming type (kg of active ingredients per hectare)

Figure 3.3 Indicators to monitor agri-environmental policy: plant protection products

This type of indicator primarily contributes to monitoring the use of plant protection products, being one of the main objectives of environmental policy in this field. Indicators that reflect the dependence of agriculture on plant protection products are rather limited so far, and the same holds for indicators of the emissions to the environment. Information on the use of biological pest control in agriculture is available to a limited extent, and this indicator may reflect the dependence of agriculture on agrochemicals. An increased use of biological products to treat pests for example indicates a reduction of the dependence on agriculture of chemical-based plant protection products. Information is also available on size of agricultural area utilized for biodynamic or ecological farming practices.

3.5 Desiccation of nature conservation areas

Policies on water consumption aim to help reduce the size of nature conservation areas that are affected by desiccation. The extraction of water from the available groundwater resources is considered a cause of lower groundwater levels in the country. Agriculture is also responsible for that extraction. Sprinkling systems are a main carrier of water for agricultural purposes. The indicators therefore focus on the size of utilized agricultural land on which sprinkling systems are used. The indicators do make a distinction between crops (figure 3.4).

Use of water for sprinkling systems

1. Utilized agricultural area covered by sprinkling systems (groundwater or surface water) by crop (1,000 hectares)
2. Water extracted from groundwater or surface water resources for sprinkling systems:
   - total by sector and subsector
   - average per farm (m^3 per hectare) by farming type

Figure 3.4 Indicators to monitor agri-environmental policy: water

3.6 Costs of environmental policy

The list of available indicators presented before mainly focuses on the use and treatment of inputs in agriculture and their emissions to the environment. The distribution of using inputs across homogeneous groups of farms is also identified as an important phenomenon related to farm structure and farm management characteristics. Besides that, investments are also required in environment-friendly equipment in order to reduce emissions to the environment. Such investments to adjust farming practice respond to environmental policy. Several of such indicators are also used in this respect (figure 3.5).

Investments among others were made in the past couple of years to increase the capacity for storing animal manure at farms with livestock. Also, investments were made to reduce the emissions caused by spreading animal manure on the field. Such investments increase production costs, and may affect competitiveness of agriculture compared to other production regions.

Subsidies may be provided by the government to stimulate investments in environment-friendly equipment. Net environmental costs of these investments then result. The agricultural sector also pays levies related to environmental policy (e.g. based on the use of energy and on the amount of manure surpluses produced).

1. Investments in environment-friendly equipment in agriculture
2. Costs of environment-activities by the agricultural sector
3. Subsidies on costs of environment-activities in agriculture
4. Levies paid by agricultural holdings for environmental policy
5. Net environment costs

Figure 3.5 Indicators to monitor costs of agri-environmental policies

4. USE OF AGRI-ENVIRONMENTAL INDICATORS

4.1 Origin of information

A set of agri-environmental indicators was identified in the previous chapter. A limited set of critical indicators is quantified in this chapter by making use of several sources of information:

- surveys. An example of that is the Farm Structure Survey (FSS) of Eurostat, which is a survey on agricultural structures of farms at EU level. It includes information on livestock population and cropping plans in the European Union. The equivalent of FSS in the Netherlands is held each year (annual agriculture census) by the Ministry of Agriculture, Nature Management and Fisheries and the CBS;
- LEI-DLO Accounting Network of the Commission of the European Communities (FADN). FADN contains farm level data on the structure of the farm (economic size, agricultural area and livestock population), total output, intermediate consumption, a balance sheet account and a profit and loss account. FADN is based on the annual accounting results for a sample of 60,000 commercial farms in the EU Member States. The sample for the Netherlands includes about 1,500 holdings, approximately 1,000 agricultural and 500 horticultural holdings. Commercial farms refer to farms that are large enough to provide a main activity for the farmer and a level of income sufficient to support the farmer's family (CEC, 1989: 4). The farms in the sample are rather heterogeneous. FADN stratifies farms according to region, economic size and farming type in order to reflect this heterogeneity adequately.
  The LEI Accounting Network contains much more technical data (including volumes on inputs, and allocation of costs and inputs to crops and types of animals) than its European equivalent. Therefore, the collection of data on inputs and investments is relatively easy and auditable (for details see Poppe, 1992; Poppe et al., 1994c). Results can easily be confronted with farm characteristics, farm income and the effects of the agri-environmental policy on the viability of the farms can be estimated;
- questionnaires may be added to regular surveys in order to quantify indicators of specific importance. Questionnaires are arranged for, among others, by CBS and LEI-DLO in order to keep records on the use of energy and plant protection products in the agricultural sector;
- monitoring programmes on the use of inputs in agriculture. Among others, the use of energy in agriculture is monitored on an annual basis. The long-term agreement between the government and the agribusiness installed a special monitoring programme, which was

commissioned to LEI-DLO as an additional module in its glasshouse horticulture sample of the LEI Accounting Network.

A limited set of indicators is reviewed in this chapter, including:
- energy consumption at the sectoral level. This is to aggregate farm level data to the sectoral level (Section 4.2);
- mineral balances at national and farm level. Balances are assessed according to the surface balance approach (national level) and farm gate approach (farm level) (Section 4.3);
- use of plant protection products at sectoral and farm level (Section 4.4);
- water consumption for sprinkling systems (Section 4.5);
- ratio between the use of inputs and output achieved from farming (Section 4.6);
- distribution among farms of inputs. This is to reflect the relationship among farm management characteristics and farm structure with mineral surplus (Section 4.7);
- costs of environmental policy (Section 4.8).

4.2 Energy

The use of energy by the agricultural sector is assessed to be around 163 Petajoule. The use of natural gas is by far the most important energy carrier in the agricultural sector. Horticulture under glass uses more than 90 per cent of the total consumption of natural gas by agriculture (table 4.1).

The information in table 4.1 originates from the LEI Accounting Network. This source provides information on energy consumption at farm level. Farms represented by the sample then are aggregated to the national level. Total energy consumption is also distinguished according to homogeneous groups of activities in agriculture (i.e. sectors). An assessment on the total amount of energy consumed by agriculture includes the following steps:
- aggregation of farms in the LEI Accounting Network, towards all farms represented by that sample;
- estimation of the share of production that is not represented by the sample;
- estimation of energy consumption per (normative) unit of net value added per crop and per animal;
- national total energy consumption in agriculture;
- correction of national total with external sources, if necessary.

Table 4.1 Energy consumption by energy carrier in 1992 (PJ and million guilders)

Sector	Natural gas		Electricity		Diesel		Total	
	PJ	Dfl	PJ	Dfl	PJ	Dfl	PJ	Dfl
Arable	0.0	0.2	0.3	16.9	3.1	65.1	3.4	82.2
Cattle	0.3	5.5	2.7	134.1	5.1	121.8	8.1	261.3
Intensive livestock	7.6	151.2	2.2	110.1	0.1	2.6	9.9	263.9
Horticulture	133.3	986.6	3.0	131.7	0.8	27.0	137.1	1,145.2
- vegetables under glass	54.3	404.9	0.9	39.3	0.3	9.5	55.4	453.8
- greenhouse floriculture	47.5	345.1	1.3	59.4	0.3	9.8	49.1	414.4
- pot plant under glass	22.8	170.4	0.6	24.3	0.2	5.8	23.5	200.6
- other	1.8	23.9	1.2	56.8	1.7	46.4	4.7	127.1
Total	143.0	1,167.4	9.4	449.6	10.9	262.9	163.2	1,879.7

Source: Poppe et al., 1994b.

4.3 Nutrients

It was already mentioned before that mineral balances can be obtained through a *surface balance approach* and a *farm gate approach*. A surface balance of minerals at national level includes the supply of minerals from animal manure, fertilizers and from other sources (e.g. deposition of nitrogen from the atmosphere). Mineral surplus equals total supply minus the uptake of minerals by crops (table 4.2).

Table 4.2 Nutrient balance of agricultural land in 1990

	Nitrogen (N)		Phosphor (P)		Potassium (K)	
	total (million kg)	kg/ha	total (million kg)	kg/ha	total (million kg)	kg/ha
Supply	1,069	532	136	68	599	299
- animal manure	529	264	94	47	502	250
- fertilizers	412	205	33	16	82	41
- other	128	64	9	4	9	4
Uptake by crops	456	227	62	31	421	210
Surplus	613	306	74	37	178	89

Source: CBS, 1992.

The nutrient balance in table 4.2 is based on the so-called surface balance approach. Input to the surface balance approach is - as far as nitrogen is concerned - the supply of nitrogen for plant growth. It includes purchase of fertilizers, the production of animal manure and deposition from the atmosphere. The output factor includes the uptake of nitrogen from crops. Total supply of nitrogen exceeds 1,000 million kilogrammes, and about half of it originates from animal manure. The uptake of nitrogen by crops is around 40 per cent of total supply. The remaining 60 per cent accounts for nitrogen surplus at national level. Nitrogen surplus per hectare is around 300 kg per hectare.

A more detailed picture of mineral flows can be obtained at farm level. Mineral balances therefore also are presented according to the farm gate approach, with input and output flows of minerals at farm level. Mineral balances according to the farm gate approach are presented by farming type in table 4.3. Input and output flows of nitrogen are shown for arable farms, dairy farms, granivore farms and mixed farms. Nitrogen surplus is lowest (173 kg of nitrogen per hectare) at arable farms, which is about half of the average of all arable and livestock farms represented by the sample of farms. The output of nitrogen from animal manure is high at granivore farms, and nitrogen surplus is relatively low because a large share of animal manure at such farms is applied elsewhere, according to prevailing standards.

Table 4.3 Nitrogen balance (kg of nitrogen) per farm by farming type in 1992

	Arable farms	Dairy farms	Granivore farms	Mixed farms	Average farm a)
Total input	14,524	14,670	23,400	15,049	15,574
- animal products	48	133	920	296	261
- feed	651	4,902	21,872	9,402	7,101
- fertilizers	6,734	7,487	297	3,397	5,557
- organic manure	4,745	532	45	805	1,211
- other	2,346	1,616	265	1,148	1,444
Total output	6,292	3,219	17,285	7,331	6,170
- crop products	5,970	95	260	1,311	1,232
- livestock	256	840	6,141	2,678	1,761
- milk products	7	1,803	27	458	998
- organic manure	7	333	9,323	2,287	1,803
- other	51	148	1,534	596	375
Total surplus	8,233	11,451	6,115	7,718	9,404
Surplus per hectare	173	393	1,415	346	347

a) Excluding horticulture.
Source: Poppe et al., 1994b.

4.4 Plant protection products

Statistics on sales of plant protection products for use in agriculture in the Netherlands presently are limited to the sales from firms that are affiliated with the Dutch Foundation for Phytopharmacy (Nefyto). Annual sales of active ingredients in 1992 have been assessed to be 15.9 million kilogrammes. The LEI Accounting Network allows to quantify use of plant protection products at sectoral level. Usage levels of plant protection products by crops are aggregated to totals by sector through the Farm Structure Survey. Data at sectoral level are limited to the arable and livestock sector as well as to horticulture under glass (table 4.4).

Table 4.4 Use of plant protection products by sector in 1992 (x 1,000 kg)

Sector	Insecticides	Fungicides	Herbicides	Nematicides	Other	Total	Average (kg/ha)
Arable	190	2,660	1,700	5,600	1,150	11,320	19.3
Cattle	40	0	700	0	550	1,290	1.0
Horticulture under glass	254	177	33	225	304	993	98.3

Source: Poppe et al., 1994b.

Table 4.5 Use of plant protection products per farm in 1992 by farming type (kg of active ingredients per hectare)

Farming type	Insecticides	Fungicides	Herbicides	Growth regulators	Nematicides	Other	Total
Arable farms	0.4	4.5	3.2	0.2	7.9	1.9	18.2
Grazing livestock	0.0	0.2	0.6	0.0	0.0	0.4	1.3
Field vegetables	4.3	2.0	1.3	0.0	7.9	1.5	17.0
Greenhouse vegetables	13.1	7.2	0.8	0.2	25.8	17.1	64.2
Outdoor floriculture	0.9	19.4	5.6	0.0	6.1	24.3	56.3
Greenhouse floriculture	18.5	13.8	2.8	2.7	3.5	19.0	61.0
Mushrooms	13.9	3.3	1.9	0.0	0.0	105.5	124.6
Orchard	1.9	8.3	3.4	0.5	0.3	1.4	15.8
Tree nursery	2.3	4.2	3.1	0.1	12.9	11.3	34.0
Average	0.5	2.2	1.6	0.1	3.4	1.3	9.2

Source: Poppe et al., 1994b.

A detailed picture of the use of plant protection products at farm level is available by farming type (table 4.5). The use of plant protection products at arable farms on average amounts to 18 kg of active ingredients per hectare. It is highest (more than 60 kg/ha) at farms with mushrooms, farms with vegetables under glass and farms with outdoor floriculture, and lowest (below 2 kg/ha) at farms with grazing livestock. The use of plant protection products per farm on average amounts to 9 kg per hectare. This includes all farms represented by the sample and total size of utilized agricultural area, including arable crops, permanent crops and forage crops.

4.5 Water

Information on the use of sprinkling systems on agricultural land is available from the LEI Accounting Network in the Netherlands. This allows the assessment of the size of agricultural land that makes use of sprinkling systems. The source of water can be identified, i.e. whether it orginates from groundwater or surface water resources, as well as the amount of water used by crop.

4.6 Use of inputs related to the output achieved

Several indicators enable the examination of the use of inputs in the context of key economic indicators of farming. First, the ratio between costs of using inputs and total costs is provided for each category (energy, nutrients and plant protection products) (table 4.6). This reflects the intensity of using inputs in agriculture. The intensity of using energy is higher than that of nutrients or of plant protection products. Costs of using energy exceed 10 per cent of total costs at holdings with vegetables under glass and at holdings with greenhouse floriculture. Monitoring of the efficiency of using inputs provides information on the trends over time on the amount of inputs required to produce one unit of output (table 4.6). A positive trend indicates that less inputs are required to produce one unit of output, compared to a previous year. Energy-efficiency at arable farms decreased in 1992 by some 6 per cent compared to the previous year. The efficiency of using energy increased in 1992 for all other farming types considered. Indicators of the ratio between costs of using inputs and net value added or family farm income are identified in a way similar to the intensity of using inputs. Also, the productivity of using inputs is identified in a similar way to the efficiency of using inputs.

Table 4.6 Intensity and efficiency of using inputs by farming type

Farming type	Intensity of inputs used a)			Efficiency b)		
	energy	nutrients	plant protection products	energy	nutrients	plant protection products
Arable	2.2	5.8	7.4	-6.4	6.3	15.3
Field vegetables	2.0	2.4	2.6	. d)	. d)	. d)
Greenhouse vegetables	17.5	2.3	1.4	14.0	15.1	25.9
Outdoor floriculture	2.2	1.5	3.7	13.1	4.3	24.9
Greenhouse floriculture	12.3	0.9	1.4	10.1	11.0	14.0
Mushrooms	4.5	19.9	1.1	14.1	-16.5	81.4
Orchard	1.2	0.8	4.2	. d)	. d)	. d)
Tree nursery	0.8	2.2	1.2	4.2	25.8	-8.7
Grazing livestock	2.0	26.5 c)	0.3	6.0	0.2 c)	5.8
Granivores	2.6	58.2 c)	0.1	8.1	10.2 c)	40.8
Mixed farms	2.5	36.9 c)	1.4	7.8	-8.0 c)	-16.3
Average	4.1	2.8	1.5	7.5	-0.5	6.1

a) Percentage of total costs; average of the period 1986-1990; b) Change in 1992 compared to 1991 (%); c) Total of fertilizers and feed; d) No assessment made

4.7 Distribution among farms of using inputs

The use of inputs may largely vary across farms due to differences in farm structure, farm management characteristics and intensity of production. Nitrogen surplus on the mineral balance of specialized dairy farms ranges between 243 kg per hectare in the group of 20% of farms with lowest (group 'low') and 608 kg per hectare in the group of 20% of farms with highest surplus (group 'high') (table 7). Nitrogen surplus on the average of all farms is 421 kg per hectare. Milk production per hectare is an important indicator that is strongly correlated with nitrogen surplus. Purchases of feed at group 'high' is also higher than that of group 'low'.

Table 4.7 Characteristics of specialized dairy farms by nitrogen surplus per hectare in 1989/90

Characteristics	All farms	Group 'low'	Group 'high'
Nitrogen surplus (kg N/ha)	421	243	608
Fertilizers used (kg N/ha grassland)	336	202	429
Utilized agricultural area (ha)	28.9	24.4	27.5
Milk production (kg/ha)	11,950	9,007	15,959
Milk production (kg per dairy cow)	6,584	5,823	6,829
Dairy cows per ha	1.8	1.6	2.4
Total use of nitrogen (kg/ha)	529	342	762
- of which feed concentrates	147	97	284
- of which inorganic fertilizers	307	186	403
Total costs per hectare (Dfl)	12,796	11,177	18,393
Total output per hectare (Dfl)	12,377	9,066	17,340
Share of output in total costs (%)	97	83	96
Family farm income (Dfl/entrepreneur)	61,491	40,121	66,669

Source: Mulder and Poppe, 1993.

4.8 Costs of environmental policy

Costs of environmental policy to the agricultural sector include investments made in environment-friendly equipment and levies paid for environmental policy. The agricultural sector may also be compensated for environment-friendly investments. One of the indicators to monitor response by the agricultural sector to meeting environmental standards is investments in environment-friendly equipment. Investments are made among others to increase the capacity to store animal manure and also to reduce the emissions of ammonia while spreading animal manure. These investments amount to a total of some 320 million guilders in 1992, and are around 5 per cent of total investments made by the agricultural sector. Net costs to the agricultural sector of environmental policy increased during the past couple of years from 189 million guilders (situation 1989) to a level of 450 million guilders in 1992 (Pouwelse, 1994). This is around 5 per cent of net value added from agriculture.

5. DATA COLLECTION AND MANAGEMENT PROBLEMS

Several data collection and management problems arose during the past couple of years concerning the use of agri-environmental indicators. They will be summarized in this chapter. The way they have been or are foreseen to be resolved will be discussed as well. The following elements have been identified:

- harmonization of coefficients, which is gaining importance to allow for a proper monitoring of agri-environmental policy;
- investments in environment-friendly equipment, which need to be defined in a proper manner;
- the use of energy, which is corrected for temperature in order to correct for variation of weather conditions and their impact on the use of energy;
- various indicators, which are presented on a hectare basis. The choice for a denominator used therefore also affects the outcome.

Data on the excretion levels by animal type (e.g. cattle, sheep, pigs and poultry) have recently been harmonized. Different coefficients were derived during the past couple of years on the production of animal manure from livestock. Various research and monitoring groups in this field (e.g. LEI-DLO, CBS and RIVM) contributed to a Working Group on the Harmonization of Manure and Mineral Coefficients from Livestock (Werkgroep Uniformering Berekening Mest- en Mineralencijfers). Such efforts presently allow for harmonized coefficients as input to assessments of manure production, manure surplus and mineral flows in agriculture.

Costs of environmental policy to the agricultural sector include the investments made in environment-friendly equipment. Difficulties however arise concerning a proper definition of such investments. A clear distinction between regular investments is difficult. Only part of an investment may be identified as an investment in environment-friendly equipment.

Several indicators are presented per hectare of land area. The choice of the denominator may largely affect outcome. Consider for example the use of energy per farm in horticulture under glass. This may be represented per hectare of utilized agricultural area or per hectare of protected area. The use of plant protection products at farm level is given per hectare of utilized agricultural area.

6. PROGRAM OF FUTURE WORK

Agri-environmental indicators presented in this report aim to link information about the state of the environment with farm economic characteristics. It is to be expected that the selection of these kinds of indicators evolve over time. The data and management problems summarized in the previous chapter will likely remain on the agenda for future work on agri-environmental indicators. Some trends in the development of agri-environmental indicators in the Netherlands are briefly mentioned in the following. They may also be part of future work on agri-environmental indicators:

- monitoring of the use of inputs by chains. An example is the use of energy in the chain of the agribusiness, including the use by primary production and by food and processing industry. Monitoring efforts on the use of inputs in the agribusiness may be based on recent studies to examine Life Cycle Analysis (LCA) in agriculture;
- monitoring of indicators at regional level. Government did formulate policy targets at the regional level. The emissions of ammonia for example, need to be reduced by some 90 per cent in regions that are most vulnerable to acidification. The implementation of policy partly remains with regional and local government. The increasing importance of environmental policy at the regional level also requires monitoring progress at that level. The interpretation of indicators at national level would also be difficult with the increasing importance of local and regional policy;
- demand for preliminary results and forecasts. Data on the accounting year 1992/93 are presently available from the LEI Accounting Network. The evaluation of agri-environmental policy however requires up-to-date information on the indicators used. Attention therefore will be given in the near future to the provision of preliminary results on several of the indicators summarized in this report, including the use of inputs and an assessment of mineral surplus.

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