Environmental RTDI Programme 2000–2006

ENVIRONMENTAL ECONOMICS

Fertiliser Taxes – Implementation Issues

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by

The Economic and Social Research Institute

Author:

Sue Scott

ENVIRONMENTAL PROTECTION AGENCY

An Ghníomhaireacht um Chaomhnú Comhshaoil
PO Box 3000, Johnstown Castle, Co. Wexford, Ireland

Telephone: +353-53-60600 Fax: +353-53-60699
E-mail: info@epa.ie Website: www.epa.ie

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ENVIRONMENTAL ECONOMICS

The Environmental Economics section of the Environmental RTDI Programme addresses the need for research in Ireland to inform policymakers on a range of questions in environmental economics, for example the options for fiscal instruments and how these might be operated. The reports in this series are intended as contributions to the necessary debate on economics and the environment.

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Project Partner's Details

Sue Scott
Head of Environment Policy Research Centre
Economic and Social Research Institute
4 Burlington Road
Dublin 4

Tel: +353-1-667-1525
E-mail: sue.scott@esri.ie

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1.1 Introduction – the problem of excess nutrient application

Fertiliser application is implicated in the contamination of both water and atmosphere. Farmers apply fertilisers because they derive personal benefits in the form of enhanced outputs and incomes, but plants absorb fertilisers up to their needs only. Surplus fertiliser over and above the needs of plants can cause harmful side effects. The current incentives facing many farmers are likely to encourage excess fertiliser application. The damage that excessive fertilisation does is not reflected in the incentives that farmers face and, given uncertainty about growing conditions, farmers have a tendency to apply more fertiliser than is warranted. The purpose of this study is to examine the implementation of a fertiliser tax as an incentive to farmers to apply fertilisers more sensitively with the objective of reducing contamination.

1.1.1 Context

Farmers are responsible for many benefits as well as harms to the environment. Before describing the specific harms that this study seeks to reduce, it is worth listing the overall positive and negative effects of farming, if briefly, owing to the shortage of material on this. This is to set the context. The positive effects of farming need to be stressed in order to provide a balanced view, especially because policies that are successful in dealing with the harms might in turn enhance these benefits as side effects.

Positive benefits of farming are numerous and include the provision of aesthetic value, recreation amenities, carbon sequestration by soils and trees, and other bonuses that are derived from good husbandry such as maintenance of habitat. In an analysis of the externalities from UK agriculture, while it was found that negative externalities amount to at least Stg £1 billion, positive externalities offset approximately half of these negative effects (Hartridge and Pearce, 2001). In addition to these environmental benefits, there are also important positive social side effects, including the provision of jobs and the contributions to the local economy and social fabric of rural communities.

The negative effects of farming can be broadly categorised as environmental and health effects (European Environment Agency, 1998; Pretty *et al.*, 2001, 2005). They are summarised as follows:

1. Contamination of water and harm to wildlife and human health by pesticides. Contamination of water and contribution to eutrophication, algal blooms and toxin-producing bacteria, de-oxygenation, fish deaths and nuisance to leisure users. These effects are caused by nitrate and phosphate released from fertilisers, livestock wastes and silage effluents. Nitrate can also affect infant health.

2. Contamination of the atmosphere by methane, nitrous oxide and ammonia derived from livestock, their manures and fertilisers.

3. Soil erosion leading to disruption of watercourses, and run-off from eroded land causing flooding and damage to resources.

4. Losses of biodiversity and landscape values.

5. Harm to health of humans due to certain residues and micro-organisms in foods.

This study is concerned with the effects on water and the atmosphere in which fertilisers are implicated. While it is not possible to isolate the effect of fertilisers, they are important contributory causes of water and atmospheric contamination. Eutrophication is a significant part of the damage to water. A definition of eutrophication is given in the EPA's report *Quality of Water in Ireland 1998–2000* (McGarrigle *et al.*, 2002) as an enrichment of waters beyond natural levels by plant nutrients resulting in excessive growth of algae and other aquatic flora. These in turn remove oxygen from water, vital for fish and other creatures, during the hours of darkness. Eutrophication is regarded as the main cause of unsatisfactory conditions in Irish rivers and streams at the present time and represents the greatest single threat to the quality of lakes and rivers.

1.1.2 How do fertilisers affect the environment?

1.1.2.1 Effects on water

Nutrients in fertilisers, chiefly nitrogen, potassium and phosphorus, promote plant growth but, as stated, they can have harmful side effects. Dealing first with the effects on water, nutrients can enter water in three ways (Ribaudo *et al.*, 1999). Run-off, which is mainly rainwater, transports nutrients over the soil surface, and the nutrients may be dissolved or be part of eroding soil particles. Secondly, 'run-in' transports nutrients to groundwater. The third way is by leaching, which is the movement of nutrients through the soil caused by percolating rain.

Nitrogen, primarily found in the soil as nitrate (NO_3), is easily soluble and is transported in run-off and leachate. **Phosphate** is only moderately soluble and less mobile in soils but erosion can transport considerable amounts of sediment-adsorbed phosphate to surface waters (adsorbed phosphate is phosphate that is attached to sediment). Phosphate is primarily a problem in fresh water, and nitrogen is primarily a problem in brackish water.

Nitrogen and phosphate that are in excess of plant needs, the so-called 'residual' or 'surplus', are indicators of potential availability for run-off to surface water or leaching to groundwater. Actual contamination of water depends on the leaching characteristics of the land and soil and the type of rainfall. Manure is also a major source of contamination.

Point sources of a mainly non-agricultural nature, such as waste-water treatment plants and industrial plants, and septic tanks and non-point atmospheric pollution from burning of fossil fuels and from vehicles are other sources of nutrients that enter watercourses.

Phosphate from fertilisers is the main cause of eutrophication in Irish fresh waters. Of late, attention has also been drawn to cadmium from phosphate fertilisers. Cadmium can cause renal dysfunction in vulnerable people. It poses a potentially serious threat to soil quality and, through the food chain, to human health.

Before leaving the effects of fertiliser application on water, nitrogen application also affects water indirectly through its emissions to air of **ammonia** (NH_3). This is because ammonia deposition is another contributory cause of eutrophication and acidification in water.

1.1.2.2 Effects on air

Turning to the effects of fertiliser application on air, the acidification just mentioned starts through nitrogen releasing ammonia to air. These emissions can travel large distances. In addition to impacts on water through the deposition of ammonia outlined above, ammonia emissions returned to the earth's surface can also cause acidification of soils. The other main source of ammonia emissions is manure.

Another emission to air from nitrogen application is **nitrous oxide** (N_2O). Nitrous oxide is a greenhouse gas and it is implicated in climate change. It is produced by nitrogen application in agriculture, and emissions can be direct, or they can arise indirectly from leachate or run-off or else by passing through a volatised stage as ammonia that is deposited. There are other contributors to nitrous oxide emissions besides agriculture, these other contributors being transport and industrial processes.

1.1.2.3 Summary of effects

To summarise, we have seen that nitrogen in fertilisers is implicated three-fold in environmental damage: (i) in eutrophication of water, (ii) in acidification of soils and water, and (iii) in production of greenhouse gases that cause climate change. Phosphorus from application of fertilisers is implicated in eutrophication. Cadmium from phosphate fertilisers causes harm to soil and food, and thus to human health.[1]

1.1.3 Costs of damage

It is helpful to have an idea of the magnitude of the damage caused by fertilisers. As noted, the damage affects health and the environment but work on valuing the damage is belated and incomplete and sometimes it is not firmly based. Work undertaken mainly abroad on

1. Given some similarities between fertiliser taxes and taxes on pesticides, the contamination by pesticides is also noted. Pesticides move to water much as nutrients do, through run-off, run-in and leachate. In addition, however, they can be carried into the air, either attached to soil particles or as an aerosol (where the dispersion medium is air). Pesticides may damage recreational and commercial fisheries and may pose risks to health through food and drinking water. They can therefore impose extra costs on water treatment plants.

valuation methods and understanding of the need and importance are advancing at a pace unforeseen a decade ago.

Estimated costs for the UK, based on the study by Pretty *et al.* (2005), include the external costs that are imposed by many aspects of agriculture, of which fertilisers are but a part. In the absence of work relating to Ireland, we will look at these costs, summarised in Table 1.1 below.

The manner of estimation by Pretty *et al.* should be noted. Only those externalities that give rise to financial costs were included. Therefore, those harms that are not rectified, though people could be willing to pay to have rectified, if asked, are excluded leading to understatement of the damage. To the extent that some actual remediation could be higher than warranted by the benefits, there could also be some overstatement of damage. The types of costs used were:

1. The treatment or prevention costs (those incurred to clean up the environment and restore human health, to comply with legislation or to return these to an undamaged state), and

2. The administration and monitoring costs (those incurred by public authorities and agencies for monitoring environmental, food and health aspects).

The estimates therefore are not those derived from determining people's willingness to pay to avoid environmental degradation, which would probably be a more inclusive method. Rather, it is implicitly assumed that people are willing to pay for the standards that

Table 1.1. Annual external costs of modern agriculture in the UK (total costs and costs per hectare, 1996).

Cost category	Actual annual cost[1] Stg £	Alternative cost[2] Stg £
Water	**347**	**428**
Pesticides in water	143	
Nitrate, phosphate, soil and *Cryptosporidium* in water	112	
Eutrophication of surface water	79	
Monitoring of water systems and advice	13	
Atmosphere	**524**	**585**
Methane, nitrous oxide, ammonia emissions to atmosphere	421	
Direct and indirect carbon dioxide emissions to atmosphere	103	
Soil	**59**	**21**
Off-site soils erosion and organic matter losses from soils	59	
Biodiversity and landscape	**150**	**38**
Biodiversity and landscape values	150	
Human health	**434**	**Not available**
Adverse effects to human health from pesticides	1	
Adverse effects to human health from micro-organisms and BSE	433	
Totals	**1514**	**1072**
Summary		
Total costs per ha of arable land and grassland (11.26 M ha)	134	
Total costs per ha excluding micro-organisms and BSE	96	
Relevant costs per kg of pesticide active ingredient (22.5 M kg used)	8.6	

[1]*Source:* Adapted from Pretty *et al.* (2005)
[2]*Source:* Hartridge and Pearce (2001).

legislation and regulations require. One could infer that these costs are democratically arrived at and they have the advantage at least of being based on actual costs incurred. However, they may not reflect the values people would put on the external gains and losses if they could express their desires through a market. In keeping with the latter approach are the estimates made by Hartridge and Pearce (2001), also given in Table 1.1 in the final column of figures.

It is emphasised that there are many gaps in research to date on the external costs of modern agriculture. The important point to note from these preliminary investigations in the UK is that the scale of damage is significant.

As the summary statistics at the end of the table show the total estimated costs of damage caused by modern agriculture in the UK are sizeable, amounting to a figure in the region of Stg £100/ha if micro-organisms and BSE are excluded, which would be appropriate if one were to undertake the analysis for Ireland.

Some of the differences in valuations between the values given by Pretty *et al.* and those given by Hartridge and Pearce are explained in the latter study. As mentioned, the former's methodology is based on costs incurred in the form of restoration or reinstatement costs to return the environment to the original or prescribed state. The latter is based on willingness to pay to avoid or rectify the damage. More importantly, the latter study is also less comprehensive in its coverage and does not include effects on health.

In the above studies, it is difficult to single out the costs imposed by fertilisers from the costs imposed by other aspects of agriculture. The costs of damage to water, excluding that due to pesticides, are Stg £204 million. Hartridge and Pearce decline to put a figure on depreciation of water sources caused by discharges of nutrients on the grounds that calculations based on available data give excessively high results. However, they put water pollution incidents and depreciation to biological water quality alone at Stg £425 million.

There is also damage to air, where again it is not immediately possible to single out the part of the Stg £524 million costs that are due to fertilisers.

1.1.4 Damage in Ireland due to application of fertilisers

The costs of damage by fertiliser and pesticide application in Ireland have not been estimated. Such estimation would be a worthwhile exercise to help guide policy. Not only would it help to inform the level of taxes that ought to be imposed, but it would also throw light on the levels of regulation that are warranted. In the meantime, it is possible to give indications of a non-monetary kind by using information published by the EPA (Lucey *et al*., 1999; McGarrigle *et al.*, 2002) and the results of the Three Rivers Project (MCOS, 2000, 2003). This project was supported by the European Union Cohesion Fund and its objective was to develop catchment-based water quality monitoring and management systems for the Boyne, Liffey and Suir river catchments.

A starting point for a description of water quality is the long-term trend. For a long time the share of channel length of Irish rivers that is 'unpolluted' has been declining and the share of 'slightly' and 'moderately polluted' length has risen, though there has been a recent slight reversal of this trend. The problem of eutrophication was already being flagged in the seventies (Flanagan and Toner, 1972, 1975; Inland Fisheries Trust, 1973, 1974). On the positive side, the share of 'seriously polluted' length, a very small part, has steadily decreased. Also on the positive side, the latest assessment of the overall situation in 2000 shows a slight improvement in the quality of waters. These trends for a 2,900 km channel length are illustrated in Fig. 1.1. Classes A, B, C and D represent waters that are, respectively, unpolluted, slightly polluted, moderately polluted and seriously polluted.

Figure 1.1 only covers a 2,900 km baseline established in 1971, but similar trends are apparent in the larger, more representative, baseline of 13,200 km, which contains more of the cleaner and more remote rivers and streams.

The shares attributed to various causes have also been estimated, shown in Fig. 1.2. It is to be noted that the

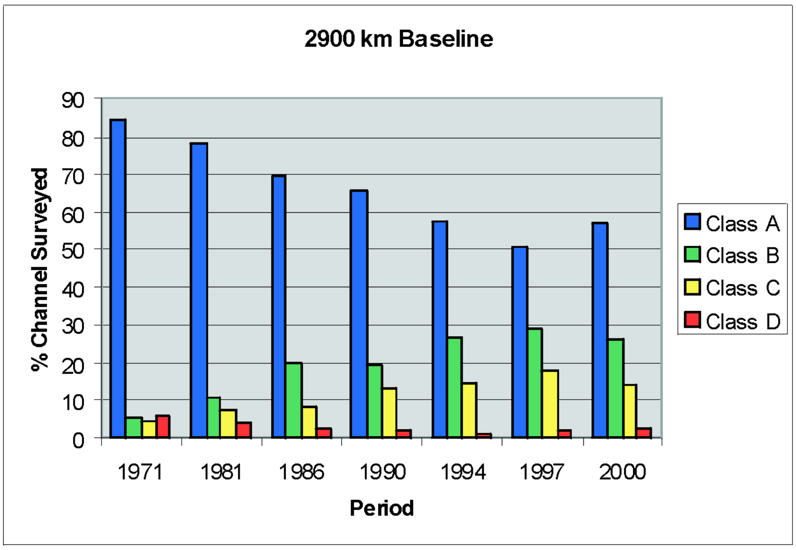

Figure 1.1. Long-term trends in water quality in rivers – percentage of channel length in four biological quality classes (A: unpolluted; B: slightly polluted; C: moderately polluted; D: seriously polluted).

Source: McGarrigle *et al.* (2002).

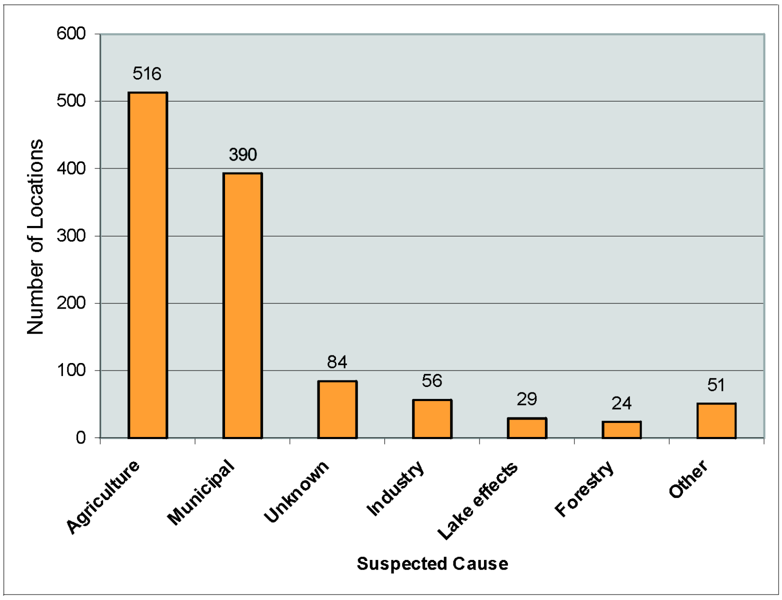

Figure 1.2. Suspected causes of slight and moderate pollution in rivers.

Source: McGarrigle *et al.* (2002).

causes are 'suspected' causes and where pollution by combinations of sources is suspected (e.g. sewage and agriculture) the sources have been apportioned equally to each source. The exact shares would be very difficult to gauge and then only in special circumstances.

As indicated in Fig. 1.2, agriculture is the dominant suspected cause of slight and moderate pollution and this has drawn attention to the importance of restraining application of fertilisers. The report of the Three Rivers Project gives the estimated total phosphorus emitted from each sector, following extensive monitoring and investigation over 3 years. Agriculture is deemed responsible for 58% of the phosphorus emitted to the Liffey, 63% of that emitted to the Boyne and 57% of that emitted to the Suir.

The chapter on eutrophication in the EPA’s report, *Ireland’s Environment 2004* (McGarrigle, 2004), describes how a number of recent agricultural catchment studies have been undertaken where automatic samplers are located at the end of catchments in which there are no towns or industries. These studies have yielded a range of figures for annual phosphorus loss from Irish grassland. The results are typically in the range of 0.5–4 kg P/ha. It is clear that, while large investments have been made in providing and upgrading waste-water treatment for municipalities, potential improvements cannot fully materialise if such diffuse pollution from agriculture is not addressed. The report notes that when it is considered that an input of 5 kg phosphorus can turn a 10-ha lake of average depth 5 metres noticeably cloudy due to increased algal growth, such losses that may appear to be agronomically insignificant can have major ecological effects (Gibson, 1997). The report goes on to explain that though farmyards used to be considered to be the source of most phosphorus losses, a growing body of research evidence demonstrates that much more phosphorus is lost from field sources. Between field and farmyard sources, some 70–80% came from fields according to two recent studies (Tunney *et al*., 2000; Jordan *et al*., 2004).

A figure for surplus phosphorus application amounting to 48,022 tonnes was calculated by Brogan *et al.* (2001), which meant a surplus of 10.8 kg P/ha of agricultural land. Other calculations are lower (Coulter *et al*., 2002). The long-term history of over-application of phosphorus has built up stores of phosphorus in soils. This could take decades to reduce and if action is not taken now, effectively it may prove to be impossible to prevent a long-term eutrophication problem in certain catchments and the “*current national phosphorus surplus and measured high loss rates in many catchments suggest that all our large lakes are under threat unless loss rates are substantially reduced*” (McGarrigle, 2004, page 214).

While phosphorus is the nutrient of concern in fresh waters in Ireland, nitrogen affects eutrophication in estuarine and sea water.

The diffuse nature of contamination by agriculture poses problems for monitoring and for policy. It is difficult to observe and measure what is causing the problems, and variability caused by the weather and site-specific features pose further hurdles. Therefore, monitoring of pollutants that do not emanate from a point source is currently difficult and expensive and, even where ambient water quality is being measured, the source of pollution, which could be natural or from far away, may not be correctly identified.

There is an alternative, second-best, approach. Having said that emissions are difficult to measure at farm level, it is possible, alternatively, to measure the surplus of nutrients that has been applied. This is done by totting up the inputs to the farm including those imported through feedstuffs and subtracting from them the amounts absorbed through products such as milk, meat and wheat. Such bookkeeping has become normal in some regions of Europe and arguably should become so where the environment is at risk. It forms the basis of some policies already in operation and offers scope for sensitive application of economic instruments, as we shall see.

The next section introduces the discussion of economic instruments by asking why do farmers naturally tend to apply surplus amounts of fertilisers. It will show that farmers are behaving in a rational way by responding as they do to the array of costs and incentives that they face at present. It is rational to over-apply fertilisers under present circumstances.

1.2 Theory – why is there a natural tendency to apply too much fertiliser?

In a world with no effective regulations or pollution charges, the farmer would perceive the price of using the environment’s assimilative capacity to be zero. The economic damages imposed on others by run-off and other emissions are ‘externalities’ as far as the farmer is concerned. External damage seems costless and the rational response on the part of the farmer is to apply fertilisers up to the point of maximum private gains including some coverage for uncertainty, and to engage in no abatement of the external damage.[2]

2. Leaving aside measures that are taken by the farmer to protect the health of family and other farm personnel, as well as the value of the farm.

As mentioned at the start, the farmer applies fertiliser because of the expected private benefit. Higher amounts of fertiliser can bring extra benefits per unit applied up to a point, but this extra benefit per unit declines with increased application. This declining benefit per unit of fertiliser is shown in Fig. 1.3, where the vertical axis represents benefits or costs in euro and the horizontal axis represents quantity of fertiliser applied. The declining benefit per unit of fertiliser is shown in the highly simplified marginal private benefit schedule labelled MPB.

The farmer incurs private costs in purchasing and applying fertiliser. Costs per unit of fertiliser applied are also likely to vary per unit, and the marginal private costs or MPC schedule is shown in Fig. 1.3 as rising with extra fertiliser application. Rational farmers will apply an amount represented by F, that is, they will apply up to the quantity where the benefit from an extra unit is equal to the cost of an extra unit, i.e. where MPB = MPC. If less were applied (on the left of F), the benefit from increasing fertiliser outweighs the cost, MPC is higher than MPB, and therefore the farmer will want to apply more. At higher quantities (to the right of F), the marginal cost exceeds the marginal benefit and the farmer will rein in the amount applied.

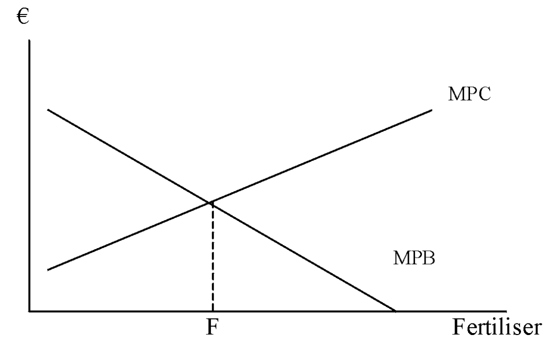

Figure 1.3. Marginal private benefit (MPB) and marginal private cost (MPC) of fertiliser application, and private optimal level of fertiliser application F.

The external costs of fertiliser application now have to be added to the picture. This is simply illustrated in Fig. 1.4 by adding these costs to the marginal private cost schedule. An additional cost representing the marginal external cost, or MEC, is added to the marginal private cost, giving the total cost from society's point of view. Taking account of society as a whole, the relevant cost MPC+MEC is at a higher level in the diagram than MPC. Low levels of fertiliser application are likely to cause little or no external damage but at higher levels of application the external damage per unit is likely to be higher. This is shown by the widening gap between the two schedules. The actual shapes of the schedules in real life would be more complicated. In reality it is 'excess' fertilisation that causes damage and not all fertiliser and this simplification is intended to illustrate the principles.

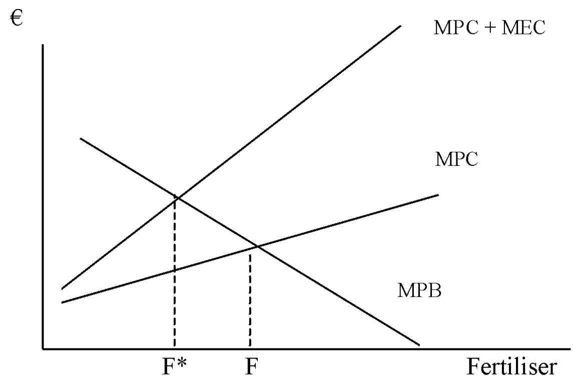

Figure 1.4. Marginal private benefit (MPB) and marginal private plus marginal external cost (MPC+MEC), and social optimal level of fertiliser application F*.

The important point to note is that the farmer's desired fertiliser application will tend to be at a higher quantity than that of society. The external costs imposed by fertiliser application do not enter the farmer's reckoning and the environment is providing a 'free sink' for excess fertilisers applied.

To sum up, the farmer would want to apply an amount of fertiliser represented by the larger quantity F. Society on the other hand, motivated by the same logic but taking also the external costs into account, has its optimum at the point where the new higher cost schedule MPC+MEC equals MPB. This is at a level of fertiliser application represented by F*. Movement in either direction from F* represents a departure from society's optimum. At a higher level of application the cost per extra unit exceeds its benefit. At a lower level of fertiliser application the benefit of an extra unit exceeds its cost and so more ought to be applied.

In fact, society's optimum may not involve quite such a large decrease in fertiliser application as implied by the discussion so far. An improvement in water quality is the ultimate aim and damage abatement by the farmer is therefore the objective, not merely reduced fertiliser application.

Abatement could be achieved by various means, including more careful fertiliser application based on acquired and calculated knowledge of ideal levels, altered timing, attention to spatial distribution and so forth. In addition, a higher level of abatement can be achieved by altering the mix of product and reducing levels of outputs. Abatement of two sorts is therefore possible in terms of 'how' and 'how much' fertilisers are to be applied, but both at a cost to the farmer whether real or perceived.

The possible cost of abatement on the part of the farmer includes the time and effort required in changing the 'how' fertilisers are applied, including keeping records of nutrient balances. In reducing the quantity, the cost to the farmer includes the reduced comfort from being less assured of good yields, and possibly changed mix and reduced output. Set against these costs are the savings on the fertiliser bill. In any event, reducing fertiliser use would be a move away from the farmer's currently perceived optimum.

One might argue that the situation is being taken care of by initiatives such as the Action Plan emanating from the Nitrate Directive and in the prescribed ammonia threshold, but this is unlikely to be the case unless the underlying pressures are adequately altered in the process. A report from the Netherlands Centre for Agriculture and Environment puts it succinctly: "*these policies are only partly effective and are difficult to police since they conflict with the price signals the farmer gets*" (Rougoor and van der Weijden, 2001).

If the incentives are not altered to move society to its optimum point, existing initiatives will be continuously straining to get farmers away from where they feel that they want to be, at their personal optimum. Costs to society diverge from private costs and farmers will have a natural tendency to apply fertilisers too liberally.

The next question is how to rectify the signals in order to make F* the farmer's preferred application level too. There are several policy instruments to hand to bring about reductions in fertiliser application to level F* and, more advantageous still, to encourage the sorts of abatement by careful fertiliser application just described. If the policies that are used do not address the underlying problem of incentives outlined here they will be operating at a disadvantage. A lot of public money can be spent with disappointing results.

1.3 Policies – economic instruments (taxes and tradeable quotas) and response

Given that there is a natural tendency to apply too much fertiliser, what are the means for removing it? A discussion of fertiliser taxes needs to be set in context. There are several approaches that are briefly outlined before proceeding to discuss economic instruments.

There are three generic types of approaches, though there are variations and important sub-categories as described by OXERA (2003) in a report to the Department of the Environment, Food and Rural Affairs in the UK (DEFRA, 2004). The three types are simplified under the headings:

- Regulation
- Education, and
- Economic instruments.

The wealth of application and experience with environmental policy of the last few decades has yielded many worthwhile combinations and variants, though their attributes still fall basically into the three original categories.

Imposition of regulations is an obvious approach to ensure that the correct practice or standard is adhered to and this is the method that is most applied. Provided that there is a means of ensuring compliance with the standard or practice, regulations are preferable to incentives when there is a specific goal or limit that must be met or when, say, a substance has to be banned. Examples of this would be the requirement of a specified distance from watercourses when pesticides are being sprayed and the mandatory requirement for farms to complete nutrient accounts, which apply in the Netherlands and Switzerland. Designated areas for protection are another example. A well-recognised difficulty with regulations stems from the diffuse nature of farm pollution, which makes monitoring and policing costly and hard to apply.

Voluntary agreements are also an option. Farmers participating in voluntary agreements, after negotiations, usually with a local authority, commit themselves to target reductions and standards. Depending on the level of sanction that can be called upon, voluntary agreements can resemble a more sensitive variety of regulations, especially if it is a threat of regulations or taxes that brings them about. Voluntary approaches can be easier to initiate, though they can also trigger significant administrative costs and their environmental effectiveness is questionable, according to a recent survey (OECD, 2003).

Education, the second approach, is now increasingly applied alongside participatory and institutional measures. If there are alternative practices that are better for the environment than current ones, then it is important for farmers to learn about them. Education is a fundamental tool and improved skills and knowledge are necessary whatever the other policies chosen, so that farmers understand the effects of their actions. Support for communication and learning amongst farmers can influence social bonds and norms and encourage voluntary transitions towards more sustainable practices. Institutional and participatory schemes can lead to local partnerships between farmers and local stakeholders and to joint management programmes, in aspects such as watershed/catchment management and integrated pest control.

There is the possibility of direct expenditure on clean-up by government, which is perhaps the option at the back of some people's minds. As this entails indiscriminate extra taxation that does not target polluters and as it does little to discourage continued pollution it could be viewed as a defeatist approach. In any case, it is hardly a feasible option where diffuse pollution is concerned. Water treatment for the removal of the effects of diffuse emissions on waters is not practicable except for example where clean-up for supplying drinking water is concerned. Direct expenditure on remediation is an option there. This has occurred in the past, where extra treatment was required to remove the effects of contamination from high sheep stockage levels, in order to ensure that water supplied met drinking water standards (ERM, 1997, p. 64) and extra treatment costs continue to arise today according to the report on the state of the environment (EPA, 2004). Except in such cases as water that is abstracted, treatment to remove agricultural emissions to rivers is impracticable.

1.3.1 Taxes

Economic instruments, by contrast, can be directed to address the underlying problem illustrated above. The issue is that the assimilative capacity of receiving waters is priced at zero, and that using it imposes costs on society but brings benefits to farmers. Leaving temporarily aside the scope for addressing the 'how' in terms of more sensitive fertiliser application, a tax on fertiliser can reduce the 'how much' and help move society to the desired point.

In order to correct the incentives so that an amount F* is applied, the tax that needs to be imposed is now illustrated in Fig. 1.5, which reproduces Fig. 1.4. The tax on each unit of fertiliser is shown here on the vertical axis as the distance $t_1 - t_0$. The farmer, now facing a cost per

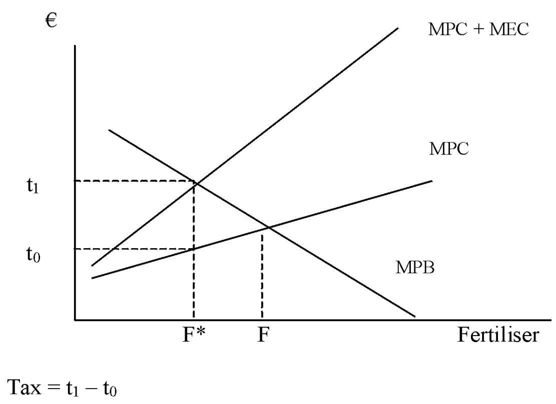

Figure 1.5. The social optimal level of fertiliser application F* and a fertiliser tax.

unit of fertiliser amounting to the MPC plus the tax, will want to apply fertiliser at society's optimum level F*. If the farmer applies more (to the right of F*), the cost per extra unit is higher than the marginal private benefit and so purchases would be reduced. At lower amounts than F* the private benefit per extra unit exceeds the total cost and so extra units of fertiliser are worth purchasing from the farmer's viewpoint. Thus, the farmer and society gravitate to society's desired level.

The advantage of the tax is that the external costs of fertilisation impinge on farmers and not just on the victims. If we now reintroduce the issue of the 'how' fertilisers are applied and if a tax could be designed to target this also, there is further scope for improvement. It is not just the quantity of fertiliser applied that matters but the excess over and above the needs of the farm's outputs and the manner of application. Pollution can be abated by a number of measures on the farmer's part and if a tax could somehow be moulded to encourage actual pollution abatement then environmental quality would be more easily achieved. We will later see, for example, an application of a tax on 'excess' nutrients and its results.

It is important to recognise that different farms are likely to face different marginal abatement costs, so that abatement will be cheap to some and expensive to others. Consultation, calculation, documentation and constraints on the manner of fertiliser application all involve costs to the farmer. Those facing higher management costs for one reason or another, perhaps because their time is under pressure or they risk losing high earning yields, would forego more private benefits from sensitive fertiliser application than other farmers. In economics terminology they would have higher marginal abatement costs than others. In dealing with the problem, society should aim for efficiency, that is, environmental quality at lowest cost. Regulating in a uniform way such that the polluters facing high abatement costs must undertake abatement is inefficient if there are low-cost abaters who can do more abatement for low cost. A carefully tailored tax, ideally on a river basin basis, could encourage farmers on average to gravitate to the point where their costs of abating are equal. Low-cost abaters will automatically undertake more abatement. This notion that the efficient solution is characterised by marginal abatement costs being equal is called the 'equi-marginal principle'.[3] A tax that aims to correct an environmental externality is called a Pigovian tax, named after the early twentieth century economist, Arthur C. Pigou (1962). A Pigovian tax constrains pollution in such a way that the equi-marginal principle is satisfied, since all farmers will want to operate where their marginal abatement costs are at the level of the tax.

Another advantage of the tax is that it encourages farmers to inform themselves about ways to reduce their emissions. It therefore encourages education, the other policy tool, and is complementary in operation. At issue is the manner in which the tax is implemented.

1.3.2 Manner of implementing pollution tax

Crucial to the success of any policy is its manner of implementation. Pollution taxes need to be directed at the policy's goals, but in the case of diffuse pollution these have to be carefully spelt out. There tend to be two sorts of taxes differentiated by their targets, called in the literature *Performance-Based Incentives* and *Design-Based Incentives*. A short discussion of each will be given before proceeding to describe more feasible taxes that are based on inputs and technology.

Looking at performance-based taxes first, logical targets for the pollution tax would be run-off from a field and ambient water quality conditions. Unfortunately, while these physical goals may be measurable in theory, it would be extremely difficult for farmers to judge the effects of their fertiliser application and, indeed, those of their neighbours, on ambient water quality. Simulation models can measure 'expected run-off', but widespread measuring of actual run-off is hard at present. Given this difficulty, Performance-Based Incentives are currently rare, though there will be a discussion later of the tax used in Florida under the Everglades Forever Act.

The alternative to targeting pollution taxes on the outcome is to target production methods, including use of

3. Equivalently, foregone marginal savings from polluting are equal. In some texts, the marginal abatement cost is called the polluter's 'marginal savings' from emitting, which is another way of looking at it. 'Savings' are made by the farmer in the sense that it is cheaper in terms of time and effort to apply excess fertiliser and not to engage in pollution-sensitive application (Perman *et al*., 1996).

inputs and technology and land-use decisions. Taxes that target the producer's use of variable inputs and production technology fall under the heading of Design-Based Incentives. Though 'second best', this may be optimal in some circumstances. Additional instruments could be used to encourage technology adoption, or exit from the activity altogether where altered practice is not feasible.

In order to be optimal, the incentive rate ought to be site specific and equal to the social cost of a marginal increase in pollution or excess nutrients from the site. But, even if site-specific incentives cannot be instituted, a uniform instrument for (let us say) the catchment provides incentives for farmers to reduce pollution at least cost. Therefore, the instrument is a cost-effective method of achieving a set of mean pollution levels. To be cost effective the uniform incentive rate should be set equal to the average of the expected marginal social costs created by pollution from each site.

Input-based instruments include fertiliser taxes and they are relatively simple to administer because they can be applied like an excise tax. Technology-based instruments, which can be 'lump sum' payments, are also relatively simple. They ought to be site specific but this again would have associated additional administrative and information costs. An efficient or cost-effective policy for controlling non-point pollution requires the authorities ideally to have perfect information about production and run-off functions, but it is possible to design second-best policies with limited information.

It is possible to levy fertiliser taxes in such a way that no tax is paid up to a specified small amount, a so-called free block. This can be one way of allowing for the fact that part of the nutrients applied on a farm are not surplus to the farm's requirements, because they are used in the production of products such as milk, meat and wheat. Bookkeeping of the amounts embodied in outputs can determine the warranted amount or else a simplified system can be operated by a simple reimbursement, based on hectares.

As mentioned, the efficiency of input-based taxes can be increased if additional instruments are used to encourage the adoption of suitable technology, including perhaps exit from the activity. For example, land consisting of poor soils, steep slopes or sandy soils overlying groundwater used for drinking water, or close to reservoirs could be identified as marginal in the sense that it would be difficult to reduce their potential damage to water quality. A land retirement scheme could be used. Co-ordinated policies would be the most promising.

1.3.3 Subsidies

Subsidies also come under the heading of economic instruments. Subsidies are more politically popular than taxes, unless they have disadvantages that are impossible to ignore. The Common Agricultural Policy's system of subsidising production is an example of where the costs have, after a long time, become recognised and there is more awareness that every subsidy has to be funded somehow. There is often pressure for subsidies to be introduced where the costs imposed on individual taxpayers are small and where taxpayers are unlikely to organise to form resistance.

Subsidies to pollution abatement have the disadvantage that they may allow farms to continue in operation that would not be in existence if they paid full costs, as would be the case in the presence of a pollution tax. They also fail to reward the pro-active farmers who had adopted environmental measures before the subsidy was put in place, and such farmers miss out on the relative advantage that they would have if a tax was in place. An expectation of subsidies delays abatement and the need for funds to finance subsidies effectively means that the victims are paying the polluter, rather than the polluter paying. Subsidies also involve administration costs and are not even free to the applicant when the time required to be spent on application is factored in. Low uptakes can be the result. For example, less than an eighth of budgeted funds were taken up in the 25% grant scheme for investments in Nitrate-Vulnerable Zones in the UK (ENDS Reports, 2000). This may reflect a perception on the part of potential beneficiaries, real or supposed, of high administrative costs and personnel time.

Taxes and subsidies can be designed to have similar environmental effects but they could have very different effects on farmers' incomes and on the revenue agency's budget. Taxes can reduce polluters' incomes while subsidies tend to increase their incomes. It is however possible to introduce taxes without much reduction in farm incomes, by providing some form of lump sum refund. Apart from a subsidy's requirement that it be funded, it also implicitly endorses society's payment for the polluter's 'right' to use the environment. A tax on the other hand implicitly assumes that society has the 'right to clean water' and that polluters should pay for pollution control.

1.3.4 Tradeable pollution allowances

The other major economic instrument is tradeable pollution allowances. These are also called permits or quotas. This approach involves creating a market on which pollution permits or allowances can be bought and sold. It has the same advantage as taxes in that it can exploit the benefits to be derived from encouraging cheaper control when pollution sources differ in their marginal costs of control. An advantage is that the method does not require that the resource management agency knows those costs. The market works as follows. Each farm is allocated permits defining the amount of pollution it may discharge or excess nutrients it is allowed. The sum of total permits for the watershed is decided on the basis of some policy goal. How these permits are allocated is worth describing as they can be allocated in a number of ways that have implications for wealth, though the final pollution outcome may be the same.

The permits can be auctioned or sold by the agency, or else they can be distributed free, on the basis of, say, pollution or excess nutrients in some base year. Requiring polluters to pay for the permits can be viewed as an assumption that society, rather than farmers, holds the right to the assimilative capacity of the environment. On the other hand, when permits are provided free of charge these initial property rights effectively reside with polluters. In this case, polluters who can reduce pollution and sell their permits may be able to make net gains. Once permits are allocated, polluters can emit up to the level that their permits allow. From an examination of their marginal costs of abatement those with cheap costs will decide to abate and sell the permits. The price of permits will emerge from the trading and will settle at the marginal cost of abatement. Those farms that buy permits do so because their abatement costs are higher than the permit price and they can then raise emissions by the amount specified in the permits bought. Polluters with lower abatement costs naturally reduce pollution by more than polluters with high abatement costs, so that total pollution control costs for the watershed as a whole are minimised.

There needs to be assurance that whatever is permitted, be it run-off or inputs, is adequately monitored and enforced, and this is the issue. Otherwise, there is no way of knowing whether sources are complying with their permit levels. Expected run-off is a feasible objective but monitoring and enforcement costs for a permit system based on expected run-off are likely to be high because simulation models have to be used, which in turn require knowledge of the farm's technology and the use of each relevant input. This is in addition to the need for producers to know how their production decisions affect expected run-off. Furthermore, the use of a simulation model of a process about which there is less than perfect understanding could invite refusal to participate. Consequently, a permit system based on inputs would be less problematic than a trade in expected run-off permits, though ring-fencing the permitted use of fertiliser within a catchment might not be without its own problems.

It is important for the smooth operation of tradeable emission rights that the costs associated with trading those permits be low. In the case of the system of tradeable emission rights in some schemes in the US, a great deal of paperwork is associated with every trade in rights. Transaction costs can be very high, according to a report on nitrogen control (van Zeijts, 1999). As a result, the number of trades can be disappointing. Unless permits are initially distributed by an auction or by sale then no revenue is forthcoming. This could be a disadvantage, relative to taxes, if compensation is desired to neutralise the administration costs and income effects of the scheme.

In general, if permits are allocated for free, income is effectively redistributed because permits are assets. "*If society cares about adverse changes in the distribution of income, there is a potentially strong case for using emissions taxes*". The problem need not arise if permits are auctioned and, as with emission taxes, the revenues are recycled through tax reductions (Parry, 2003, 2004).

1.3.5 Response to fertiliser taxes

Returning to taxes, the rationale for imposing taxes is that the rise in price will change behaviour for the better, but what is the evidence to support this? Responsiveness to price changes is measured in terms of the price elasticity of demand, which is the percentage change in quantity bought as a result of a 1% change in price. The response may in fact take some time to materialise fully if it entails changing habits, technology or knowledge, let alone 'getting round to it'. A time delay is likely, therefore, and until these changes have come about the response can be quite small.

Surveys of studies that have estimated price elasticities of demand for fertilisers are reported in several documents. There is some variation in estimates. A range from –0.1 to –0.5 is given in the survey reported in a study published by CLM (van Zeijts, 1999). The study also summarises the review of elasticities by Bäckman (1999), which largely endorses the range except for a few higher elasticities at –0.7 and some approaching –0.9. All being less than 1 in absolute terms, these magnitudes mean that responsiveness is 'inelastic'. The meaning of inelastic is that the response is proportionately less than, rather than more than, the price change. This does not mean that there is no response at all, which is sometimes the wrong interpretation given to the term. The range is similar to that for energy demand and it has not deterred a half a dozen or so countries of the EU from imposing carbon taxes on fuels with a view to reining in consumption. Furthermore, the measured elasticities tend to indicate the short-run response, as availability of data usually makes this easier to estimate. The procedure of assuming a modest price elasticity of –0.3 is followed here but the possibility that the long-run response may be higher ought not to be overlooked.

Another consideration is the effect of any fertiliser price rise or tax on the different sorts of emissions that the fertiliser gives rise to. What is the effect on P and N and then on the sub-components of these, such as on nitrate, ammonia and nitrous oxide? Three possible assumptions associated with a 10% reduction in fertiliser use are spelt out in the CLM study (giving no results for P, unfortunately for this study). These are:

1. That a 10% reduction in fertiliser use will result in a 20% decrease in surplus N which in turn results in all three kinds of emissions of N being reduced equally by 20%.

2. A 10% reduction in the use of inorganic nitrogenous fertiliser in the EU would reduce N_2O emissions from agriculture by 8% (based on a report by AEA Technology Environment, 1998).

3. The Intergovernmental Panel on Climate Change (IPCC) of the UN and others use a standard ratio that each kg reduction in fertiliser reduces N emissions by 0.0125 kg N_2O-N. Agricultural emissions of N_2O reduce by 3.7%.

In addition, energy is required in the production of N fertiliser, estimates of which range from 11 to 18 kWh (40–65 MJ) per kg N.

To summarise the picture on price elasticities, the short-run response to tax-induced price rises would not be large but neither would it be negligible. Two further considerations apply. One is the need to accompany reforms with education on how to apply nutrients so that they are scaled to the farm's requirements. Secondly, the benefits of any reductions include, in addition to reduced nutrient emissions to water, the reduced emissions from the manufacture of the nutrients in fertilisers and feedstuffs.

1.4 Conclusions on Part 1

This section has seen that the extent of the problem of excess nutrient application is serious, not so much by comparison with quality of waters elsewhere but in terms of what has happened to Irish waters. To give an indication, unless nutrient loss rates are substantially reduced, "*all our large lakes are under threat*" according to the EPA (2004). Damage to waters from nutrient applications in the course of producing farm output for sale is an externality. What is important is the fact that the natural tendency to apply excess nutrients could persist unless the signals are changed.

There are several policies from which to choose to reduce excess applications and encourage sensitive application, and these fall under the broad headings of regulations, education and economic instruments. There are numerous variants on these policies – an example would be voluntary agreements which are sometimes negotiated in the context of potential sanctions as a back-up if they fail. In this case, voluntary agreements would be close to being regulations. Education is generally a prerequisite for the success of any policy that is applied. Criteria against which policies should be judged are that they be correctly targeted, that understanding should improve, that information requirements are reasonable and helpful, that administration and enforcement costs are kept low and that incomes of farm families be protected. Policies should also be judged on whether they can be easily policed and are efficient or cost effective in protecting the environment. Economic instruments, and corrective taxes in particular, can score well on these criteria but it is evident that in practice a mix of policies is needed. These would ideally consist of the regulations that are essential, education to enhance farmers' skills and knowledge, and economic instruments with accompanying social measures as required.

Part 2 looks at analyses undertaken abroad and experience gained with economic instruments.

Part 2 Experience of Taxes Elsewhere

2.1 Introduction

In this section, attention turns to analyses and experience with tax policies abroad. Taxes are being used more widely to help bring about desired environmental outcomes. It is recognised that they allow people to use their own specialised knowledge about their operations and that the reform need not entail an increase in tax; rather, it can simply be a shift from one sort of tax to another. Examples of taxes that have been introduced include carbon and energy taxes variously applied in half a dozen or so EU countries, CFC taxes applied in Denmark and in the USA, nitrous oxide charges in France, Italy and Sweden, leaded and unleaded petrol differentials in all EU countries, and a landfill tax in the UK.

Taxes applied to agriculture are, however, less usual. Fertiliser taxes have been applied in Austria (1986–1994) and Finland (1976–1994) and currently apply in the Netherlands, Sweden and again in several States of the USA. Manure charges are applied in Belgium and the Netherlands (European Commission, 2003). Pesticide taxes are applied in Belgium, Denmark, Finland, Sweden and several States of the USA.

This is a rich source of experience, and information relating to application of fertiliser taxes in these countries will be summarised. There is one recent example that is particularly relevant and this is the levy on surplus nutrients introduced in the Netherlands at the beginning of 1998. As this levy is the closest policy to a correctly targeted tax it will be discussed in some detail. In addition, several analyses of fertiliser taxes will be described.

2.2 Analyses of Fertiliser Taxes

A fair number of studies of economic instruments to tackle diffuse pollution from agriculture have been undertaken but two analyses in particular will be described here. They are both on nitrogen control. One is the extensive study called *Economic Instruments for Nitrogen Control in European Agriculture,* funded by DGXII of the European Commission and carried out by six European research institutes in the Netherlands, Germany, Italy, Finland and Hungary (van Zeijts, 1999). This report is the first co-ordinated approach to studying nitrogen control at European level. It is comprehensive and took on board most of the research previously undertaken on the topic. The other study, undertaken by CLM, the institute in the Netherlands that participated in the above report, is called *Towards a European Levy on Nitrogen – a New Policy Tool for Reducing Eutrophication, Acidification and Climate Change,* and it follows up its analysis with a proposal for a reimbursable levy (Rougoor and van der Weijden, 2001).

In the first study, nine different economic instruments were examined. These were:

Three levy systems on:

(1) N in chemical fertiliser

(2) N in chemical fertiliser and in feed concentrates

(3) N surplus for each farm

Three tradeable permit systems on:

(4) N in chemical fertiliser

(5) N in chemical fertiliser and in feed concentrates

(6) N surplus for each farm

Three payment systems, consisting of:

(7) subsidies on single measures

(8) subsidies for packages of measures

(9) and premiums for low nitrogen surplus.

These economic instruments were judged against a number of criteria. The most important criteria were:

- the effectiveness in reducing nitrogen emissions
- the income effects on farms
- the administration and control costs
- equity and fairness, and finally
- compatibility with other policies.

The first two criteria, namely effectiveness and income effects, receive most attention and the evidence collected was that derived from previous modelling studies, from existing empirical findings and from modelling carried out in the course of the study.

It is the *levy systems* that are of most relevance to this paper and in this summary we focus mainly on them. Subjected to the levies would be fertiliser importers, producers and traders, depending on the coverage of the levy. A similar regime would apply if nitrogen in feed concentrates were also subject to the levy. A levy on the nitrogen surplus would be calculated for each farm on the basis of the farm's nitrogen balance. The calculation would include the inputs of fertiliser, manure, purchased feed, estimated nitrogen fixation by leguminous crops and deposition of airborne nitrogen, and then the nitrogen that 'goes out of the farm' in crop and animal products. The levy could be specified to allow each farm to have a 'free block', that is, a small amount of surplus N that is free of the levy.

The environmental effects, as derived from a review of the literature, from empirical evidence and from their own modelling, suggest that levies can bring about significant results. A fertiliser levy of 50% of the price of N in chemical fertiliser reduces fertiliser use by 9–23% with reductions in nitrogen surpluses of 10–15%. The higher the levy the lower the extra environmental benefits, owing to decreasing price elasticity. A combined levy on nitrogen inputs in both fertiliser and feed does not generate better results because land is used more intensively to enable feed purchases to be reduced. The levy on surplus N had similar environmental effects as the fertiliser levy and is more appropriate for fine-tuning and solving local and regional problems. Regional variation in levy-free thresholds and tax levels makes the levy on surplus N a more sensitive instrument.

Farms that have more adjustment options, such as intensive farms, farms that can substitute organic fertiliser for chemical fertiliser and mixed farms, tend to react more to the levy. Only relatively high levies stimulate drastic adjustments such as changes in crop choice. The reaction is enhanced when the farmer has information and skills to help with adjustments.

The effects on income, according to the authors, are ambiguous. The effects depend on the extent to which farmers' current application is inflated by an allowance for risk. They also depend on the substitution possibilities, as already mentioned. Those that can substitute organic manure or can grow leguminous crops have more options. Pure arable farms and areas that have high inputs, such as prevail in the Netherlands, Belgium and the Italian Po Valley, suffer the most. Overall, the model calculations indicate an income loss of roughly 1–7% under the 50% levy. However, this is not allowing for the re-spending of the revenues. Reimbursement can apparently reduce or eliminate possible negative effects on farm income. In the case where it is the surplus N that is levied, income losses can be reduced considerably by including an allowable surplus.

Turning briefly to the findings on *permit systems*, which cap total emissions, the effect on nitrogen pollution depended on whether or not permits were tradeable. Applied over large areas with regional differences, tradeable permits could result in varied levels of reductions and in local concentrations of emissions. As for the effects on income, free or 'grandfathered' permits are comparable to the levies with full reimbursement. Tradeable permits lead to less income reduction than non-tradeable permits, except that the transaction costs of trading can be high. Variations according to farmers' intensiveness of land use and substitution possibilities also apply.

The third policy of *subsidies* can be cost effective if a large group of farmers is able and willing to participate, the study found. An example would be a subsidy for manure storage capacity. The success of subsidies to management measures, as opposed to investment measures, depends on behaviour and can be difficult to administer. Subsidies on packages of measures can be better still, but the number of participating farms is sometimes rather low. Examples of where uptake was modest are the subsidies under the UK scheme for Nitrate-Sensitive Areas, and for organic farming. An example of a premium based on results in Dutch water protection areas had encouraging environmental outcomes, with surplus reductions of about 20% in

2 years. The income effects are highly dependent on other factors.

The second study discussed here called *Towards a European Levy on Nitrogen* looked specifically at a levy and made suggestions for implementation (Rougoor and van der Weijden, 2001). The authors took stock of lessons learned from the experiences with a levy on nitrogen in fertilisers in Austria, Sweden and Finland. The rates had ranged between 10 and 72% of the price of fertiliser and price elasticities were found to lie between –0.1 and –0.5. They also undertook various prior model calculations to estimate the effect of a levy on N use.

Their conclusion was that a European nitrogen levy on fertiliser and feedstuffs should be imposed on the producing industries and on imports. A 100% levy on the N content in fertiliser (i.e. not on the total fertiliser) would result in at least a 10% reduction in the use of fertiliser N and a 20% reduction in N surplus. Emissions from agriculture of NO_3 and of NH_3 would drop by between 10 and 20% and of N_2O would drop by 3.7–20%. That is to say, emissions contributing to eutrophication and acidification and, to a minor extent, emissions of greenhouse gases would be reduced.

To alleviate adverse income effects, they suggested that the simplest solution is for revenues to be redistributed as a flat rate based on land area. Though farms with high livestock density would lose out, they do have the option of replacing fertiliser with manure. Extensive farms would benefit from the reimbursement according to land area, and organic farms would benefit most. These are additional favourable attributes of the proposal.

The authors pointed out that a levy applied to the surplus of N, rather than to the total of N, would have advantages, though it could be slower to implement and requires adequate bookkeeping on the part of farmers.

A noteworthy point to emerge from their study is the paucity of up-to-date data on fertiliser N use in Europe. In trying to construct a table of fertiliser N use in Europe, the authors had to resort to figures dating back as far as 1990 on which to base their estimates. It may come as a surprise to find that such an important substance should be so hard to track.[4] Up-to-date data are sometimes more likely to be available if the item is subject to tax, the recorded revenue enabling one to calculate the tax base, and this can be a useful by-product of taxes.

2.3 Experience of a Levy on Surplus Nutrients in the Netherlands – MINAS

Meanwhile, a levy applied to surpluses was introduced in the Netherlands. Levies on nitrogen (N) and phosphate (P_2O_5) surpluses above a ‘levy-free allowance’ per hectare were imposed from the beginning of 1998 for the agricultural sector. The description of the levy given here draws on the study for the European Commission (2003) and papers by Bos *et al.* (2003) and van Eerdt *et al.* (2004). The levy system is called MINAS, which stands for MINeral Accounting System, and it operates nationally.

The goal of MINAS is to reduce mineral surpluses and to increase mineral efficiency, in support of the objectives underlying the Nitrates Directive (91/676/EEC), the entire country having been classified as vulnerable. This means that agricultural production contributes to drinking water problems in the whole country, causing waters to exceed the limit of 50 mg nitrates/l.

Under MINAS, farmers keep records of flows of nitrogen (N) and phosphate (P_2O_5) entering the farm in feed, chemical fertiliser, seeds and plant material, animals and manure. They also keep records of flows leaving the farm in animals, animal products, plant products and, again, manure. A balance at farm level can thus be set up and the surplus of N and P_2O_5 can be calculated by subtracting the outputs per hectare from the inputs per hectare. Not all inputs are included in the calculation: the N that is ‘fixed’ or absorbed from the atmosphere by leguminous crops and deposition from the atmosphere are not incorporated, as they would be in an ideal ‘agronomic balance’.

Table 2.1 shows the items for which nitrogen and phosphate are estimated that would be included in an ideal agronomic balance and, in the final two columns, the items for which nitrogen and phosphate are actually estimated under the MINAS system.

4. For Ireland, this information is readily available from the Department of Agriculture, the Central Statistics Office and from the EPA (2002).

Table 2.1. Inputs and outputs accounted for in MINAS, ideal and actual.

		Ideal agronomic balance		MINAS balance	
		N	**P**	**N**	**P**
(1) Inputs to farms					
	Organic manure	X	X	X	X
	Mineral fertiliser	X	X	X	X[4]
	Seeds, plant material	X	X	X	X
	Feeds	X	X	X	X
	Animals	X	X	X	X
	Biological fixation	X		X[1]	
	Deposition	X	X		
	Net mineralisation	X	X		
(2) Outputs leaving farms					
	Organic manure	X	X	X	X
	Animal products	X	X	X	X
	Crop produce	X	X	X[2]	X[2]
(3) Losses	NH_3 stables and manure storage			X[3]	
Surplus		(1)–(2)	(1)–(2)	(1)–(2)–(3)	(1)–(2)

Source: Bos *et al.* (2003).

[1]Excluding N fixation by clover in grass–clover mixtures. Default values are used for leguminous, arable and horticulture crops.

[2]Default values are used for arable crops intended for human consumption (165 kg N and 28 kg P/ha). For fodder crops, default nutrient contents are used, that, multiplied with actual quantities sold, yield total nutrients leaving the farm.

[3]'Unavoidable' gaseous N loss from stables and manure storage facilities. The value of this term is a function of animal type and animal number.

[4] Intended but not included.

The levy-free allowance was set for the succeeding 5 years and became more stringent by reducing over time. For any surplus above this levy-free surplus, the farmer paid a levy per kg. Table 2.2 shows the amount of levy-free surplus nutrients and the tax rates applied to the amount of surplus above this.

The table shows a significant tightening up of the system over the period, with the levy-free surpluses declining, and the rates of levy increasing steeply, especially in the case of phosphate. Initially, application was partial, with only livestock farms having more than 2.5 livestock units per hectare and pigs and poultry farms required to take part. The levy has applied to all farm holdings since 2002. It is the government that takes final decisions on implementation of MINAS and on exemptions.

MINAS was applied in conjunction with other policies (such as a manure contract system), some of which have been phased out. The introduction of MINAS had the advantage that it makes it attractive to farmers to use manure in such a way that N efficiency is optimal, so it helps with compliance with these policies. In focusing on nutrient surplus, MINAS automatically provides the stimulus to explore all routes to reduce surpluses, including the careful selection of feed.

2.3.1 Initial reports on MINAS

MINAS was introduced in 1998 and, as we shall see, it is due to be abandoned but, as a unique application of a well-targeted economic instrument, it is worth looking at its results. It is still early days to foretell the results completely because its effects on management, structure, education and so forth need time to work through. An analysis of MINAS was undertaken by Ondersteijn (2002) based on data on specialised dairy farms over the 3 years 1997–1999, which cover the introduction of the system.

Table 2.2. Rates of levy applied to nitrogen and phosphate surpluses in the Netherlands (€/kg), and levy-free surpluses (kg/ha).

Year	Levy-free surplus, kg/ha				Rate of levy, €/kg	
	Nitrogen		Phosphate		Nitrogen	Phosphate
	Grassland	Arable land				
1998–1999	300	175	40		0.7	1.1
2000	250	125	35		0.7	2.3
2002	220	110	30		0.7	2.2
			Grassland	**Arable**		
2003 ***(clay and peat)***	180	100	20	25	2.3	9.1
2003 (sandy soils)	140	60	20	25	2.3	9.1

Sources: European Commission (2003), Bos *et al*. (2003).
Conversions: 1 g crude protein (CP) = 6.25 g nitrogen (N).
1 g phosphorus (P) = 2.29 g phosphate (P_2O_5).

Participating farmers received technical and managerial support from consultants, laboratories and research institutes. As Ondersteijn points out, the levies can be severe if the farmer has high nutrient surpluses. In the first and second year of operation, 38% and 49%, respectively, of the MINAS balances that had been checked relating to specialised dairy farms had to pay a levy. For extensive dairy farms, namely those with less that 2.5 livestock units per hectare, the levies worked out on average at €2340 and €2020 for the respective 2 years. For dairy farms with 2.5 or more livestock units per hectare, an average of €1820 and €1840 was paid by those who were levied. Strikingly, the less intensive dairy farms ended up paying a higher levy.

The surpluses are subject to large variation and Ondersteijn notes that differences are attributed to management factors such as grazing, feeding and fertilising. Reducing surpluses is therefore assumed to be most effectively achieved through an improvement in management. Ondersteijn uses the farm data to check the contributions of farm management as opposed to farm structure to nutrient surplus, and also the effect of changes in these on farmers' gross margins. The variables he uses in the analysis for 'farm structure' include farm size (in Dutch size units), the proportion of land with marketable crops, the N factor (N production in manure by livestock per hectare), farm intensity (milk production per hectare), milk production capacity of the herd and the share of grassland in fodder crops. The choice of 'farm management' variables is based on the four main tactical management areas[5] and a measure of operational management (measured by the difference between actual and standard feed purchases). The study shows that farm structure (such as intensity, marketable crop and fodder crop shares of land) was indeed far less important than farm management in explaining N surplus.

Of the farm structures that influence N surplus, Ondersteijn finds the most important to be farm intensity (effectively milk quota per hectare) and, working in the opposite direction, milk production per cow. Of the farm management variables, nitrogen use in fertiliser is the main contributor to high surpluses. For each kg of N in fertiliser per hectare, the surplus N increases by between 0.76 and 0.84 per hectare. Similar determinants are found to explain phosphate surpluses. An exception on the structure side is that a higher grassland share reduces the phosphate surplus. On the management side, the two important influences are the use of P in fertiliser and the net amount of P imported to the farm in manure. Of interest is Ondersteijn's conclusion that reducing nutrient surpluses will therefore be more effective if farmers try to optimise nutrient management rather than change farm structure. As for farmers' gross margins, improved operational management will reduce the nutrient

5. These were heifer management, grazing management, fertilisation, and feeding management and purchases. Heifer management is measured as the number of Livestock Units of young stock kept per 10 cows. Grazing management is measured in terms of Livestock Unit grazing days per hectare of grassland. Fertilisation is characterised by amount and by whether chemical or organic. Feeding management is measured by the amount and composition in terms of N and P content.

surpluses and at the same time increase the financial returns.

The main farmer characteristic that Ondersteijn found to be important in explaining improvements in environmental management was education. Better-educated farmers chose to increase the intensity of their farming system, and cope with the corresponding increase in environmental pressure by improving the production capacity of the herd and improving operational management. The indications were that environmental improvements can be achieved regardless of the way a farmer chooses to develop the farm. The implication drawn by Ondersteijn is that forcing farmers to work in a particular manner by constraints or obligatory measures might not be as effective as leaving them freedom to change in the way that they choose for themselves. Policies with a results-oriented focus, such as MINAS, are more effective.

2.3.2 Administration costs and development of MINAS

The MINAS tax on surplus nutrients entails sizeable administrative costs in both collection and payment. On the collection side of MINAS, there are costs incurred by the new Levies Bureau and General Inspection Service (AID), amounting to €24.2 million. (It should be said that MINAS in fact costs only €11.3 million over and above the costs incurred by the previous system that was in place in 1996 to deal with manure.)

On the part of the farmer, the administration costs include the time needed to set up a system to itemise inputs and outputs and derive a nutrient balance, and the services of an accountant to check the figures; the latter is put at between €113 and €227 per farm per year for the MINAS system (European Commission, 2003). When the farmer's own time is added in, we saw that total administration costs incurred by the farm were reported by the European Commission study (2003) to lie between €220 and €580 per farm per year and can be compared with a straight levy system on fertiliser and feed which it is estimated would have cost but €9 per farm. The straight levy would have encouraged the use of substitute manure, which is to be desired though without care it too can be a cause of pollution. The trade-off between good targeting and cost is stark. These figures exaggerate the costs, because again they are not necessarily extra costs. If farmers are likely to have to calculate the nutrient inputs per hectare in any case under new regulations and if those exceeding the specified limit (210 kg N/ha declining to 170 kg N/ha after 4 years) will be required to undertake nutrient management planning, extra administration resources will already be required.

Analysts commenting on the administrative burden note the fact that much of the administration is in fact caused by the additional systems that deal with manure (Westhoek, 2002, H. Westhoek, personal communication, 11–12 August 2003). One is the manure contracting system which obliges farmers to have contracts to deal with their livestock's manure. The other is the tradeable manure production rights system (MAO). By contrast, the MINAS system for a dairy farm is quite simple. In addition, in the revenue bureau it is linked to the income tax system which provides the possibility of important counterchecks. The farmer's income tax is based on revenues less costs, which the farmer has an interest in reporting as a low net figure. This implies low farm revenues (low exports of nutrients) and high costs (high purchases of fertilisers and concentrates). By contrast, under MINAS, the farmer has an interest in showing the opposite, namely high exports and low inputs. Good reporting is thereby encouraged. The comparisons are not routinely checked by government except in cases of doubt, though the accountants helping farmers will frequently cross-check.

The MINAS surplus thresholds were due to be tightened in 2003. Farmers who did not alter their nutrient management could face large fines, which Ondersteijn estimated would reduce their gross margin by 8% on average and could threaten the continuation of some farmers. He noted that relative to the best farms in his sample, farmers could in principle achieve the same output with 20% less nutrient surpluses. Farmers had improved nutrient productivity by 60% per year on average over the 1997–1999 period and these improvements were positively related to improvements in financial results in the period under study. The most effective way to start reducing nutrient surpluses on dairy farms was to focus on nutrient management within the current farming system. If the farm still exceeded the threshold, a milk-oriented breeding programme could increase milk production per cow, and consequently reduce herd size. If that was not sufficient, a reduction in farm intensity or disposal of manure were options, though returns per hectare would decrease with reduced intensity. Ondersteijn was critical of the new Manure Transfer Agreement System (MTAS), introduced on foot of objections about MINAS from the European Commission regarding the absence of regulations on manure application, required in the Nitrate Directive. Due to the introduction of the MTAS, he claimed that the costs of manure disposal have risen.

The positive features and outcomes of MINAS had led to recommendations from the Dutch government and independent Dutch environmental NGOs that a derogation be allowed on certain provisions of the Nitrates Directive. The NGOs in question consist of the Netherlands Society for Nature and Environment, the Clearwater Foundation, and the Centre for Agriculture and Environment Foundation.

The NGOs' grounds for seeking a derogation were that the "*Commission must be tough on goals, but flexible on means*" and that the MINAS system has two major advantages:

1. It focused not just on input of nutrients, but on the balance of input minus output, which is what really matters for the environment.

2. It included not just animal manure but also N fertiliser and other N nutrients.

The NGOs pointed to the fact that MINAS was effective, judging from the decline in nitrate concentrations in groundwater in many areas and the results of several pilot projects across the country. They granted that the MINAS system still had shortcomings. They argued that some inputs of N and P were still ignored in the reckoning and standards were not strict enough to realise the goals of the Directive for groundwater. Their recommendations were:

1. Stricter MINAS standards for N surpluses per hectare, specified by soil type.

2. In the medium term, a stepwise tightening of the MINAS standards for P surpluses per hectare to well below 20 kg/ha, specified by soil type.

3. The inclusion of three additional kinds of N input in MINAS, namely, N from clover in grassland, N from mineralisation in peat soils and N from air deposition.

4. The inclusion of P fertiliser.

The thrust of their approach is that MINAS should be improved and tightened to levels which, based on sound scientific research, are sufficient to realise the goals of the Nitrates Directive.

Revenues under MINAS go to central government and are not earmarked, though apparently expenditure on other manure policies is partly influenced by the magnitude of the revenues received.

2.3.3 Environmental effects of MINAS

As to the environmental effects, previous studies of anticipated effects of MINAS had the difficulty that no measures of the specific price elasticities required were available. The price elasticities of demand that have been calculated to date relate to demand for fertiliser *per se*, and not to *surplus* nutrients.

Recent indications are that improvements in nitrogen surpluses are evident, part of which are attributable to MINAS. Figure 2.1 shows trends in nitrogen surpluses from 1986 to 2002. From 1990 until 1996 the surpluses showed no signs of improvement except in the areas of dry sand (RIVM, 2003). The chart shows that with the introduction of MINAS in 1998, surpluses have declined in a consistent fashion. The reason for saying that part of the improvement is attributable to MINAS is that the policy was not introduced on its own but alongside a support programme.

More important than the surpluses is the actual quality of waters. The aim of the reduction in nitrogen surpluses is an improvement in water quality and progress in attaining the European nitrate standard of 50 mg/l. Preliminary results of analyses of groundwater under three types of soil are given in Fig. 2.2, from Fraters *et al.* (2004) of RIVM.

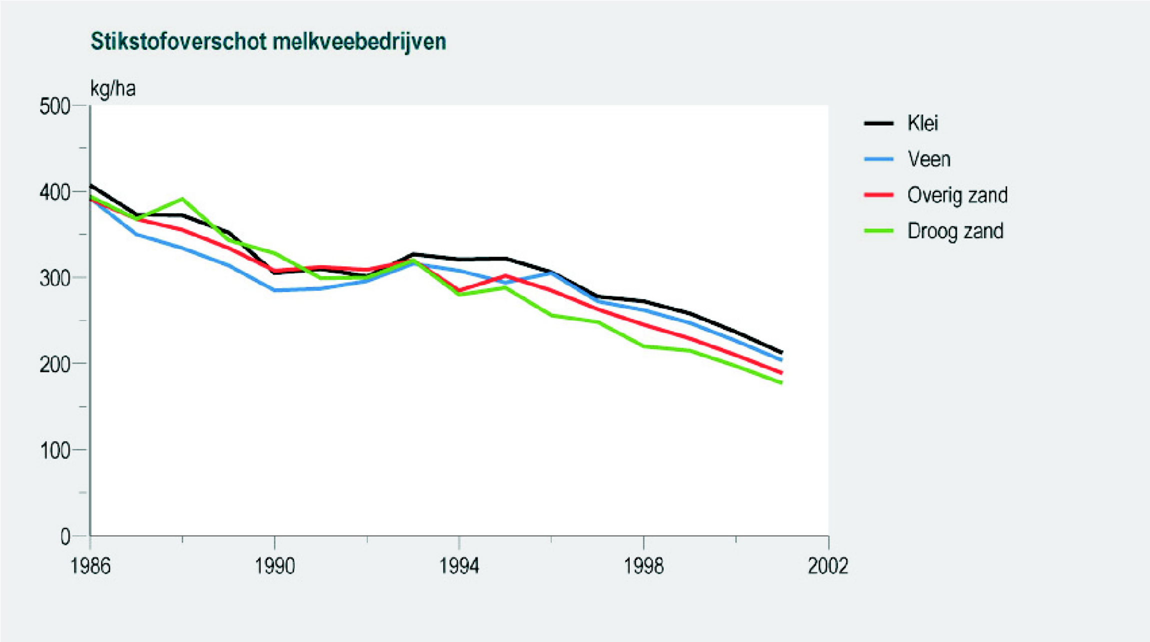

Figure 2.1. Nitrogen surpluses of dairy farms on four types of soil (MINAS definition). Klei, clay; Veen, peat; Overig zand, other sand; Droog zand, dry sand.

Source: RIVM (2003) Environmental Balance, p. 82

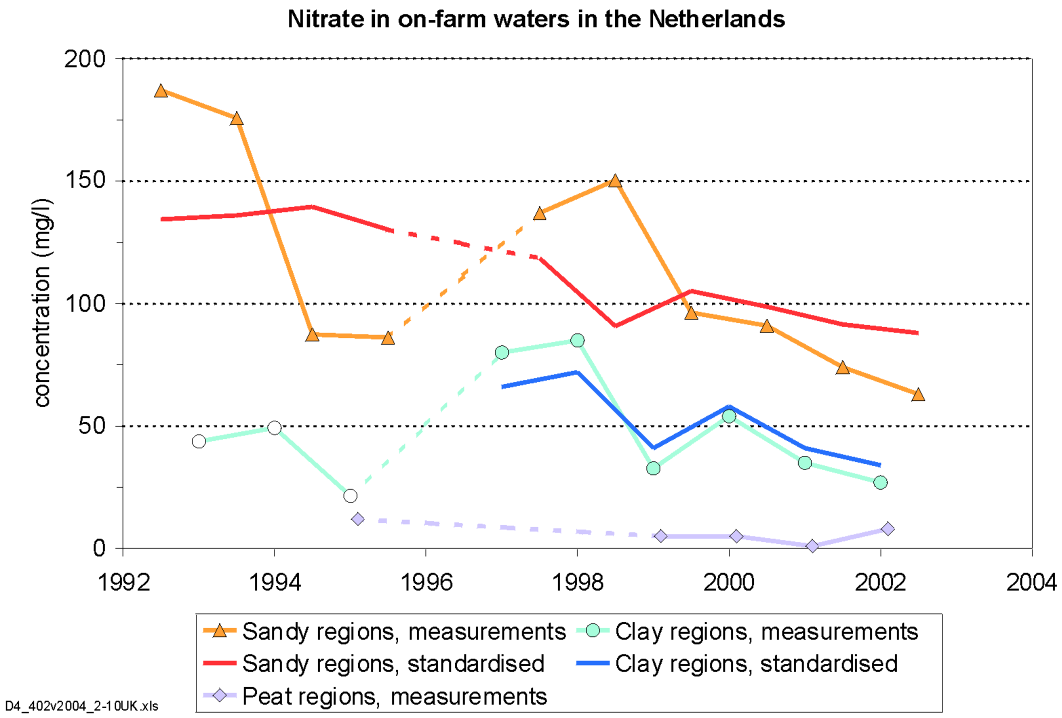

Figure 2.2. Quality of groundwater, measured and standardised nitrate concentrations.

Source: Fraters *et al.* (2004).

It is evident that there was a substantial improvement in nitrate concentrations in sandy regions with the standardised levels showing a remarkable decline from about 135 mg/l before the operation of MINAS to about 95 mg/l in the last 4 years. No clear trend is discernible on farms in the clay and peat regions, nitrate concentrations in the latter being insignificant in any case. The large variations that can be seen were mainly due to differences in precipitation, which affect the dilution and depth of the groundwater table (a rise in the latter leads to increased de-nitrification). Variations were also due to changes in the composition of farms being monitored and, in cases where land exchanges had taken place, to changes in the share of the soil type into which the farm had been classified. The limited run of data on standardised nitrate concentrations in clay regions shows a steady decrease in nitrate concentration in recent years.

These improvements are reflected in Table 2.3 that gives the changes in percentages of farms meeting the standard, that is, the percentages of farms with nitrate concentrations in waters of 50 mg/l or below. Percentages relate first to upper groundwater in farms in sandy areas and secondly to drainage waters in farms in clay areas. There is much improvement still to be made but the trend for the dairy sector on sandy soils in particular is encouraging as this is where the nitrate problem is worst.

Further environmental results are reported. A distinct relation has been found between the nitrogen losses under MINAS from dairy farms with sandy soils and the groundwater nitrate concentration (van Eerdt *et al.*, 2004).

Turning now to phosphorus, which was not the main target in MINAS, the concentrations of phosphorus in surface water have not decreased at all, and the ecological status of ditches and brooks remains poor. Although the agricultural sector managed to bring down the phosphorus surpluses by 30% since 1997, soils are still accumulating phosphorus, and leaching of phosphorus did not decrease. This points to the difficulties associated with phosphorus build-up and expected delays before improvements materialise in any event.

2.3.4 MINAS to be abandoned

In October 2003, the end of the MINAS system was sounded. The European Court of Justice rejected the application of MINAS as a means of implementing the Nitrates Directive. The major reasons for the Court's rejection were:

1. The Directive requires clear limits on the amount of nitrogen fertilisers applied to land. By contrast, MINAS does not set such limits but imposes levies on farmers' surplus nitrogen.

2. The Netherlands had not established rules clearly limiting the quantities of manure spread on land to the maximum of 170 kg/ha set in the Directive.

3. The Netherlands had not adopted binding laws or regulations as regards storage capacity for livestock manure on farms as required in the Directive. The Directive only allows authorisation of certain farms to depart from the minimum, on a case-by-case basis, to the extent that it is demonstrated that the livestock manure which cannot be stored on the farm will be disposed of in a manner which will not

Table 2.3. Percentage of farms with nitrate concentrations of 50 mg/l or less.

	1992–1995	1997–1999	2000–2002
Sandy areas	Upper groundwaters		
Arable farms	10%	30%	30%
Dairy farms	5%	25%	40%
Other farms	–	10%	20%
Clay areas	Drainage waters		
Arable farms	–	55%	60%
Dairy farms	–	70%	75%

Source: van Eerdt *et al*. (2004); RIVM (2004).

cause harm to the environment.

4. The Directive requires use standards to be fixed so that Member States may lay down in advance that the amount of livestock manure applied to land is not to exceed the amount allowed per hectare.

The Netherlands government have decided to abandon MINAS and replace it with N and P application standards in 2006 and penalties for non-compliance. Under the new system, only farms where the environmental risks are high will have to register and be inspected in relation to their nutrient balances which they will still have to report on. Extensive farmers, though not then required to send in the farm's registrations of nutrients, will still have to undertake the bookkeeping on their farms in order to prove that the farm complies with the standard. The administration will have less registrations to deal with, though compliance may need more supervision without the hidden hand of the tax incentive. A problem with MINAS was the large number of legal cases brought by farmers who opposed the rules. The new system will target those farmers who cause serious environmental problems, perhaps reducing the number of legal actions.

The implementation of MINAS during its 8 years of existence since 1998 as a tax on surplus nutrients, will have provided an experiment capable of analysis and comparison with other methods of environmental protection. It would have been preferable if MINAS had been allowed to operate for a longer period in order for its full effects to become evident, mindful that pollutants with stock effects, such as phosphorus, take time to dissipate. On the basis of the 6 years available for analysis, it has already performed the role of an interesting and valuable exercise. The verdict on its short period of operation to date is that the environmental objectives for nitrogen and phosphates in waters have not been achieved, but concentrations of nitrogen have decreased considerably, as have costs per unit of emissions reduced (RIVM, 2004).

2.4 Analyses in the UK

The future course of the Common Agricultural Policy (CAP) forms the context for policy on diffuse water pollution by agriculture. In the UK, the Department of the Environment, Food and Rural Affairs (DEFRA) commissioned a study to explore how the agreement of 26 June 2003 on the CAP would change farming patterns and practices which presently impact on diffuse water pollution (IEEP, 2004). The CAP agreement primarily brings about 'decoupling', that is, payments to farmers will no longer be based on their outputs. This means that farm output will be guided by consumer demand to direct what is produced. In addition to increased market orientation and sensitivity, other pressures such as 'modulation' (whereby farms with higher income receive reduced payments), cross-compliance and agri–environment schemes will come into play.

The expected impact of the reforms is for production to become more concentrated in the most productive regions, with overall reduction in arable and dairy production. Reductions in beef and lamb production will see their extensification. This could see larger farms, a reduction in stock numbers and in associated organic waste, although increased numbers on individual farms. The result could also mean a continuation of smaller dairy and stock farms that develop 'added value' products and local sales, and reduced stock numbers in the uplands. Fertiliser and manure applications could become more concentrated, as well as pesticide applications. Overall, the CAP reforms could see a reduction in levels of N and P in ground and surface waters. However, some increases in N and P can be expected on a localised basis and in specific catchments.

The Water Framework Directive will require significant reductions in the levels of all relevant pollutants – possibly by as much as 50–80% by 2015 according to some estimates – if 'good status' is to be achieved in UK waterbodies. The reductions in pollution from the CAP reform, therefore, make a contribution in the right direction but the report indicates that considerable work will be needed to address diffuse water pollution from agriculture at farm and at catchment level.

In June 2004, therefore, a *Strategic Review of Diffuse Pollution from Agriculture with an Initial Appraisal of Policy Instruments to Control Water Pollution from Agriculture* was published by DEFRA (2004). It pointed out that the steady improvement in water quality in England still leaves 60% of waters with phosphorus concentrations greater than 0.1 mg/l. The improvement has been brought about by investment in sewage treatment and reductions in detergents containing phosphates so that now 50% of phosphates in water are calculated to be due to agriculture. As regards nitrogen, the proportion of nitrate leached from agricultural land has increased from 57 to 64% of total nitrates in water since 1983 (WRc, 2004). The review considered the damage to water due to agriculture (excluding pesticides) to be in excess of the conservative estimate of Stg £140 million per year, which excluded the valuations that people would put on such things as damage to wildlife and eco-systems as well as the clean-up costs to water-using industry. Comparing this with its estimates of the costs of the farm changes to help deliver good chemical and ecological water status, in the range of Stg £80–200 million per year (RPA, 2003), the benefits of action are likely to be justified by the benefits attained.

Although diffuse pollution can often be concentrated in local catchments, the review considered it likely that virtually all rivers in England have significant nutrient enrichment problems. Cross-compliance, education and agri–environment schemes would make some contribution to improved water quality but the review considered that further approaches would be required.

Infraction fines could be imposed under the Water Framework Directive in respect of each waterbody deemed not to have satisfied good water status by 2015. Past experience indicates that such fines could be Stg £25–50 million per infraction per year. With this in mind, the review makes a preliminary appraisal of four broad approaches to dealing with diffuse pollution from agriculture in the UK. These are:

1. Regulations imposed after some delay, to prevent farms being put at a competitive disadvantage by early regulation.

2. Early regulation to allow a more gradual approach that allows identification of the most cost-effective measures. Both Approaches 1 and 2 would entail significant difficulties and costs with verification.

3. A supportive approach, through a package of measures including voluntary action, information, some regulation and possibly some financial instruments.

4. Economic instruments so that farmers are faced with some of the external costs of their pollution. The costs farmers impose on society are thereby made the farmers' own costs when they come to make farming decisions. Economic instruments are most suited to addressing broad pollution problems whereas addressing geographical variations could be administratively costly. By providing most encouragement to those that can abate their pollution most cheaply, costs of on-farm changes to reduce diffuse water pollution are minimised under economic instruments.

The review considered that regulation at the national scale should be at a low level except for regulation of worst practice. 'Farm planning' is resource intensive, requiring expertise, but may be cost effective provided the required changes at farm level are subsequently implemented. Grant aid and the services of taxpayer-funded 'catchment officers' could be provided to impart a focus for abatement activity, possibly operating along with voluntary initiatives. Co-operation between farmers and a number of interested parties is also a possibility whereby, for example, water companies could see reduced water purification costs and retailers could market local environmentally friendly food and could bring their expertise and support to the farmers.

Where changes to farm systems or improvements are required, such as enhanced slurry storage or fencing, grant aid may be necessary. As the benefits would be to the environment rather than to the farmer, the review claims that such aid would not contravene the rules on State Aids. (The point that more farmers are thereby kept in operation is overlooked by this argument.) But it would not be compatible with the polluter pays principle.

On the subject of levies, the review points out that many inputs into the farm system cause significant environmental damage when they make their way into watercourses. There is a broad national problem with nutrient emissions and there appears to be a close correlation between levels of inputs and the emissions that cause environmental damage. The review considers that with levies in place:

- Some water quality benefits are likely to accrue from reduced use of potentially polluting inputs.
- There would be some increased costs to farmers, but these would be offset at the national level by revenues and the administration costs incurred would be lower than by other approaches.
- The level of response from farmers would be somewhat uncertain, but the risk of excessive abatement costs would not arise as the levy is unlikely to be applied at levels that would reduce input use by more than is required.
- Improvements in efficiency of input use over time are encouraged by offering farmers the continued possibility of incurring lower levies.
- Impacts on farm incomes may be relatively high in the case of those already doing badly financially.

The review concluded that such levies would not be sufficient in isolation but that they could contribute to reducing the use of polluting inputs at a broad and shallow level. They could complement other instruments such as targeted regulation, regulation of worst practice, provision of catchment officers and grant aid, which could address more specific issues. The useful synergies between these policies are noted. Levies raise the profile of the aims, while information could increase the response to the levies.

This review is an ‘initial appraisal’ according to its title but it puts flesh on the possibilities for economic instruments outlined in another report also commissioned by DEFRA, from OXERA (2003), which flagged economic instruments as possible future approaches. Their concern about regulations and indeed permit trading (one of the economic instruments) was that they are only feasible where they can be enforced credibly, that is, where the regulated activity can be measured at reasonable cost, and credible action can be taken against the farmer who is non-compliant. OXERA points out that taxation can be differentiated locally if it is imposed on a non-traded and stationary tax base, such as nutrient concentration in soil. This could allow the tax rate to vary to reflect local environmental conditions, which could be a consideration later with river basin districts set up under the Water Framework Directive. OXERA’s conclusion is that a start has been made on addressing diffuse water pollution from agriculture but that few of the probably necessary actions have yet been taken and that much more action will be needed.

A release from DEFRA in June 2004 stated that the government were targeting agricultural water pollution. Possible actions include a series of river-catchment specific actions, plus taxes on fertilisers or nutrient surpluses to apply all over the UK (ENDS, 2004). Such actions would have relevance for Ireland, facilitating the introduction of similar policies here.

2.5 Experience of Fertiliser Taxes in Sweden

Taxes were imposed on fertilisers in Sweden in 1985 in two parts. One part was the so-called price regulation charge and the other part was an environmental charge. The charges were raised on nitrogen, potassium and on phosphorus, the last being replaced by a charge on cadmium in phosphorus.

Revenues from the price regulation charge were originally used to finance export subsidies, but that charge was abolished in 1992 leaving only the environmental charge. Unlike Austria, Sweden did not abolish its fertiliser tax upon accession to the EU in 1995. The government saw the tax as a good way to finance environmental projects and it was expected to be beneficial to the environment. Since 1995, the tax on fertiliser in Sweden has been about 20% of the price of fertiliser.

It has been estimated that the 31% tax applying in 1991–1992 probably reduced the use of nitrogen fertilisers by 15–20% and the reduction in usage due to the 1997 tax level is estimated at 10% (Rougoor *et al.*, 2001). The administration costs were estimated at less than 0.8% of the revenues.

2.6 Analyses and Experience in the USA

In the USA, pollution from non-point sources is now the single largest source of water quality impairments.

Technology subsidies and land retirement subsidies, such as the Conservation Reserve Program (CRP), are the tools that have been extensively used for reducing agricultural pollution to water from non-point sources. Only a few States have used input-based incentives and their impact on agricultural non-point pollution problems has not been determined. Studies of actual or proposed economic incentive-based policies for reducing agricultural non-point pollution are limited.

Informative simulation studies have been undertaken. They contend that incentives can be targeted at a limited number of inputs and achieve environmental goals in a cost-effective manner. To be effective, the tax base needs to be highly correlated with environmental goals.

To give some examples, two studies found that in order to limit expected nitrogen run-off levels from lettuce production in the Salinas Valley in California, it is more cost effective to tax irrigation water than to tax nitrogen fertiliser inputs. Water had a high correlation with run-off and producers happened to be more likely to use less water than less nitrogen (Helfand and House, 1995; Larson *et al*., 1996). The former authors also found there to be little to choose from between uniform or site-specific taxes. Other studies on the other hand found that site-specific incentives significantly outperform uniform approaches, due to local geographic and hydrologic conditions, though the additional administrative and information costs were not factored in to the assessments.

2.6.1 Subsidies in the USA

The Department of Agriculture and most States have for a long time offered farmers incentive payments for adopting good practices. Programmes such as the Water Quality Incentive Program (WQIP) and the Environmental Quality Incentive Program (EQIP) make payments for management practices, such as conservation tillage. Payments are designed to offset any private loss a farmer may incur by adopting the practice, and any increased risk of uncertain yields among other things. To elicit a change in technology on the part of the farmer, a subsidy ought to equal the present value of the stream of expected net losses from adopting the practice as well as overcome adoption hurdles. A study of the WQIP found that the incentive payments were too low in some regions to secure the adoption of some of the recommended practices (Higgins, 1995).

These results were supported by a survey undertaken in the Corn Belt in which only 17.5% of farmers indicated that they would be interested in enrolling in the WQIP. Another 27.8% stated that they might be interested. The average payment requested by those expressing some interest in the programme was almost $76/acre and only 18.8% were willing to accept the WQIP maximum of $25 or less (Kraft *et al.*, 1996).

2.6.2 Land retirement subsidies in the USA

In addition, there are incentives for exit from farming and land retirement. The US Department of Agriculture's CRP uses subsidies to retire cropland that is especially prone to producing environmental problems. In exchange for retiring cropland for 10–15 years, CRP participants receive an annual rent per acre and half the cost of establishing a permanent land cover consisting usually of grass or trees. Areas are assigned an 'environmental benefits index' (EBI) based on the area's potential improvement. Farmers then bid, or tender, rental payments to enrol. Similar schemes have been proposed for Ireland for the achievement of environmental objectives, such as wildlife maintenance (Scott, 1997). Bids with higher EBI to rental payment ratios are accepted ahead of bids with low ratios.

The idea of tendering means that the environmental improvement is achieved at least cost. The use of the EBI ensures that site-specific considerations are taken into account. By 1999, the CRP had converted some 8% of US cropland to conservation uses since 1985. Attendant net social benefits have been estimated at between $4.2 and $9 billion (Hrubovcak *at al.*, 1995).

In general, subsidies and government cost sharing have been found to be significant in promoting soil conservation (Ervin and Ervin, 1982; Nielsen *et al*., 1989). Water quality improvements are an indirect effect and enhancement of soil quality and its improved long-term productivity are of benefit to farmers.

2.6.3 Subsidies subject to environmental compliance in the USA

Cross-compliance policies tie receipt of benefits to some level of environmental performance. A drawback is that the benefits, and thereby the incentive effect, reduce, relatively speaking, when crop prices are high, which is just the time of greatest pressure on the environment. Compliance mechanisms cannot usually target farms in a least-cost way because the incentive will not usually reflect contributions to water damage. Also, difficulties with administration, information and monitoring requirements already discussed still apply. However, in a study by the US Department of Agriculture, it was found that conservation compliance by producers of program crops who farm highly erodable land, has resulted in significant reductions in soil erosion, with a national benefit to cost ratio greater than 2:1. That is, the monetary benefits from quality improvements in air and water and in productivity outweigh the costs to government and producers by at least 2:1. In fact, average annual water quality benefits from conservation compliance have been estimated to be about $13.80/acre (USDA, 1994). It is noted from the surveys of schemes that farmers who help to maintain the quality of the soil are relatively successful. This is not surprising, given that the soil is the farmer's key asset.

2.6.4 Taxes in the USA

Taxes are an unusual tool for environmental protection in the USA. Furthermore, an unusual tax, in that it is based on outcome, is the tax being used in Florida to reduce phosphorus discharges to the Everglades, the south Florida wetlands, rich in flora and fauna.

The tax is described by Ribaudo *et al.* (1999). The Everglades Forever Act calls for a uniform, per acre tax on all cropland in the Everglades Agricultural Area. The tax was implemented in 1994 at a rate of $24.89 per acre per year, increasing every 4 years to a maximum of $35 per acre by 2006 unless phosphorus is reduced 25% basin-wide (State of Florida, 1995). Reductions in phosphorus are determined through monitoring of run-off water that collects in drainage ditches. Being a well-defined area, it is easy to monitor, unlike a major river with many tributaries. Though the tax is based on cropland – that is, it is related to the production resource used – its application depends on phosphorus levels – a performance incentive. The tax creates the incentive to adopt best-management practices, and also for producers to apply pressure on recalcitrant neighbours. The number of producers is not so large that free-riding is much of a problem.

Ribaudo *et al.* (1999) conclude that this tool is flexible in that producers are not restricted in how they manage their operations to meet the phosphorus goal. However, the basis upon which the tax is placed – acres of cropland – is not necessarily consistent with the goal of the tax, phosphorus reduction. A more efficient approach would be to tax phosphorus loads directly, though how to avoid smuggling if the tax were localised is the problem.

Another example of a tax shows the potential for synergies with other policies, such as education. Education can enhance performance on such activities as nitrogen testing, and may even alter producers' preferences. A sales tax on fertiliser in Iowa was used to support nutrient management programmes in that State (Mosher, 1987). The current tax rate was apparently too low to affect behaviour but accompanying research and education may be increasing the efficiency of fertiliser use as the application rate on corn is indeed lower than for the other States in the Corn Belt.

2.6.5 Tradeable permits in the USA

Point/non-point trading programs have been set up to restore water quality in several US waterbodies. The advantage of tradeable allowances lies in the fact that farms have different marginal costs of control, which do not have to be known by the resource management agency for the scheme to work. Point source polluters buy emissions allowances from farmers when the farmers can abate more cheaply – abatement overall is achieved at the lowest cost in theory.

In practice, given the difficulty of monitoring farmers' emissions in terms of expected run-off, trades are not enforceable and in several programs none has occurred. Instead, if non-point source reductions failed to meet the ambient quality goals that had been set, then point sources would be held responsible for meeting the goal themselves. That the scheme is not really operational means that potential efficiency gains are foregone, as seen from the variations in estimated marginal abatement costs between point sources and non-point sources within locations, shown in Table 2.4.

There are no schemes currently operating in the US for trading allowances based on non-point inputs alone. The necessary component of a trading scheme is missing,

Table 2.4. Estimated phosphorus abatement costs for point and non-point sources.

	Abatement cost ($ per lb)	
Location	**Point source**	**Non-point source**
Dillon Reservoir, CO	860–7861	119
Upper Wicomico River, D	16–88	0–12
Honey Creek, OH	0–10	0–34
Boone Reservoir, TN	2–84	0–305

Source: Malik *et al.*, 1992.

namely, that the activities that are permitted be capable of being monitored and enforced in a credible manner.

2.7 Monitoring

The difficulties of measuring and attributing diffuse pollution to the responsible person or activity mean that performance-based measures are generally infeasible at present. If satellite tracking could undertake monitoring of emissions, policies would be easier to implement. In current circumstances, there is no single policy tool that can address the issues. Several tools are needed.

At present, monitoring may be easier for incentives than for regulations because it can be applied through existing markets. A fertiliser tax can be implemented as a sales tax immediately and data on sales can be consulted, whereas a fertiliser standard requires that each production site be monitored for fertiliser. The fertiliser tax also has the advantage of raising revenue, which can be used to support the water quality policy. Funds are needed for administration, to help technology change, to promote education and research, or to retire marginal land.

2.8 Conclusions on Part 2

Examples of the studies and application of economic instruments to tackle excess nutrients have been described. The main area of focus is the tax on excess nutrients introduced in the Netherlands in 1998, called MINAS, as this is the one satisfactory test bed of a policy that comes closest to the requirements of an efficient policy. It addresses the need to rectify the rational desire to apply too much nutrients, as shown in Part 1, and closely targets diffuse water pollution through taxing excess nutrients.

The discussions of policy instruments in the UK were also examined because their analysis has advanced to the stage of starting to consider the costs and benefits of different approaches and to put in place the necessary underlying research. The consideration of fertiliser taxes in the UK points to the possibility that the introduction of such taxes in Ireland could be eased.

Approaches in Sweden and in the USA were also described. Although the tax approach is not the main one in the USA, it had enough experience of a variety of policies to show up interesting issues, particularly the difficulties of implementing tradeable permits.

The next part of this study looks at how the above information can be applied to serve Ireland's problem of excess nutrients. The aim will be to give pointers to help policy to aim for the most appropriate target, excess nutrients, while keeping administration costs low.

Part 3 Options for Ireland

3.1 Background

The scope for applying fertiliser taxes in Ireland is now examined, bringing to bear the principles discussed in Part 1 and the experience gained from policies applied in other countries described in Part 2.

Current policies targeted at diffuse pollution in Ireland will be summarised. The main tax-based options will then be outlined, taking account of features that would be desirable. Desirable features are that the reform should be simple to introduce, administer and comply with, that the underlying incentives should be corrected and that there should be an expectation of favourable results without causing undue social stress. If the reform can generate information relating to performance which would otherwise require additional form-filling and costly monitoring to produce, that would be better still.

An example of a simple tax will be presented, not as a recommendation but as a means of providing figures that can form a basis for informed discussion. The example will summarise the implications of using an existing tax, such as VAT, to keep bureaucratic costs down. Fertilisers and feed are currently zero-rated for VAT and the example will look at raising this to the low VAT rate of 13.5%. The deduction or flat-rate compensation would automatically be due and that should obviate social stress. The paper concludes with a general assessment and lists some outstanding issues.

It needs to be stressed at the outset that doing nothing is not an option if eutrophication is to be addressed. The EPA in its recent report on the state of the environment describes how it can take decades to run down the phosphorus burden that is typically found in many soils and that if urgent measures are not put in place to balance inputs and outputs of phosphorus on farms it simply may not be possible to prevent widespread eutrophication in the long term (McGarrigle, 2004). Meanwhile, the Water Framework Directive requires, by 2015, the restoration of polluted waters to good status and maintenance of high ecological status where it exists at present. Infringements will be subject to fines but the foregone benefits to Ireland's citizens and tourism and the values that people would put on these could well be larger still.

3.2 Fertiliser Use and Emissions

Though sales of fertiliser in value terms have been fairly static these last 4 years, the quantities have been generally declining. Table 3.1 lays out the broad magnitudes for this period and it give figures for 1990 and 1982 for comparative purposes. Already by 1982, warnings about eutrophication of Irish waterways had been clearly sounded for a decade. The recent declines in fertiliser purchases, from 1,850 thousand tonnes in 1999 down to 1,628 thousand tonnes in 2003, are due in large part to recommendations to farmers by Teagasc to reduce phosphorus spreading (Teagasc, 1998).

It was seen in Part 1 that the application of fertilisers that is not taken up by plants can result in emissions that are implicated in three sorts of environmental damage: (1) in eutrophication of water, (2) in acidification of soil and water and (3) in emissions of greenhouse gases.

Table 3.1. Sales of fertilisers, expenditure on fertiliser and number of family farms.

	1982	1990	1999	2000	2001	2002	2003
Total fertilisers, kt	1468	1793	1850	1730	1546	1523	1628
Of which:							
Nitrogen, kt	275	379	443	408	369	364	388
Phosphorus, kt	62	65	51	49	43	42	44
Potassium, kt	148	158	126	123	107	106	111
Expenditure, €m	272	326	339	339	351	341	371
No. of family farms, k			143.7	141.3	139.4	136.3	not available

Sources: CSO and Department of Agriculture, *Output Input and Income of Agriculture 1990-2003.*

Eutrophication has been identified by the Environmental Protection Agency (EPA, 2002) as "*probably Ireland's most serious environmental pollution problem*".

Agricultural sources accounted for some 46% of polluted river sites (that are 'slightly polluted' and 'moderately polluted') on Irish rivers surveyed in the 1998–2000 period. In the vast majority of cases, these sites are impacted by eutrophication effects, and approaching half the eutrophication of Irish rivers is due to agricultural sources (McGarrigle, 2004). Agriculture is estimated to be responsible for 73% of all inputs of phosphorus to waters and 82% of all inputs of nitrates to waters. High nitrate levels are reported in approximately 20% of well sampling stations and high ammonia values were found in groundwaters in eight counties. These are likely to be due to poor control of animal wastes and poor siting or construction of septic tanks as well as fertiliser application, the effect of each component being hard to isolate.

Surplus application of phosphorus to agricultural land is a large part of the issue. Surplus phosphorus estimated by Brogan *et al.* (2001) has reduced from nearly 11 kg/ha in 1997 to about 8 kg/ha in 2002. Though fortunately in decline, this continuing surplus is harmful as well as wasteful to the farmer. Explanations should be sought in the fact that calculating the appropriate application for individual soils is time consuming, applying a surplus brings an 'insurance' benefit and in any case the 'sink' is free.

Ideally figures should be put on the costs of the damages from diffuse agricultural pollution as is being undertaken in the research programmes of other countries and incorporated in policy discussions (*vis*. DEFRA 2004). It was seen in Part 1 that extra water purification costs alone of some Stg £231 million were incurred in the UK due to agriculture. In addition to such damage costs, damage costs of acidification and greenhouse gas emissions, and estimates of the marginal costs (the costs imposed by an extra unit emitted), would help in the determination of the optimal level of tax. These are exercises in basic research that are overdue to help policy formulation (Scott, 2004).

3.3 Policy Context

Agriculture is subject to many policies. We have seen that the quantities of fertilisers applied have been declining in recent years. This can probably be attributed to education of various types, that is, to publicity given to declining water quality, the education programmes of Teagasc and in particular to their more recent advice on fertiliser application. Farmers by and large are motivated by their attachment to their land and they are likely to want their farm to be, and appear to be, well managed (Ryan *et al.*, 2003).

Reform of the CAP means that in certain areas there is likely to be reduced pressure on the environment in future, but consolidation of farms into bigger units could herald potentially polluting concentrations of larger farms in other areas. The majority of subsidies will be paid independently of the volume of production, but these subsidies or so-called 'single farm payments' will be linked to the respect for environmental, food safety and animal welfare standards (Europa, 2003). More money is expected to be available to farmers for environmental programmes and in the market-led situation farmers are likely to gear production to be closer to what consumers want. In so far as this includes environmental transparency, this could mitigate the increased polluting potential of the higher farm concentrations. One estimate of the effects of decoupling on the cattle population over the decade to 2010 is for numbers to decline from 7.2 million to 6.05 million, which would be conducive to agriculture meeting greenhouse gas emission targets outlined in the National Climate Change Strategy. It is also estimated that fertiliser use could decline by 10.4% (Ryan *et al.*, 2003).

CAP reform does not mean, however, that efforts to avert eutrophication can be reduced or that the problems can be viewed as merely the result of old CAP incentives. In addition to the above-mentioned concentrations, Ireland's agriculture sector will face more competitive conditions and the reduction in direct payments ('modulation') to bigger farms means that they will face a more commercial situation. If the environment still offers a free 'sink' the motivation to use it will naturally prevail, as ever.

The expected reduction in cattle numbers is starting from a high base. The present organic load generated by agricultural livestock is equivalent to that of a human population of 68 million persons and, as already mentioned, the average hectare of agricultural land is estimated to receive an excess of 8 kg of phosphorus each year (Brogan *et al.*, 2001; EPA, 2002). There is a great deal of variation in behaviours and conditions, but many soils are now considered to contain phosphorus at levels where losses to surface water will occur during periods of heavy rainfall.

There is increasing understanding of nutrient pathways to waters and of the required safeguards. Research projects on *Eutrophication from Agriculture Sources* and *Modelling Phosphorus Loss from Soils* under the ERTDI Programme of the EPA (2003) will point to measures that would see improvements. This information is becoming available and will be capable of being applied. The question still remains as to how to bring about the final step of actual application. Until it is addressed correctly, the gap between current conditions and potential improvement will persist or be slower and more expensive to overcome than necessary.

3.4 Current Policies

The main policies currently in place are now outlined, drawing on a paper written by Humphreys *et al.* (2003). The Water Pollution Acts of 1977 and 1990 and regulations made under them, including regulations giving effect to EU Directives, constitute the main legislation governing water management and protection.

Under the Phosphorus Regulations introduced in 1998 (S.I. No. 258), local authorities are required to take measures in order to comply with specified water quality standards. Targets are set for recovery of rivers and lakes that are currently below certain threshold standards. More importantly, ‘no deterioration’ targets are set for rivers and lakes that are currently satisfactory. The standards can be met in one of two ways: by reaching annual median phosphorus concentrations or by achieving biological status targets (such as the Q ratings or A, B, C ratings for rivers, and trophic status for lakes).

In meeting the standards, the local authorities can implement bye-laws and a number of local authorities have done so to regulate farming practices in specified catchments. In general, the bye-laws include the requirement that farmers draw up plans that describe their manure storage facilities, their soil fertility and their fertiliser use. The adequacy of their animal housing facilities can be surveyed as well as management of their facilities and their water collection and disposal systems. The availability of resources is apparently an issue for many local authorities and few are using the nutrient management planning powers available to them (McGarrigle, 2004).

In the case of rivers monitored for phosphorus, a 1.1% increase in target compliance from the reporting period of 2 years previously has been recorded though compliance with the specifically biological status targets has declined. A continuing decline is recorded in the number and percentage of river stations of highest biological quality, Q5, and of the next highest quality, Q4–Q5 (Cleneghan, 2003).

Another measure, which will be extended under CAP reforms already mentioned, is the requirement for cross-compliance that accompanies payment. The Department of Agriculture, Food and Rural Development (DAFRD) has drawn up rules governing Good Farming Practice that outline the farm practices required to comply with environmental standards. In addition to rules similar to the bye-laws are requirements of buffer zones and rules on application of manure around waterways and water supplies. Failure to comply can result in prosecution and/or forfeiture of payments.

Tax allowances are available to farmers who have nutrient management plans in place and who incur capital expenditure for pollution control facilities. Grant support is also available for improvements in farm waste storage and handling facilities on farms.

Farms that participate in REPS (the Rural Environment Protection Scheme), a scheme set up on foot of the Agri–Environmental Regulation of 1992 (EEC 2078/92), receive annual payments of around €151/ha for a maximum of 40 hectares for complying with regulations. The regulations include limiting inputs of nitrogen to a maximum of 260 kg/year. During 1994–1999 some 46 thousand farms involving 1.5 million hectares, which is about 36% of farmland, participated, since when the number has declined to around 40 thousand. An increase in payments is envisaged to reverse the decline. There is an ERTDI analysis under way of the effectiveness of the scheme and, among other tasks, the analysis is defining the environmental benefits of REPS.

3.4.1 Two European Directives

Two European Directives in particular are now the focus of attention as they have strong implications for agriculture and diffuse water pollution and the manner of addressing it. These are the Nitrates Directive already mentioned above and the Water Framework Directive (91/676/EEC and 2000/60/EC, respectively).

Dealing with them briefly in turn, the Nitrates Directive requires Member States to designate vulnerable zones or else apply Action Programmes to the whole national territory. Ireland is applying the whole territory approach, reflecting the understanding that higher concentrations expected from CAP reforms could see more areas becoming vulnerable than at present. Measures to be included in the Action Programmes cover (Richards, 2004):

- the periods when fertilisation is prohibited
- the required storage capacity for livestock manures
- the limitation on land spreading based on land characteristics and the balance between output needs and supply
- the requirement that livestock manure spread annually is <170 kg N/ha.

At the time of writing, consultations on Ireland's draft Action Plan are in progress. Larger dairy farmers in particular are concerned at the draft plan's organic manure limits of 170 kg N/ha, given that this represents the output of two cows per hectare and many farms would either exceed the limits or deem the standard to be unnecessary or unproven.

Two observations on these policy initiatives are warranted in particular. The first is that, cross-compliance, REPS and tax allowances apart, the policies are largely regulatory in nature. This is striking especially as one might expect, given that there is no evidence to the contrary, that a balanced mix of policies involving incentives and disincentives is likely to have most effect. Secondly, the demands on monitoring and enforcement are heavy, and these have resource implications. As stated in the Three Rivers Project, a number of measures will "*require strong political will at a national level to ensure implementation. Manpower and financial resources must be made available to Local Authorities and other bodies to implement these measures*" (MCOS, 2003). Estimates of the resources required are not to hand.

By contrast with the prescriptive nature of the Nitrates Directive as to farming practice, the Water Framework Directive focuses more on environmental objectives and the external costs that give rise to stress on water resources. The Directive requires that by 2012 'programmes of measures' be implemented in all catchments in order to achieve good water status by 2015. The nature of its prescriptions is of a different type from that in the Nitrates Directive. It prescribes management structuring in river basin districts, cost recovery by the water supply and waste-water treatment utilities and that the major sectors, industry, households and agriculture, each pay for the costs of water services, including environmental costs, taking account of the polluter pays principle. As seen in Part 2 of this report, the UK authorities were considering a range of approaches to meet the directive's requirements, combining regulations, education, supportive action and economic instruments.

3.5 Investment in Waste-Water Treatment

Investment in waste-water treatment plants and upgrades and the integration of phosphorus removal has been undertaken over the last decade with the expectation of downstream improvements in water quality. A recent study of schemes financed by the Cohesion Funds has assembled information on water quality from readings taken before and after the upgrades to determine what improvements have ensued (DKM *et al*., 2004). An example of the results is shown in Table 3.2. This gives the readings downstream of two investments, in Trim and in Navan. The plants were commissioned in 1999 and in 2000, respectively, meaning that the lapse of time may reveal improvements due to the investments. The table

Table 3.2. Biological Quality Ratings (Q Values) and phosphorus readings (in italics) downstream of investments in waste-water treatment plants at Trim and Navan.

Downstream sampling stations' codes	1971	1981	1986	1990	1994	1997	2000	2003*	2004*
New plant at Trim in 1999									
1450	–	–	–	–	–	–	–	–	–
							0.048	*0.037*	*0.032*
1500	5	5	4	3–4	3–4	3–4	3–4	3–4	–
	–	–	–	–	–	–	–	–	–
1600	–	4	4–5	3–4	3–4	3–4	3–4	3–4	–
	–	–	–	–	–	*0.082*+	*0.039*	*0.034*	*0.032*
1800	–	4–5	4–5	3–4	3–4	3–4	3–4	3–4	–
	–	–	–	–	–	–	–	–	–
New plant at Navan in 2000									
1900	4	3–4	4	2–3	3	2–3	3–4	3–4	–
	–	–	–	–	–	–	*0.047*	*0.036*	*0.029*
2010	–	–	4	3–4	3–4	3	3–4	3–4	–
	–	–	–	–	–	–	–	–	–
2100	4–5	4–5	4	4	3–4	3	3–4	3–4	–
	–	–	–	–	–	*0.95*+	*0.054*	*0.042*	*0.042*

Source: EPA Water Quality in Ireland, 2002, 07/B/04, OS Catchment No 159.
Phosphorus recordings, in italics, are the median MRP concentration in mg P/litre, supplied by K. Conboy, Meath County Council.
* Update from EPA (Kevin Clabby).
+ Recording relates to 1995–1997. Levels improved in 1998 to 0.060 and 0.080, at stations 1600 and 2100, respectively.
Q values: Q5 is pristine, unpolluted; Q4 is unpolluted; Q3–Q4 is slightly polluted; Q3 is moderately polluted; Q2 is heavily polluted; Q1 indicates gross pollution.
The standards for phosphorus in rivers require that the median MRP concentration should not exceed 0.030 in Q4 waters and 0.050 in Q3–Q4 waters.

gives two measures, the quality ratings and the phosphorus readings, where available, before and after the plants were commissioned.

The biological quality ratings show no improvements as yet as the waters are still in the slightly polluted category. The phosphorus readings show significant improvements and it is seen that these are a continuation of the improvements that were already occurring before the upgraded plants were put into operation. This result could indicate rewards to the efforts of farmers in the region as well as to the plant. Improvements in phosphorus concentrations since the plants were commissioned still leave the waters in the slightly polluted category, prompting the question as to whether this is due to agriculture or due to the fact that the full improvements from investment in plant have not had time to materialise. The results are not decisive but they suggest that improvements ensue from both investment and from efforts on the part of farmers. Unless it is merely too soon for the results of the investments to have materialised, they also suggest that other measures beside investment in plant are required.

3.6 Tax-Based Options

Tax-based policies implemented abroad have been described in Part 2 and, taking stock of this information, tax-based options for Ireland will now be considered, bearing in mind some of the following issues. There is wide variation in conditions on farms. Monitoring and enforcement of correct nutrient application and management practices could be costly. Burdensome documentation and extra form-filling imposed on farmers could tie up resources in a sector that is already having to face an increasingly demanding commercial environment. Ways to keep administration costs low are needed, while enabling the authorities to have information that indicates whether fertiliser application is excessive or otherwise.

A straight tax on fertilisers, such as an excise tax on its own, though administratively simple, could have a damaging effect on income and be ineffective (Lally and Riordan, 2001), in the short run at least. Another consideration raised by the Tax Strategy Group is the threat of cross-border smuggling from Northern Ireland if a significant price difference arises as a result of an environmental tax imposed on fertilisers in the Republic (Department of Finance, 1999). The fact that fertiliser taxes are viewed as an option in the UK could be significant.

The MINAS tax in the Netherlands has some excellent features in many respects. It is targeted at the correct item, namely surplus nutrients and its introduction has been accompanied by a high-quality programme of information. Effectively only polluting farmers pay. The rates of tax were pre-announced and were to increase gradually. MINAS is attributed with contributing to the environmental improvements illustrated in Fig. 2.1 in Part 2. It was also seen that the administration costs were high, though not as high as sometimes supposed or as high as some alternatives, and that concerted efforts were needed to address this problem.

It can be deduced that, whatever policies are employed, providing guidance to farmers on management practices and facilities makes a positive contribution. Secondly, a tax such as MINAS provides the correct long-term motivations to farmers but at the same time it may be over-elaborate. This is not to say that only water quality problems as serious as those in the Netherlands deserve a serious approach, especially when one considers the extent of the deterioration from the high quality of waters in Ireland in living memory. If the correct item is targeted, surplus nutrients, the approach is worthwhile. Thirdly, administration needs careful consideration in order to keep it simple. According to sources who are familiar with MINAS, it is the bookkeeping on nutrients that should be the primary requirement of farmers in Ireland and it should be compulsory. Fourthly, to address the economic roots of pollution, consideration needs to be given to replacing the ‘free sink’ with realistic incentives.

3.7 An Example of a Fertiliser Tax for Ireland

A simple approach to charging nutrient surpluses will be looked at, which assumes that the Value-Added Taxation (VAT) system could be exploited.

Some farmers are registered for and subject to VAT and others, who are the majority, are not registered for VAT. In the case of VAT-registered farmers, there is a similarity between what they are already doing in filling their VAT returns and the calculation of nutrient surpluses. Both require farm inputs and outputs to be recorded. This fact could mean that for those farmers who are registered, the calculation and taxation of any nutrient surplus could be achieved in the one bookkeeping exercise. VAT-registered farmers are few, numbering about 4,500, but they tend to be engaged in tillage with large enterprises and use a relatively large amount of fertiliser. They are therefore important and will be looked at in more detail. The case of those farmers, the vast majority, who are not registered for VAT will also be considered.

The costs in time for administering taxation are real costs that impinge on both the revenue collection agency and on the enterprise that pays the tax. Tax administration costs can be a serious burden. It was seen from the European Commission study described in Part 2 that the MINAS tax on surplus nutrients entails sizeable administrative costs.

On the part of the farmer, the administration costs include the time needed to set up a system to itemise inputs and outputs, and hence a nutrient balance, and the cost of employing an accountant to go through the figures; the latter is put at between €113 and €227 per farm per year for the MINAS system (European Commission, 2003). When the farmer’s own time is added in, we saw that total administration costs incurred by the farm were reported by the European Commission study to lie between €220 and €580 per year. These figures exaggerate the costs, because they are not necessarily extra costs. If farmers were likely to have to calculate the nutrient inputs per hectare in any case under regulations in place and if those exceeding the specified limit (210 kg N/ha declining to 170 kg N/ha after 4 years) would be required to undertake nutrient management planning, extra administration resources would already be required. Nevertheless, the point is made that it is important to look into the possibilities of finding a procedure that is simple and quick, in particular with regard to bookkeeping on nutrients.

In this respect a helpful development is the endorsement by the National Statistics Board (2003) of the establishment of better links between statistics collected by different government departments and agencies. The Board points out that this should enable relationships between different areas to be recognised in policy formation. The example that it cites in *Strategy for Statistics 2003–2008* is wider use of the PPS number (Personal Public Service Number). The Board states that its strategy is to focus on how to "*harness all the potential of existing data sources while ensuring that the burden of data collection on individuals and enterprises is not excessive*".

It describes how this needs a 'whole system' approach. This would involve all areas of the public sector where administrative records are maintained from which official statistics can be generated. It would need to be made subject to safeguarding personal confidentiality and meeting the stringent standards of the Data Protection Commissioner. Procedures that get rid of processes that require double submissions to government are elements of strategies aimed at streamlining operations elsewhere also.

The exploitation of synergies in form-filling has been achieved to good advantage in the case of the introduction of Ireland's Plastic Bag Levy. The fact that bookkeeping imposed by the levy could be integrated with VAT returns meant that the additional costs to retailers of implementing the plastic bags levy was modest (Convery and McDonnell, 2003).

Taking these positive developments into consideration and refocusing on fertilisers, if the VAT system can be harnessed to supply information on the nutrient inputs and outputs of registered farmers, it would be a step towards providing a nutrient balance with little extra form-filling on the part of these enterprises. Invoices recording quantities of fertiliser and feed brought in and quantities of produce sold off the farm would already be on the farmers' desk. The VAT form in Appendix 1 of the *Guide to Value-Added Tax* (Revenue, 2003) would need to be extended and, subject to the procedures on information security, Revenue could engage a few scientific personnel to assess the figures entered. The foremost requirement to undertake nutrient bookkeeping is thereby met, and farmers who then had unwarranted surpluses could be identified. In the case of transgressors, farmers found to be applying excess nutrients could be dealt with in accordance with legislation.

Though it might be ideal, it is unlikely that Revenue could apply sanctions in the form of restricted deductibility within the VAT system, because deductibility is limited by the VAT Directive. This does not appear to be an option at present. However, it is "*possible to use the information on agricultural inputs and outputs obtained through the VAT system as a tool to identify the farmers contributing to the imbalances of nutrients, in order to promote a different behaviour by these farmers*" according to a personal communication from the European Commission Directorate General, Customs and Indirect Taxation (1996). A useful tool is potentially available therefore in the VAT system for providing information to help identify sources of surpluses that might be causing diffuse pollution.

Turning to the main body of farmers who are not VAT registered, no information would become available from them through the VAT system. The VAT they pay on their inputs does not mean that they are out of pocket, because they automatically claim a flat-rate compensation paid on their sales. The only qualification is that the rate does not catch up with rises in VAT rates on inputs for 3 years. This is because the flat-rate compensation is calculated on the basis of the average VAT paid by non-registered farmers on inputs purchased over the 3 previous years. The flat-rate compensation is currently 4.4% and farmers receive it by adding it to the price of their sales. This 3-year delay would require temporary measures to ease the transition.

Fertilisers and feed are currently zero rated for VAT, meaning that farmers pay no VAT on these inputs. Ireland is one of the few countries, if not the only one, in the EU 15 that does not impose a positive rate of VAT on fertilisers. If however a non-zero rate of VAT were imposed on fertiliser, it would have the positive effect of raising the price of fertiliser, while ensuring that compensation came through when the flat rate was adjusted upwards. Such a reform would send the right signals without financial disadvantage to farmers using average amounts of fertilisers, shifting up the price of fertilisers relative to other inputs.

The financial implications for registered farmers of raising the rate of VAT from zero to some positive rate are minor. Their ability to deduct the VAT they will have paid on their fertiliser inputs effectively means that they have given Revenue a temporary loan. The benefit of information being gathered is the major benefit.

In order to assess the implications of such a tax on fertilisers, the following section looks at the fertiliser tax's share of farm incomes and, more importantly, of disposable incomes of farm households, leaving aside consideration of deduction or flat-rate compensation.

3.8 A Numerical Example of a Tax (leaving aside VAT deduction and compensation)

This analysis investigates a possible tax on fertilisers and compares it with farmers' incomes, as a yardstick. The income figures given are of two sorts. The first is farm income, which is income derived solely from the farm, and the second is the household's disposable income, which includes non-farm income as well. Disposable income is a better measure of a household's circumstances and of its resources. These figures for income are net of costs of farm inputs. Disposable income is income after addition of state transfers and deduction of tax.

This exercise was made possible by a co-operative undertaking between Teagasc and the Central Statistics Office, and the resulting tables of data are reproduced in Appendix 3.[6] Overall expenditures on fertiliser and incomes are shown in Table 3.3.

6. Extra information on the farms in Teagasc's National Farm Survey that participate in the CSO's Household Budget Survey 1999–2000 (HBS) was extracted by G. Quinlan. The information was added to the farm households in the HBS, which contains additional information on non-farm incomes, and then analysed by J. Dalton of CSO in the HBS framework.

Table 3.3. Annual expenditure on fertiliser, farm income and disposable income in 1999–2000, € per farm household.

	€/year	Fertiliser expenditure relative to:
Expenditure on fertiliser	3,031	–
Farm income	13,085	23%
Total disposable income	29,759	10%

It can be seen that expenditure on fertiliser is sizeable by comparison with incomes, amounting to 10% of total disposable income and a huge 23% of farm income on its own.

Table 3.4 shows details of expenditure on fertilisers and expenditure relative to total household disposable income, when considered against size of farm expressed in Utilised Agricultural Area (UAA).

The pattern of rising percentages with UAA is to be expected. The bigger farms are those engaged in dairying, cattle and tillage, and they would tend to be fertiliser intensive. The pattern of fertiliser purchases by farm system is shown in Table 3.5.

It can be seen from Table 3.5 that the farmers who are most fertiliser intensive relative to their disposable incomes are tillage farmers, as expected. The two dairying systems are next in line in fertiliser intensity.

Table 3.4. Annual expenditure on fertilisers, in nominal terms and relative to household disposable income, by Utilised Agricultural Area (UAA).

UAA	Annual expenditure on fertilisers, €	Expenditure on fertilisers relative to disposable income, %
< 10	416	2
10 < 20	895	4
20 < 30	1,733	7
30 < 50	3,090	10
50 < 100	6,135	15
100 +	12,677	22
Average of all farms	3,031	10

Table 3.5. Expenditure on fertilisers relative to total disposable income, by farm system.

Farm system	Expenditure on fertilisers relative to disposable income %
Dairying	14
Dairying + other	15
Cattle rearing	5
Cattle other	8
Mainly sheep	4
Mainly tillage	17
Average farm	10

The extent of fertiliser expenditure in relation to income when households are categorised by decile of income is shown in Table 3.6. Categorising the population of farm households by 'decile' means that the households have been ranked according to income and then divided into ten even groups. The group with the lowest income is called the first decile, the next, higher, income group is the second decile and so on up to the highest income group, which is the tenth decile. In this table, we can see the potential vulnerability of farms in the lowest two income groups, who spend the equivalent of 17–28% of disposable income on fertilisers. The high amount spent on fertiliser on such low incomes leads one to question whether they are viable at all, or whether they are applying vastly excessive amounts of fertiliser for their scale of activity. Cross-tabulations could be undertaken, though they were not carried out here, and care would be needed owing to the small number of respondents in each cell when the sample is subdivided.

Having seen the patterns of expenditure on fertilisers, the imposition of a fertiliser tax is examined next. For illustration it is assumed that the zero rate of VAT on fertilisers is raised to the low VAT rate of 13.5%. In the absence of deductibility and any decline in purchases, this would yield some €50 million. The rate of 13.5% does not represent the marginal damage cost, which is not known, but it is chosen here because it is a rate that would be allowed, according to the Tax Strategy Group of the Department of Finance (TSG 03/07). It seems to be a reasonable rate to apply in order to gain an indication of the effect a fertiliser tax could have on the farm household's disposable income. Figure 3.1 indicates the

Table 3.6. Expenditure on fertilisers relative to farm income and disposable income, by income decile, %.

Gross income deciles	Expenditure on fertiliser relative to: Farm income	Disposable income
1st	48	28
2nd	34	17
3rd	23	11
4th	28	10
5th	24	10
6th	25	12
7th	26	9
8th	20	9
9th	21	9
10th	20	10
Average	23	10

share of household disposable income that such a tax would represent.

The tax would be less than 2% of disposable income in the four smaller categories, and would be nearly negligible in the lowest. Some farms in the two high categories could in all probability be already registered for VAT, in which case deductibility returns the tax to them, and by filling in a slightly extended VAT form that includes quantities, information on their nutrient inputs and outputs is provided to the system which could verify that their nutrients are in balance.

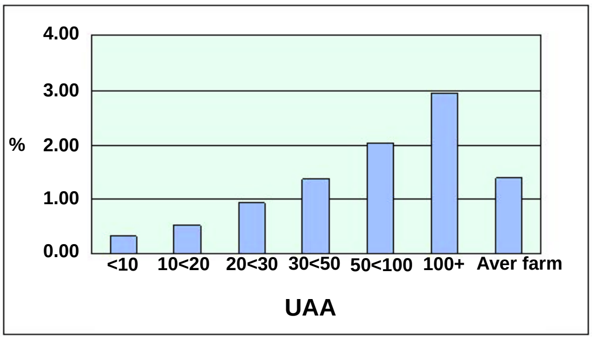

Figure 3.1. Fertiliser tax as a share of household disposable income, by size of farm expressed in Utilised Agricultural Area (UAA).

The impact of the tax by farm system is shown in Fig. 3.2. Looking at shares of household disposable income, farmers engaged in 'Mainly tillage' and in the Dairying systems experience the strongest impact.

Again the figures of most relevance from the farm household's point of view are the percentages relating to disposable incomes, but the percentages relating to farm incomes are interesting in telling one about the enterprise. It is tillage farmers that are more likely to be VAT registered and to be able to deduct the VAT paid on their inputs. Next, the dairy farmers would feel the biggest impact; again those that are VAT registered would have it deducted, those not registered would receive the flat-rate compensation based on the raised average rate. Intensive fertiliser users could be encouraged to register for VAT in order to be able to deduct. With the information on their nutrient inputs and outputs becoming available to the authorities in the extended VAT returns, they may be encouraged to rein in any excess.

Finally, the impact of the fertiliser tax is shown by income decile. Figure 3.3 shows how the imposition of VAT at 13.5% on fertilisers could impact harshly on the two lowest income deciles, as expected. The tax would represent more than 2% of disposable income, and that is on households with the lowest incomes. The flat-rate deduction would help them, but the figures here may reveal an underlying problem of inadequate or precarious income that could be vulnerable under the commercial conditions brought about by CAP reform, regardless of whether there is a fertiliser tax. As some form of retirement scheme is likely to be needed in any event, these farms could avail of that, but the Farm Assist payments can also be called upon. As they stand, households in the lowest decile are stating that they have a weekly disposable income of €87/week. This is less than the single person's maximum weekly Farm Assist payment of €135/week.

3.9 The Environmental Effect

It was seen in Part 1 that estimates of the price elasticity of demand for fertilisers vary but a modest figure in the region of –0.3% is assumed. Therefore, the rise in fertiliser price of 13.5% from the imposition of tax (leaving deductibility and flat-rate compensation temporarily aside) can be expected to reduce purchases by 4.05% in the short term. In the longer term, the effect could be larger in the way that a higher price can provide

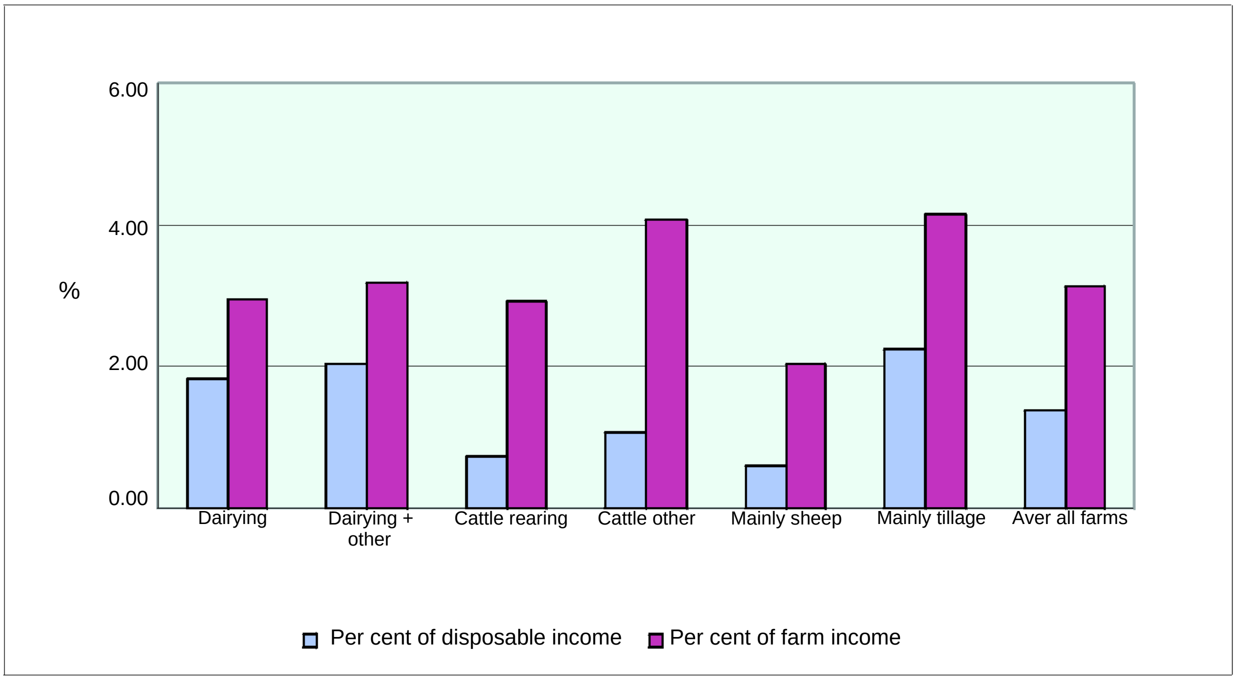

Figure 3.2. Fertiliser tax as a share of household disposable income, by farm system.

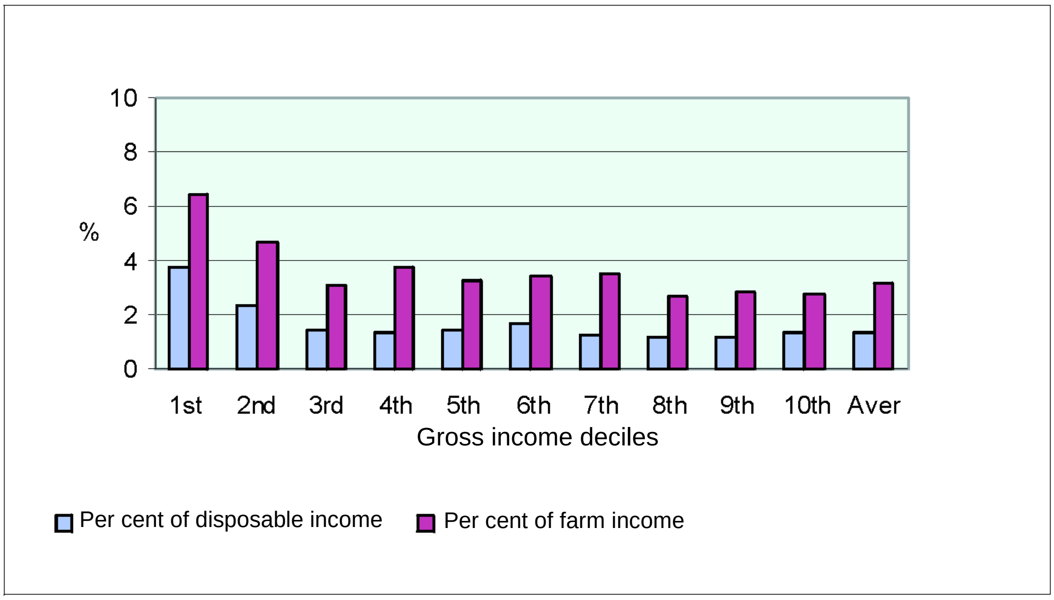

Figure 3.3. Fertiliser tax as a share of household disposable income and farm income, by income decile.

an ongoing incentive to further efficiency and encourage the development and adoption of new technologies.

An idea of the environmental result can be given in terms of the minimum effect only, noting that 8 kg P/ha is the most recent estimate of surplus P that is being applied to land and this is the target variable to try to reduce (McGarrigle, 2004, p. 215). What inroads into this surplus of 8 kg P could the 4.05% reduction in general fertiliser application make?

Taking the 2003 quantity of fertiliser applied, 1,628 thousand tonnes as shown in Table 3.1, the 4.05% decrease on foot of the price rise would amount to reduced application of nearly 66,000 tonnes of fertiliser. This refers to fertiliser in general and is therefore unspecified as to nutrient content. With 4.37 million hectares being the ‘area farmed’, according to the Crops and Livestock Survey June 2003, such a reduction means an average reduction of 15.1 kg of fertiliser per hectare. This could underestimate the decrease per relevant hectare because not all the area farmed is subject to fertiliser application.

Estimation of the reduction in P per hectare that could be expected on foot of the reduction of 15.1 kg/ha in unspecified fertiliser is not readily possible. On the crude basis of the proportion of nutrient P to *total* fertiliser, given in Table 3.1, where the quantity of P is about 3% of total quantities applied, this could translate into a reduction in the region of 0.5 kg P/ha. That is an inroad of one-sixteenth on the excess of 8 kg P/ha. Given the use of conservative figures, and given that marginal damage per unit of pollution tends to be greater than average damage per unit, this reduction in excess nutrients can be regarded as a minimum estimate.

As for the effect on the environment of taking deductibility and flat-rate compensation into account, in the case of VAT-registered farmers the effect on their behaviour of simply imposing a positive rate of VAT might be negligible if they would see themselves as getting back the VAT. Numbering some 4,500 or so, they would, however, have the incentive to keep their nutrient inputs and outputs in balance, given that the VAT system would reveal their nutrient behaviour and that they would be subject to the legislative controls. It was seen that if farmers would undertake nutrient bookkeeping, this would be a major advance.

The expected effect in the case of those not registered could be the full 4% decline in their fertiliser use on average, given above.

Depending on how the policy is applied and the support from other policies, imposing VAT on fertilisers could play a useful role in addressing diffuse pollution from agriculture.

3.10 Conclusions on Part 3

Current policies are being put in place to reduce diffuse and point-source pollution. These include the phosphorus regulations, the measures under the Nitrates Directive, and Water Framework Directive, and investment in waste-water treatment. Many of the approaches are prescriptive, and require credible monitoring, verification and enforcement. Economic instruments that target the underlying incentives have not been widely applied, though they can have many advantages including reducing the need for monitoring and verification.

An example of a possible economic instrument was given that would involve extending the VAT system to deal with fertilisers. It would require farmers to fill in quantities, not just values, of inputs and outputs from the farm in the VAT returns. Records of inputs and outputs would enable the nutrient balance to be calculated by scientific personnel who would be engaged to work within the Revenue system.

If the present zero rate of VAT on fertiliser were left unchanged, this reform would at least mean that nutrient bookkeeping could be required on the part of the biggest farms, numbering some 4,500. Nutrient bookkeeping is considered to be a foremost requirement for combating diffuse pollution.

If the zero rate of VAT were raised to 13.5%, deductibility and flat-rate compensation would protect incomes. VAT-registered farmers would be able to deduct VAT, but nutrient bookkeeping would have been achieved.

Farmers who are not registered for VAT would face a relative price change, and a reduction in fertiliser use of the order of 4% could be expected on their part. Those farmers who are relatively fertiliser intensive would feel the impact on their incomes and those in the low-income deciles revealed in the analysis would need assistance to reduce their fertilisation and to make their incomes viable, or perhaps help them to retire in the face of the commercial conditions expected under CAP reforms.

Part 4 Summary and Conclusions

4.1 Context

- The extent of the problem of excess nutrients from fertiliser application is serious and unless loss rates are substantially reduced, all our large lakes are under threat from eutrophication.
- Fertiliser application is implicated in two other problems: acidification of soils and water, and in production of greenhouse gases that cause climate change.
- The costs of damage measured to date elsewhere, though incompletely, are sizeable and justify commensurate effort directed at abatement.
- The main types of policies that are available, regulation, education, and economic instruments, all have a role to play. The criteria for applying policies should be that they can be correctly targeted, can be effective with reasonable administration costs, and that they be fair and without socially undesirable effects. Given the diffuse nature of agricultural pollution, and the many possible causes, policing it is particularly expensive and points to the need for correct incentives to minimise compliance costs.
- Because the damage caused is external to the farm, there will be a natural tendency to apply excessive amounts of fertiliser. In making their decisions, farmers do not usually face the costs that insensitive fertilisation imposes on others. Over-application takes care of risk, saves bother in finding out the precise correct requirement, and in any case the use of the environmental ‘sink’ to absorb the surplus is free.
- The imposition of an economic instrument such as a tax on fertilisers is a good way to rectify this problem and the ensuing price rise would result in decreased application. A price rise of 10% would be expected to reduce application by roughly 3% in the short run – by possibly more if other measures such as education are also employed.

4.2 Experience of Taxes Elsewhere

- Analyses undertaken by six European research institutes found that a levy on fertiliser nitrogen (N) could bring about significant results and applying the levy to *surplus* N would be more appropriate for fine-tuning. The levy on surplus nutrients would involve bookkeeping to calculate the nutrients brought in to the farm and those going off the farm embodied in farm produce. A combined levy on N in fertiliser and feed did not generate better results.
- The reason that the levy was favoured over prescriptive regulations was that it gives farmers more adjustment options, in terms of inputs, practices and structures. The levy could also be adjusted to allow for differences in terrain and to permit a certain level that would be levy free.
- The Netherlands has had 6 years of experience with the tax on excess nutrients, called MINAS, which stands for MINeral Accounting System. Farms have to register and submit accounts of N and P (phosphorus) on farms and their surpluses. The levy was pre-announced and the rates became progressively higher.
- Initial results suggest that improvements in nitrogen surpluses have taken place, as shown in Fig. 2.1. MINAS is considered partly responsible for this. It was introduced alongside a support program, which shares some responsibility for the success. The quality of water has also shown signs of improvement (Fig. 2.2 and Table 2.3). MINAS is to be abandoned, unless a derogation is obtained, because the European Court of Justice did not regard it as satisfying the requirements of the Nitrates Directive.
- Experience in the USA with a system of tradable emissions permits between point source and diffuse sources has revealed implementation hurdles and particularly the difficulty of enforcing trades. Because run-off cannot be measured the target is expected run-off, but monitoring is still difficult.

- A strategic review by the Department of Food and Rural Affairs in the UK recently considered all the main policy instruments for controlling diffuse pollution from agriculture. It took account of the damage costs from diffuse pollution and the infraction fines that could be due for infringements under the Water Framework Directive if good water status is not achieved. An initial appraisal of policy options is made. It considers fertiliser levies to have worthwhile attributes and that they could be used to reduce polluting inputs at a broad and shallow level. They could be used with other policies with which useful synergies are noted.

4.3 Options for Ireland

- Policies of a largely prescriptive nature are in place or are in the process of being finalised – these consist of among others the Phosphorus Regulations and measures under the Nitrates Directive. These on their own require a strong commitment of resources for monitoring, verification and policing.

- A tax or levy is another option that would help to address the underlying incentive to apply excessive amounts of fertiliser. A whole new system of administration and bookkeeping would be undesirable and there are calls and helpful suggestions, from the National Statistics Board for example, for more synergies to be exploited in reporting and administration, to produce more information for the effort expended and to cut down on form-filling.

- With these considerations in mind, the option of exploiting the VAT system to address over-fertilisation presents itself. Given the foremost need for bookkeeping on nutrients, with minor changes to the VAT forms information could be routinely obtained from VAT-registered farms on their inputs and outputs. These farmers number some four to five thousand and would have large intensive farms. The records of inputs and outputs would enable the nutrient balance to be estimated and checked with the help of scientific personnel engaged by Revenue, subject to safeguards for confidentiality. Such a procedure would appear not to contravene VAT rules. Farmers thus identified as applying excessive nutrients could be dealt with under legislation.

- The current zero rate of VAT on fertilisers in Ireland is unusual, if not unique, in the EU 15. A positive rate on fertilisers could be justified and the rate could be raised to 13.5%, which is the current low VAT rate. Deductibility in the case of VAT-registered farmers, and flat-rate compensation in the case of the vast majority of farmers who are not registered (over 95%), would mean that they would suffer no long-term loss of income. The exception would be those non-registered farmers who apply above average amounts of fertiliser. Non-registered farmers would find that fertilisers had become relatively more expensive and usage would tend to reduce by some 4%, and by possibly more depending on other polices in place. Registered farmers would be subject to the analysis of their nutrient balances as described above.

- The impact of a fertiliser tax on farm income and on disposable income, that is including off-farm earnings, has been calculated. The results, shown in Part 3, are given by farm size, farm system and farm incomes. The impact of a fertiliser tax of 13.5% on the disposable incomes of farm households averages under 1.4%. It ranges from under 0.5% in the case of farms with the lowest farm size (under 10 UAA), to just under 3% for the largest farms (of farm size 100 or more UAA, shown in Fig. 3.1). This is without considering deductibility or flat-rate compensation.

- To ensure against the possibility of temporary hardship, the Farm Assist programme would need to be prepared for any VAT change. Farm retirement programmes introduced on foot of CAP reform would need to be sensitive to the difficulties of fertiliser-intensive farms that were not registered and have low incomes.

- The 4% reduction in fertiliser usage could amount to an average reduction of 15.1 kg/ha. This is leaving aside VAT deductibility and it refers to general fertiliser, which is unspecified as to nutrient content. It should be viewed in the context of the current nutrient-specific surplus of 8 kg P/ha estimated by the EPA.

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Acronyms and Abbreviations

P	Phosphorus	1 g P = 2.29 g phosphate
P_2O_5	Phosphate	
CP	Crude protein	1 g CP = 6.25 g Nitrogen
N_2O	Nitrous oxide, a greenhouse gas	1 tonne of N_2O = 310 tonnes of CO_2 equivalent
NH_3	Ammonia, acid rain precursor	1 tonne NH_3 = 1.8824 tonnes SO_2 equivalent

Appendix 1 Pesticides Levy

The Department of the Environment, Transport and the Regions (DETR) in the UK undertook a preliminary study of a pesticide tax in 1999. The analysis indicated a number of conclusions, the main ones being the following:

- A tax or charge scheme can be designed to meet the objectives of the instrument. For reasons both of economic efficiency and environmental effectiveness a banded per kg tax instrument with supporting measures is preferred.
- The environmental benefits of the instrument are extremely difficult to quantify. The reduction in use of between 8% and 20%, with a banded 30% or equivalent tax, disguises larger reductions for more hazardous products.
- The estimated compliance costs and deadweight losses (added together) amount to some Stg £4–10 million. Environmental benefits of at least this order are required from a 30% or equivalent tax. Given the potential scale of damage costs, it is not unreasonable to expect at least this level of benefits, particularly from a banded instrument which concentrates on reductions in the use of more hazardous chemicals.
- The major trade-off between these benefits and the socio–economic consequences of a tax or charge are the potential effects on profitability and earnings in certain farming sectors. These effects could result in some 2% or 300 farm enterprises becoming unprofitable. The increase in costs could result, in the absence of any adjustment, in the loss of some 1,000–2,000 full-time equivalent jobs. In the longer term, the instrument could improve job retention by promoting early adjustment to market conditions consistent with possible future CAP reform.
- In the light of experience with other instruments, advance notice of the intention to introduce the instrument would improve its effectiveness and reduce the adjustment period and related costs.

The tax approach was not developed because farmers said they would implement voluntary agreements, though there may be a return of interest in the tax option. Correctly implemented, a pesticides tax requires higher charges to be levied on those products that do most harm. The hazard ought to be ranked and then reflected in the setting of tax rates.

A Pesticides Voluntary Initiative led by the Crop Protection Association was set up and it is seeking to reduce the impact of pesticides on the environment. It has three major targets. Its main success was to overshoot its target to have 200,000 ha of arable land under crop protection management plans by the end of March 2004. Thanks largely to several crop assurance schemes, which have made these plans mandatory, the coverage achieved by mid-March was 641,000 ha – though this is still only 12.5% of the arable area. Performance on the remaining two targets was less successful. By mid-March, 4,180 pesticide sprayers had been tested against a target of 5,000 for the end of the month, while 13,310 spray operators had joined a national training and registration scheme against a target of 15,000.

It is noted that the targets set under the Voluntary Initiative need to be related more directly to environmental impacts to enable its success to be measured. The above targets relate to the ‘how’ and not to the environmental improvement. Evidently, a pesticides levy is still considered to be an option to be subjected to further technical research.

Appendix 2 The VAT Form

€ VAT Return of Trading Details

(Enter Euro's or 00 Only)	Supplies of Goods & Services & Intra-EU Acquisitions		Deductible Inputs (i.e. purchases, Intra-EU acquisitions & imports)	
	Supplies of Goods & Services Net of VAT	Acquisitions from EU Countries Net of VAT & VAT free imported parcels	Stock for Resale (purchases, Intra-EU acquisitions & imports) Net of VAT	Other Deductible Goods & Services (purchases, Intra-EU acquisitions & imports) Net of VAT
VAT Rate	Total Value €	Total Value €	Total Value €	Total Value €
Exempt	E3	E4	E5	E6
0% Exports	D4			
0% Home	D1	D2	J1	J2
	C5	C6	H5	H6
	AC5	AC6	AH5	AH6
	P1	P2	R1	R2
	B5	B6	G5	G6
TOTALS	Z1	Z2	Z3	Z5

(DO NOT LEAVE TOTALS BOXES BLANK)

I declare that this is a correct return of trading for the period specified:-

Signed: ____________________ Status: ____________________ Date: ____________________

RTD EUR

Notes on the Completion of the Return of Trading Details:

This form **must** be completed by all registered traders giving a breakdown of the supplies of goods and services, imports and deductible inputs at the various rates applicable during the year. This should include all Irish, Intra-EU and overseas trade.

The "VAT Return of Trading Details" is an ANNUAL return, covering the period shown on the front of the form.

If no trade was carried out during the period enter "00" in the total box Z1.

Enter purchases net of VAT and sales net of VAT on this form. A declaration of VAT payable by you or repayable to you should be made on a VAT3 form.

The TOTALS boxes (Z1, Z2, Z3 and Z5) should include **all** turnover including that at the zero and exempt rates - these boxes are not intended to show the amount of VAT charged or paid.

For traders availing of the 7th Directive Margin Scheme, relating to the sale of second hand goods only, the margin obtained on the supply of such goods should be included in the **total** figures for **supplies** shown.

If you have any further queries as to how you account for trading details on this form, ring 1890 203070 and ask for the Return of Trading Details helpline.

Queries regarding liability to VAT or on the rate of VAT to be charged should be directed to your local Inspector of Taxes.

Please return the Return of Trading details by the due date. Failure to do so will leave you liable to a penalty of €1,520.

Appendix 3 Data on expenditure on fertilisers derived from surveys undertaken by Teagasc and the CSO

Table A1. Expenditure on fertiliser and crop protection, farm income and total household income, per farm, broken down by gross income decile, 1999/2000 euro per week.

Gross income deciles (per week)	Expenditure on:		Total direct income, A	Of which farm income	State transfers, B	Gross income, A + B	Disposable income (after tax)	No. of households in sample	Weighted no. of households
	Fertiliser	Crop protection							
1st <143.54	24.3	1.6	72.09	51.09	20.55	92.64	86.95	52	55.66
2nd –231.89	31.93	2.16	123.87	93.07	68.86	192.73	182.88	59	58.64
3rd –324.61	27.8	2.46	191.34	123.1	83.74	275.09	257.61	52	57.81
4th –415.93	33.51	4.17	283.96	120.63	87.22	371.18	348.17	59	57.23
5th –515.54	46.13	7.07	385.6	189.48	83.76	469.36	440.71	57	57.08
6th –634.16	63.57	20.57	508.4	250.48	60.48	568.88	522.42	65	56.82
7th –786.48	58.49	8.38	644.57	228.19	60.29	704.86	623.42	66	57.18
8th –979.44	68.79	6.6	810.1	345.39	83.24	893.34	791.92	74	57.30
9th –1238.22	84.31	14.37	1026.07	404.97	69	1095.07	965.71	72	57.05
10th >1238.22	143.53	47.15	1661.06	706.94	50.69	1711.74	1496.79	88	57.60
All farm households	58.28	11.47	571.26	251.64	66.92	638.19	572.28	644	572.38

Source: Teagasc and CSO (J. Dalton), sample of National Farm Survey households participating in the Household Budget Survey.

Table A2. Expenditure on fertilisers and crop protection, farm incomes and total household disposable income, per farm, broken down by farm system, 1999/2000 euro per week.

Farm system	Expenditure on:		Total direct income, A	Of which farm income	State transfers, B	Gross income, A + B	Disposable income (after tax)	No. of households in sample	Weighted no. of households
	Fertiliser	Crop protection							
Dairying	96.78	4.27	734.55	442.71	59.67	794.21	712.64	152	111.29
Dairying + other	98.84	15.02	686.11	418.77	51.37	737.48	655.07	123	86.96
Cattle rearing	25.15	0.9	442.05	116.29	69.25	511.3	463	117	135.05
Cattle other	35.65	3.23	434.24	118.14	75.71	509.95	451.01	108	115.88
Mainly sheep	23.36	1.69	513.33	154.75	83.78	597.11	537.06	97	93.53
Mainly tillage	146.86	142.81	924.16	478.89	42.21	966.37	882.17	43	28.79
Other	–*	–*	–*	–*	–*	–*	–*	4	0.88
All farm households	58.28	11.47	571.26	251.64	66.92	638.19	572.28	644	572.38

Source: Teagasc and CSO (J. Dalton), sample of National Farm Survey households participating in the Household Budget Survey.

*No details are given as the sample size is too small.

Table A3. Expenditure on fertilisers and crop protection and income, per farm, classified by Utilised Agricultural Area (UAA), 1999/2000 euro per week.

UAA	Expenditure on:		Total direct income, A	Of which farm income	State transfers, B	Gross income A + B	Disposable income (after tax)	No. of households in sample	Weighted no. of households
	Fertilisers	Crop protection							
<10	8.00	0.61	277.34	64.76	95.55	372.89	341.84	24	38.97
10<20	17.22	1.06	407.40	83.53	89.71	497.11	449.41	82	122.28
20<30	33.33	1.91	467.57	149.70	64.84	532.40	481.54	111	130.68
30<50	59.42	7.41	611.56	295.33	58.70	670.26	592.96	226	161.46
50<100	117.99	24.40	818.45	466.92	51.29	869.74	778.04	153	95.51
100+	243.79	112.17	1207.25	828.64	32.54	1239.79	1120.60	48	23.47
All farm households	58.28	11.47	571.26	251.64	66.92	638.19	572.28	644	572.38

Source: Teagasc and CSO (J. Dalton), sample of National Farm Survey households participating in the Household Budget Survey.