

# Bulletin

of the International Dairy Federation

---

---

443/  
2010

## Environmental issues at dairy farm level



**VIEW THE UPCOMING IDF EVENTS AT:**

<http://www.fil-idf.org/EventsCalendar.htm>

## Bulletin of the International Dairy Federation 443/2010

© 2010, International Dairy Federation

### GENERAL TERMS AND CONDITIONS FOR USING THIS ELECTRONIC PUBLICATION

#### **Introduction**

Use of the material provided in this publication is subject to the Terms and Conditions in this document. These Terms and Conditions are designed to make it clear to users of this material what they may and may not do with the content provided to them. Our aim has been to make the Terms and Conditions unambiguous and fair to all parties, but if further explanation is required, please send an e-mail to [info@fil-idf.org](mailto:info@fil-idf.org) with your question.

#### **Permitted Use**

The User may make unlimited use of the Content, including searching, displaying, viewing on-screen and printing for the purposes of research, teaching or private study but not for commercial use.

#### **Copyright**

Site layout, design, images, programs, text and other information (collectively, the "Content") is the property of the International Dairy Federation and is protected by copyright and other intellectual property laws. Users may not copy, display, distribute, modify, publish, reproduce, store, transmit, create derivative works from, or sell or license all or any part of the content obtained from this publication. Copyright notices must not be modified or removed from any Content obtained under the terms of this licence.

Any questions about whether a particular use is authorized and any requests for permission to publish, reproduce, distribute, display or make derivative works from any Content should be directed to [info@fil-idf.org](mailto:info@fil-idf.org)

#### **Availability**

Although the International Dairy Federation publications are developed in view of maximum user-friendliness, the International Dairy Federation cannot guarantee any of these products to work on or with any particular computer system.

#### **Liability**

Although the International Dairy Federation has taken reasonable care to ensure that the information, data and other material made available in its publication is error-free and up-to-date, it accepts no responsibility for corruption to the information, data and other material thereafter, including but not limited to any defects caused by the transmission or processing of the information, data and other material. The information made available in this publication, has been obtained from or is based upon sources believed by the International Dairy Federation to be reliable but is not guaranteed as to accuracy or completeness. The information is supplied without obligation and on the understanding that any person who acts upon it or otherwise changes his/her position in reliance thereon does so entirely at his/her own risk.

Send any comments or inquiries to:  
International Dairy Federation (I.N.P.A.)  
Diamant Building  
Boulevard Auguste Reyers 80  
1030 Brussels  
Belgium  
Phone: + 32 2 733 98 88  
Fax: + 32 2 733 04 13  
E-mail: [info@fil-idf.org](mailto:info@fil-idf.org)  
Web: [www.fil-idf.org](http://www.fil-idf.org)

# Bulletin of the International Dairy Federation

PRICE : Free of charge

443/2010

## CONTENTS

### Environmental issues at dairy farm level

<b>Foreword</b>	<b>1</b>
<b>Introduction</b>	<b>2</b>
<b>1. Overview of the main environmental issues at farm level and the work that has already been done in the guide to good dairy farming practice</b> T. Hind	<b>3</b>
<b>2. The global environmental consequences of the livestock sector's growth</b> P.J. Gerber, H. Steinfeld	<b>4</b>
<b>3. Nutrient issues on Irish farms and solutions to lower losses</b> J. Humphreys	<b>13</b>
<b>4. Energy Use on Dairy Farms</b> J. Barnett, J. Russell	<b>23</b>
<b>5. Pesticide consumption at farm level and residues in the environment and in milk</b> S. Bertrand	<b>33</b>
<b>6. Outcome from Edinburgh summit, Climate Change – the heat is on</b> J. Gilliland, A. Fagerberg, P. Gerber, M. Gill	<b>39</b>



Subscription Price for the electronic version of the 2010 Bulletin : 335 Euro for all issues.

Address orders to :

INTERNATIONAL DAIRY FEDERATION / FEDERATION INTERNATIONALE DE LAITERIE

Diamant Building, Boulevard Auguste Reyers, 80 - 1030 Brussels (Belgium)

Telephone : +32 2 733 98 88 - Telefax : +32 2 733 04 13 - E-mail : [info@fil-idf.org](mailto:info@fil-idf.org) - <http://www.fil-idf.org>

# Environmental issues at dairy farm level

## Foreword

The author of the first paper identifies the problem faced by the dairy sector in the following words: *"if the dairy sector does not take responsibility for its environmental impacts, it is certain that policy makers and indeed food retailers will do so. This could be more damaging and it is better that the industry tries to tackle it head-on."* In fact the dairy sector has been giving these issues serious attention for many years, starting significantly before the global environment attracted as much public interest as it does today.

IDF would like to thank the organizers and the hosts, in Dublin and Edinburgh, of the two events at which the reports in this issue of the Bulletin of IDF were first presented. IDF also thanks the speakers, T. Hind (GB), P.J. Gerber and H. Steinfeld (FAO), J. Humphreys (IE), J. Barnett and J. Russell (NZ) and S. Bertrand (FR) and J. Barnett (NZ) for their work in putting together and editing the text.

Christian Robert  
Director General  
International Dairy Federation

Brussels, May 2010

## Introduction

The agriculture sector today is facing three challenges: the need to produce more (to feed the growing population), to produce better (respect the environment), and to produce something different (environmental services...). These three goals lead to contradictions and tensions that need to be resolved in an agricultural land area that is limited. The Dairy Industry is no exception to these challenges. At international and national level, the dairy Industry has to address its environmental impact or face criticism. The main concern or pressure is the impact of the Dairy Industry on Climate Change, because of the methane released by the rumen of the dairy cows. But it concerns also the impact of the dairy farm on soil, water, air and how to maintain biodiversity.

This issue of the Bulletin of IDF comprises the papers from an Environment workshop held on 4 October 2007 at the IDF World Dairy Summit in Dublin and the summary from the first IDF Dairy Farming Summit held on 25-27 June 2008 in Edinburgh. These papers are an attempt to address the main environmental issues for the Dairy sector but do not try to cover them all, seeing that the time for the workshops was limited.

The bulletin does not cover Climate Change in detail because the IDF has already published a specific bulletin on the Climate Change issue in 2008 (Reduction of Greenhouse gas Emissions at farm and manufacturing level, Bulletin of IDF No 422).

Sophie Bertrand  
Action Team Leader

## 1. Overview of the main environmental issues at farm level and the work that has already been done in the guide to good dairy farming practice

T. Hind<sup>1</sup>

There is an increasing public consciousness about the environment and the impact that livestock farming has on it. The relative contribution to environmental damage and improvement from livestock farming is somewhat unsurprising when pasture land takes up some 27% of the world's surface area.

The level of concern about the environment around the world is not uniform. Even in the developed world, where environmental issues are seen as priority, the relative importance of those issues and the emphasis varies considerably.

The main environmental issues at farm level include:

1. Water – protecting drinking water from diffuse water pollution and contaminants from farming as well as sustaining the availability of fresh water
2. Soil – maintenance of soil structure, erosion and contamination
3. Habitats – the protection of habitats from 'intensive' dairy farming activities and ensuring biodiversity in the farmed environment
4. Air – reducing the level of ammonia and greenhouse gases that come from cattle
5. Climate change – minimising any negative impacts of climate change and mitigating potentially damaging activities.

It is very easy to become defensive about the contribution of dairy farming to environmental damage. But it is important to recognise that the story is not so clear-cut. The science underpinning many of the 'facts' is imperfect. According to many measurements, dairy farming's contribution to environmental is reducing. And farming does a good job in achieving wider sustainability objectives. It also has a good story to tell.

However, if the dairy sector does not take responsibility for its environmental impacts, it is certain that policy makers and indeed food retailers will do so. This could be more damaging and it is better that the industry tries to tackle it head-on. The case for taking responsibility is compounded by the fact that the dairy farmers themselves know which programmes or measures are most achievable. There are a number of examples from around the world that show how dairy farming is working to improve its environmental footprint.

The IDF Guide to good dairy farming practice sets out a small number of measures that constitute a basic level of protection. There is a question mark about whether it should go further. However it must be borne in mind that the standards required to protect the environment are likely to vary from country to country and an approach based on setting standards does not always secure positive improvement. It is better to focus on a relatively small number of 'win-win' measures that deal with a multitude of sins such as nutrient planning, anaerobic digestion and improvements in breeding and feeding.

There is a danger that dairy industries in different parts of the world are seeking to exploit their environmental performance to compete with each other. The classic example of this is the food miles versus carbon footprint debate that has been taking place between the UK and New Zealand dairy industries. The real competition in the eyes of the public however lies between dairy and non-dairy and it is incumbent on the entire world dairy industry to take on the anti-dairy lobby rather than take on itself.

---

<sup>1</sup> NFU Chief Dairy Adviser, United Kingdom.

## 2. The global environmental consequences of the livestock sector's growth

P.J. Gerber<sup>1</sup>, H. Steinfeld<sup>1</sup>

### Abstract

The growth of the livestock sector is being achieved at substantial environmental cost. Today, livestock is a major stressor of the global environment, occupying a quarter of emerged land (a third of agricultural land), contributing to a fifth of anthropogenic greenhouse gas emissions, using 8 percent of water resources and threatening a wide range of endangered species. Livestock is also a crucial engine of rural growth and an asset for improving food security. Policies are required to guide the sector in achieving contrasted development objectives. Potential pathways include encouraging resource efficiency, correcting environmental externalities and accelerating technology change.

### 2.1. Introduction

The increase in demand for animal products driven by growing populations and incomes is stronger than for most food items. Global production of meat is projected to more than double from 229 million tonnes in 1999/2001 to 465 million tonnes in 2050, and that of milk to increase from 580 to 1043 million tonnes (FAO, 2006). The bulk of the growth in meat and milk production will occur in developing countries, with China, India and Brazil representing two thirds of current meat production and India predicted to grow rapidly, albeit from a low base. Poultry will be the commodity of choice for reasons of acceptance across cultures and technical efficiency in relation to the use of feed concentrates. It is expected that intensive systems will contribute to most of the increase in production, as they have done in the past three decades.

The livestock sector has a primary and growing role in the agricultural economy. It is a major provider of livelihoods for the larger part of the world's poor. It is also an important determinant of human health and component of diets. Global demand for livestock products is projected to double by 2050, yet despite this growth, per capita consumption in developing countries will be no more than half that in developed countries (FAO, 2006). But already the livestock sector is a source of instability to many ecosystems and contributes to global environmental problems. Greenhouse gas emissions from livestock production and consequent waste, and from pasture expansion into forests are important contributors to climate change. The presence of livestock in the vast majority of the world's ecosystems affects biodiversity and in both developed and rapidly developing countries, it is often a major source of water pollution (Steinfeld *et al.*, 2006).

The future of the livestock environment interface will be shaped by how we resolve the balance of two competing demands: one for animal food products and the other for environmental services. Both demands are driven by the same factors: increasing populations, growing incomes and urbanization. The natural resource base within which these must be accommodated is finite and the continuing expansion of the global livestock sector must, therefore, be accomplished and accompanied by substantial reductions in livestock's environmental impact.

This paper draws from a report submitted to the 20<sup>th</sup> session of the Food and Agriculture Organisation of the United Nation (FAO) Committee On Agriculture (COAG), held on 25 to 28 April 2007 in Rome. It summarizes recent studies on these issues – especially "Livestock's Long Shadow, environmental issues and options" (Steinfeld *et al.*, 2006) – and suggests possible lines of action for dealing with the environmental challenges posed by the sector.

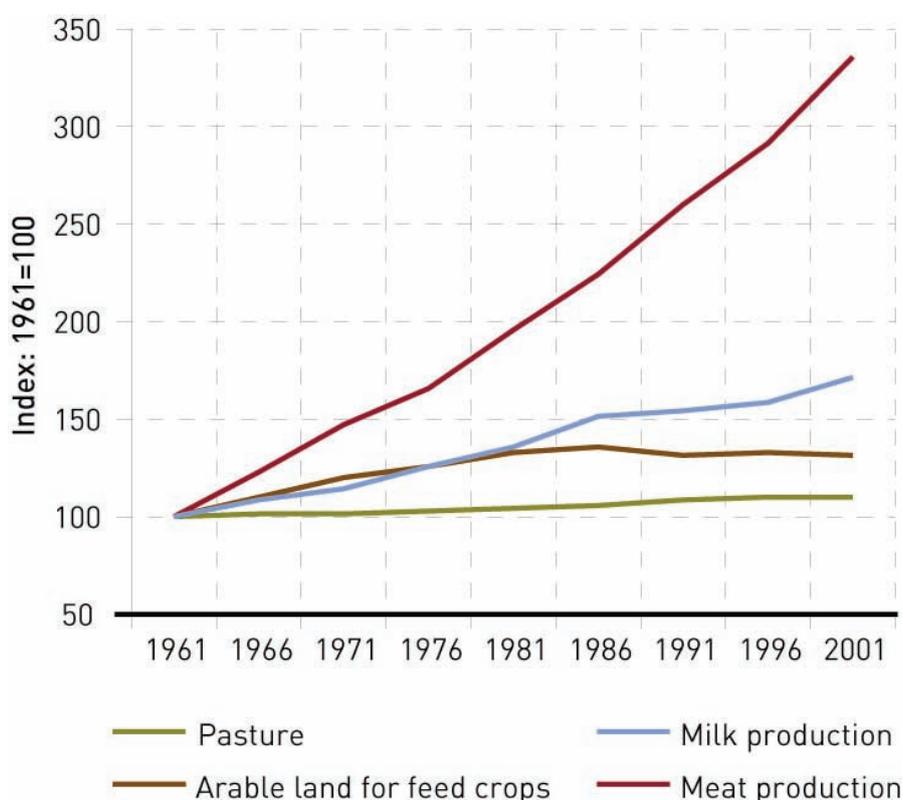
---

<sup>1</sup> Livestock information, sector analysis and policy branch of the Food and Agriculture Organization of the United Nations (FAO) - Livestock Environment And Development (LEAD) initiative (Rome, Italy).

## 2.2. Environmental impacts

### 2.2.1. Humanity's largest land user

Livestock's land use includes (a) grazing land and (b) cropland dedicated to the production of feed, and amounts to approximately 70 percent of all agricultural land. (Figure 2.1)



**Figure 2.1 :** Trends in land-use area for livestock production and total production of meat and milk.

The total land area used for livestock grazing is 3.4 billion hectares which is equivalent to 26 percent of the ice-free terrestrial surface of the planet. A large part of this is too dry or too cold for crop use, and only sparsely inhabited. While the grazing area is not increasing on a global scale, in tropical Latin America there is rapid expansion of pastures which encroaches into valuable ecosystems, with 0.3 to 0.4 percent of forest lost to pasture annually. Ranching is a primary reason for this deforestation.

About 20 percent of the world's pastures and rangeland have been degraded to some extent, which may be as high as 73 percent in dry areas (UNEP, 2004). The Millennium Ecosystem Assessment (MEA, 2005) has estimated that 10 to 20 percent of all grassland is degraded, mainly by livestock. However, some of the dryland grazing ecosystems have proved to be quite resilient and degradation has shown to be partly reversible.

The total area dedicated to feed crop production amounts to 471 million hectares, equivalent to 33 percent of the total arable land. Most of this is located in Organization for Economic Co-operation and Development (OECD) countries, but some developing countries, e.g. in South America, are rapidly expanding their feed crop production, notably of maize and soybean. Again, a considerable part of this expansion is taking place at the expense of tropical forests. It is expected that future growth rates of livestock output will be based on matching rates of growth of

feed concentrate use (FAO, 2006). Without the necessary precautions, intensive production of feedstocks can result in land degradation, including soil erosion and water pollution.

### 2.2.2. Gaseous emissions and climate change

Recent estimates of global Green House Gas (GHG) emissions from different sources by the Intergovernmental Panel on Climate Change (IPCC), the United Nations Framework Convention on Climate Change (UNFCCC) and the "Stern Review", show that land use changes consequent on deforestation contribute 18.3 percent to total GHG emissions whilst agriculture accounts for 13.5 percent (of which agricultural soils is 6 percent, livestock and manure 5.1 percent) and the transportation sector 13.5 percent (of which road transport is 10 percent).

Estimates of GHG for the livestock sector are substantial when the different forms of emissions throughout the livestock commodity-chain are taken into account. GHG emissions arise from feed production (e.g. chemical fertilizer production, deforestation for pasture and feed crops, cultivation of feed crops, feed transport and soil organic matter losses in pastures and feed crops), animal production (e.g. enteric fermentation and methane and nitrous oxide emissions from manure) and as a result of the transportation of animal products. It can thus be shown that livestock contribute about 9 percent of total anthropogenic carbon-dioxide emissions, but 37 percent of methane and 65 percent of nitrous oxide emissions. The combined emissions expressed in CO<sub>2</sub> equivalents amount to ca. 18% of anthropogenic GHG emissions. The commodity-chain methodology used in the report (Steinfeld *et al.*, 2006) is not used by the IPCC and, therefore, emissions may be attributed in a different manner.

Carbon dioxide is released when previously-forested areas are converted for feed into grazing or arable land. The expansion of pasture and cropland at the expense of forests releases significant amounts of carbon dioxide into the atmosphere as does the process of pasture and arable land degradation, often associated with a net loss of organic matter. Carbon dioxide releases resulting from fossil fuel consumption used for the production of feed grains (tractors, fertilizer production, drying, milling and transporting) and feed oil crops need also to be attributed to livestock. The same applies to the processing and transport of animal products. Methane is emitted from rumen fermentation and from livestock waste when stored under anaerobic conditions, for example, in so-called lagoons. Nitrous oxide emissions from intensive feedcrop production and related chemical fertilizer application need also to be considered.

Though not linked to climate change, ammonia is a polluting gaseous emission and 30 million tonnes of it emanate from livestock waste, accounting for 68 percent of the total ammonia released.

Technical options are available to mitigate the gaseous emissions of the sector. Carbon dioxide emissions can be limited by reducing deforestation and the sector can contribute to carbon sequestration through a range of practices including: restoring organic carbon in cultivated soils, reversing soil organic carbon losses from degraded pastures and sequestration through agro-forestry. Improved livestock diets and better manure management can substantially reduce methane emissions, whilst careful nutrient management (i.e. fertilization, feeding and waste recycling) can mitigate nitrous oxide emissions and ammonia volatilization. Furthermore, the use of biogas technology provides a means of redirecting emissions from manure management and increasing farm profit (e.g. from savings on energy bills, electricity trading) and providing environmental benefits, such as reduced fossil fuel consumption).

### 2.2.3. Depletion of water resources

The livestock sector accounts for about 8 percent of global water use the major part of which (about 7 percent) is used for irrigation of feed crops and pasture (mostly in developed countries). The water used for product processing, drinking and servicing is less than one percent of global water use, but it is often of great importance in dry areas; for example, livestock drinking requirements represent 23 percent of total water use in Botswana. The compacting effect of grazing and hoof action on the soil can have important consequences for water infiltration and water erosion.

Water quality can be affected by livestock as a result of the release of nitrogen, phosphorus and other nutrients, pathogens and other substances into waterways, mainly from intensive livestock operations. The industrialisation of the livestock sector, often in a number of concentrated locations, separates the sector from its supporting land base and interrupts the nutrient flows between land and livestock, creating problems of depletion at the source (land vegetation and soil) and problems of pollution at the sink (animal wastes increasingly disposed of into waterways instead of back on the land).

Water pollution often occurs through the release of animal manure into freshwater sources. These wastes are not cleared of sediments, pesticides, antibiotics, heavy metals and biological contaminants. Livestock land-use and animal waste-management appear to be the main mechanisms through which livestock contribute to the water depletion process.

Multiple and effective options for mitigation exist in the livestock sector that would allow the reverse of current water-depletion trends. Mitigation options usually rely on three main principles: reduced water use (e.g. through more efficient irrigation methods and animal cooling systems), reduced depletion, (e.g. through increased water productivity and alleviated pollution from waste management and feed crop fertilization) and improved replenishment of the water resources through better land management.

#### 2.2.4. Biodiversity erosion

Livestock affect biodiversity in many direct and indirect ways. Livestock and wildlife interact in grazing areas, sometimes positively, but more often negatively. Livestock help to maintain some of the open grassland ecosystems, but animal diseases pose new threats to wildlife.

Pasture expansion, often at the expense of forest, has vast negative consequences on some of the most valuable ecosystems in Latin America, whilst rangeland degradation affects biodiversity on all continents. Crop area expansion and intensification for livestock feed undoubtedly affects biodiversity negatively, sometimes with dramatic consequences (soybean expansion into tropical forests). Water pollution and ammonia emissions, mainly from industrial livestock production, reduce biodiversity, often drastically in the case of aquatic ecosystems. Pollution, as well as, for example, over-fishing for fishmeal production for animal feed, affects biodiversity in marine ecosystems.

Livestock's important contribution to climate change will clearly have repercussions on biodiversity, while the historic role of livestock as a driver and facilitator of invasions by alien species continues – in particular by way of introduction of exotic pasture seeds and livestock diseases.

### 2.3. Differences between species, products and production systems

There are huge differences in the environmental impact from the different forms of livestock production, and between species.

Cattle provide a multitude of products and services, including beef, milk, hides and draught power. In mixed farming systems, cattle are usually well integrated into nutrient flows and can have a positive environmental impact. In many developing countries, cattle and buffaloes still provide animal draught for field operations, and in some areas, animal traction is on the increase (e.g., parts of sub-Saharan Africa), potentially substituting for fossil fuel use. Livestock also consume crop residues some of which would otherwise be burned. However, cattle raised in extensive livestock production systems in developing countries are often only of marginal productivity. As a result, the vast majority of feed is spent on the animal's maintenance, leading to resource inefficiencies and often high levels of environmental damage per unit of output, particularly in overgrazed areas.

The dairy sector is more closely connected to the supporting feed resource than is the case for other forms of market-oriented livestock production. Most milk operations tend to be close to areas of feed supply because of their daily demand for fibrous feed, allowing for nutrient recycling. However, excessive use of nitrogen fertilizer on dairy farms is one of the main causes of high nitrate levels in surface water in OECD countries. There is also a risk of soil and water contamination by manure runoff and leaching from large-scale dairy operations.

In conclusion, livestock environment interactions are often diffuse and indirect; and damage occurs at both the high and low end of the intensity spectrum.

### 2.3.1. What needs to be done?

Given the projected expansion of the livestock sector, major corrective measures need to be taken to address the environmental impact of livestock production that will otherwise worsen dramatically. Growing economies and populations together with the increasing scarcity of environmental resources and rising environmental problems are translating into a growing demand for environmental services, such as clean air and water, and recreation areas. Increasingly, this demand will broaden from immediate factors of concern, such as reducing the nuisance factors of flies and odours, to the intermediate demands of clean air and water, and then to the broader, longer-term environmental concerns, including climate change, biodiversity, etc. At the local level, markets will undoubtedly develop for the provision of such services as is already the case for water in many places. At the global level, the emergence of such markets is uncertain although promising models already exist, for example for carbon trading.

### 2.3.2. Encouraging natural resource use efficiency

Current prices of land, water and feed resources used for livestock production often do not reflect true scarcities. This leads to overuse of these resources by the livestock sector and to major inefficiencies in the production process. Any future policy to protect the environment will, therefore, have to introduce adequate market pricing for the main inputs, for example, by introducing full-cost pricing of water and grazing fees. Ensuring effective management rules, under private or communal ownership of the resources, is a further key policy objective to improve resource use.

There are many tested and successful technical options available to mitigate environmental impacts. They can be used in resource management, in crop and livestock production, and in reduction of losses post-harvest. However, for these to be widely adopted and applied, appropriate price signals are required which more closely reflect the true scarcities of production factors and correct the distortions that currently provide insufficient incentives for efficient resource use. The recent development of water markets and more appropriate water pricing in some countries, particularly where water is scarce, are steps in that direction.

### 2.3.3. Correcting for environmental externalities

Although the removal of price distortions at input and product level will help enhance the technical efficiency of natural resource use in the livestock production process, this may often not be sufficient. Environmental externalities, both negative and positive, need to be explicitly factored into the policy framework, through the application of the "provider gets polluter pays" principle.

Correcting for externalities will lead livestock producers into management choices that are less costly to the environment. Livestock holders who generate positive externalities need to be compensated, either by the immediate beneficiary (such as with improved water quantity and quality for downstream users) or by the general public (such as with carbon sequestration from reversing pasture degradation).

While regulations remain an important tool for controlling negative externalities, there is a trend towards taxation of environmental damage and incentives for environmental benefits. It may gain momentum in future, tackling local externalities first but also, and increasingly, trans-boundary impacts through the application of international treaties, underlying regulatory frameworks and market mechanisms. Government policies may be required to provide incentives for employment of the necessary institutional innovation.

### 2.3.4. Accelerating technological change

A number of technical options could lessen the impacts of intensive livestock production. Good agricultural practices can, for example, reduce pesticide and fertilizer losses in feed cropping

and intensive pasture management. Conservation agriculture and other forms of resource preserving technologies can restore important soil habitats and reduce degradation. Combining such local improvements with restoration or conservation of an ecological infrastructure of landscapes may aid the reconciliation of conservation of ecosystem functioning and the expansion of agricultural production. Improvements in extensive livestock production systems can also make a contribution to biodiversity conservation. Adopting silvopastoral systems and planned grazing management that limit overgrazing of plants, increase biodiversity, quantity of forage, soil cover and soil organic matter, can thus reduce water loss to evaporation, runoff and sequestering of carbon dioxide. Options exist to increase production and achieve a variety of environmental objectives.

Improved and efficient production technologies exist for most production systems. However, access to information and technologies and capacity to select and implement the most appropriate are restraining factors. But they can be reduced through interactive knowledge management, capacity building and informed decision making at policy, investment, rural development and producer levels. Technological improvements need to be oriented towards the optimal integrated use of land, water, human, animal and feed resources. In the livestock sector, the quest for optimizing efficiencies will be through feeding, breeding and animal health. Research and management of feed crop production needs to be aimed at higher yields in more locally adapted eco-friendly production systems. Socio-economic research for rural development needs to provide a better understanding of the external factors that enable realization of the improvements in the first two sectors.

### 2.3.5. Reducing negative environmental and social impacts of intensive production

An estimated 80 percent of total livestock sector growth comes from industrial production systems. The environmental problems created by industrial systems mostly derive from their geographical location and concentration. In extreme cases, size may be a problem: sometimes units are so large (a few hundred thousand pigs, for example) that waste disposal will always be an issue, no matter where these units are located.

What is required, therefore, is to bring the amount of waste generated into line with the capacity of accessible land to absorb it. As far as possible industrial livestock production must be located where cropland is within economic reach so it can be used for disposal of the waste, without creating problems of nutrient loading rather than being geographically close to areas offering market access, or feed availability. Policy options to overcome the current economic drivers of the peri-urban concentration of production units include zoning, mandatory nutrient management plans, financial incentives and facilitation of contractual agreements between livestock producers and crop farmers. Regulations are also needed to deal with heavy metal and drug residues in feed and waste, and to address other public health aspects such as food-borne pathogens.

Whether industrialized or more extensive, livestock production systems, will need to meet lowest possible emission demands with full waste treatment adapted to local conditions. This requires close coordination and integration with other development activities like bioenergy, transport, urban and peri-urban development, forestry and others. Associated additional costs need to be absorbed across the various economic sectors.

In parallel, there is a need to address the environmental impacts associated with production of feed grain and other concentrate feeds. Feed is usually produced by intensive agriculture, and the principles and instruments developed to control environmental issues there need to be widely applied.

## 2.4. Diversifying extensive grazing with the provision of environmental services

Grazing systems can be intensified in areas where the agro-ecological potential so permits, in particular for dairy production, and where nutrient balances are still negative. In many OECD countries, excess nutrient loading is a major issue in grass-based dairy farming. Reductions in

the number of livestock have been imposed, sometimes with very positive results. However, the vast majority of extensive grazing lands are of low productivity. Grazing of meat animals occupies 26 percent of the ice-free terrestrial surface but the contribution that extensive grazing systems make to total meat production is less than 9 percent.

A world with around 9 billion people by 2050 and a growing middle class will suffer a growing demand for environmental services. Extensive systems will thus have the responsibility to include the provision of environmental services as an important, and sometimes predominant, purpose. This can be facilitated by payments for environmental services or other incentives to enable livestock producers to enhance resource sustainability.

The central argument here is that the opportunity cost for livestock to use marginal land is changing. Livestock used to populate vast territories because there was no viable alternative use, whereas possible other uses (e.g. for biodiversity conservation, carbon storage, bio-fuels) are now competing with pasture in some regions. Water-related services will likely be the first to grow significantly in importance in future, with local service provision schemes the first to be widely applied. Biodiversity-related services (e.g. species and landscape conservation) are more complex to manage, because of major methodological issues in the valuation of biodiversity, but they already find a ready uptake where they can be financed through revenues from tourism. Carbon sequestration services, through adjustments in grazing management or abandonment of pastures, will also be difficult. But, given the potential of the world's vast grazing lands to sequester large amounts of carbon and to reduce emissions, mechanisms must be developed and deployed to use this potentially cost-effective avenue to address climate change.

Suggesting a shift from some of the current negative grazing practices to environmental-service oriented grazing raises two questions of paramount importance: how to distribute profits from environmental services and how to deal with the considerable numbers of poor who currently derive their livelihoods from extensive livestock, for example in Mauritania (where it provides 15 percent of GDP), the Central African Republic (21 percent) or Mongolia (25 percent).

Not all environmental services of sustainable livestock production will be easily paid for through immediate product pricing. Alternative employment generation and social safety nets are some of the needs to ensure sufficient knowledge and labour to maintain marginal, but important, production areas which require effective integration/collaboration with other rural development activities particularly in countries where poverty and lack of public resources and governance result in unsustainable land use.

More encompassing external assistance will be required in countries where global assets such as biodiversity, climate and food security are concerned but where the economic potential for other sectors is limited.

#### 2.4.1. The challenge ahead

As an economic activity, the livestock sector generates about 1.4 percent of the world's GDP (2005) but it accounts for 40 percent of agricultural GDP. With a 2.2 percent global growth rate for the last ten years (1995 to 2005) globally and 5.5 percent growth rate in developing countries, the livestock sector is growing faster than agriculture as a whole whose share of overall GDP is declining. However, the livestock sector is much more important than its modest contribution to the overall economy would suggest. Livestock provide livelihood support to an estimated 987 million poor people in rural areas (LID, 1999). Livestock products in moderation are also an important element of a diverse and nutrient-rich diet.

These diverse aspects of livestock's importance are important to national decision-making for the sector. Different national policy objectives - about food supply, poverty reduction, food safety and environmental sustainability, take on different levels of importance depending on factors such as stage of development, per capita income and general policy orientation of a country. Furthermore, the objectives of sector policies and the instruments used to achieve environmental goals should be tailored according to the farming systems and the stakeholders they target.

An important issue is that, compared to their economic consequences, the environmental impacts of the livestock sector are not being adequately addressed. The problem lies mainly with institutional and political obstacles and the lack of mechanisms to provide environmental

feedback, ensuring that externalities are accounted for and entrusting the stewardship of common property resources to the sector.

The first challenge, therefore, is to raise awareness among stakeholders of the scale of the environmental problem. Environmentally-motivated action currently focuses on the functions and protection of specific ecosystems. As we have seen, the mobility of the livestock industry allows its relocation without major problems becoming apparent. However, the pressure on the environment is usually shifted elsewhere, and manifests itself in different forms. For example, intensification may reduce pressure on grazing lands but increase pressure on waterways. Thus, another challenge is to add a sector perspective to the analysis of environmental issues.

The complexity of livestock environment interactions and their many manifestations make concerted actions more difficult. Investment and production choices are driven by a variety of factors, many of which are outside the livestock / agriculture sector. This is also true of many other environmental and developmental issues and is a major reason why policy-making for the environment lags behind other areas. In this sense, the livestock sector is driven by its own set of policy objectives and decision-makers find it difficult to address economic, social, health and environmental objectives simultaneously. Frequently they also lack the tools, information and platforms to initiate and implement such complex decision making processes.

Industrialization of the livestock sector affects both production units and the various food chains yet it still allows large numbers of small-scale and marginalized producers in many parts of the world to retain their important livelihood source. The fact that so many people depend on livestock for their livelihoods and health limits the available options to policy-makers, and involves difficult and politically sensitive decisions on trade-offs. Policy-makers need to address the multiple objectives of livestock development: affordable supply of high value food; food safety; and livelihoods and environmental soundness. Perhaps the biggest challenge is, therefore, to build the institutions and cross-sectoral capacities, both nationally and internationally, which will address the complex environmental issues with a sense of urgency, while considering social and public issues.

Reducing livestock's environmental impact has a net cost that will need to be borne by the sector and the consumers. The environmental challenge raises issues of smallholder competitiveness, reduced purchasing power of the non-affluent consumers and reduced national competitiveness especially in those countries that do not compensate rising production costs with increased transfers to producers.

Despite these difficulties, the impact of livestock on the local and global environment is so significant that it needs to be addressed with urgency. The challenge for policy makers is to balance the interests of consumers and producers, and to ensure an equitable outcome of this process.

Expecting the livestock sector to deliver on all fronts is ambitious. The policy framework for the livestock sector, as for other areas, is characterized by a large number of trade-offs that need to be balanced at both national and local levels. For example, a large commercial expansion of the sector, benefiting from economies of scale and with upgraded food safety standards, creates barriers to smallholder producers. Many simply will not have the financial and technical means to compete and will be forced out of business. Likewise, distortions and externalities can be corrected but the costs of higher input prices and environmental controls will have to be passed on to the consumer, in the form of higher prices for meat, milk and eggs. Balancing these trade-offs and arbitration among stakeholders is a further challenge to policy makers.

The reduction of pressure on the livestock sector would simultaneously also ease environmental pressure and costs and should influence policies in both developed and developing countries while assuring adequate nutritional needs [health] and security of the various population groups.

Given the planet's finite natural resources, and the additional demands on the environment from a growing and wealthier world population, it is imperative for the livestock sector to move rapidly towards far-reaching change. Four lines of action are suggested:

First, the quest for improved efficiency in the use of resources for livestock production must continue if much-needed price corrections for inputs are to be achieved, and the current suboptimal production replaced with advanced production methods for feed production, livestock

production and processing, and distribution and marketing. Policy-makers are called upon to steer and facilitate this process.

Second, there is a need to accept that the intensification of livestock production is an inevitable consequence of the process of structural change that exists in most of the sector. The key challenge is to make this process environmentally acceptable by identifying the right location so as to enable waste recycling on cropland, and applying the appropriate technology, especially in feeding and waste management. Locating industrial livestock units in suitable rural environments and not in congested peri-urban but otherwise favoured settings, provides both the required land area and opportunity for recycling of nutrients. The consideration of social impacts is crucial if adverse environmental effects are to be mitigated when changes are being made to the structure of livestock market chains.

Third, extensive land-based production will continue to exist. However, decision-makers will need to ensure that grassland-based production includes the provision of environmental services as a major purpose, probably as the most important one, in vulnerable areas. Policy makers need to provide a framework for landscape maintenance, biodiversity protection, clean water and eventually carbon sequestration from extensive grazing systems, in addition to that for the production of conventional livestock commodities.

Last, but certainly not least, for the suggested changes to occur, there is an urgent need greatly to exceed the expectations of existing policies at local, national and international levels. A strong political will and urgency, together with the identification of potential contributors and beneficiaries, are required to initiate action and investment in creative ways to avert the environmental risks of continuing "business as usual."

## References

1. CAST, 1999. Animal Agriculture and Global Food Supply. Council for Agricultural Science and Technology (CAST) ISBN 1-887383-17-4.
2. FAO, 2006. World Agriculture: towards 2030/2050, Interim Report. Rome, Italy.
3. Gerber P, Chilonda P, Franceschini G, Menzi H, 2005 Geographical determinants and environmental implications of livestock production intensification in Asia. *Bioresource Technology*, 96:263–276
4. LID, 1999. Livestock in poverty focused development. Crewkerne: Livestock In Development
5. Millennium Ecosystem Assessment, 2005. Ecosystems and human well-being: synthesis. Washington D.C. Island Press.
6. Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. and de Haan, C., 2006. Livestock's long shadow Environmental issues and options. FAO, Rome.
7. UNEP, 2004. Land degradation in drylands (LADA): GEF grant request. Nairobi, Kenya.

### 3. Nutrient issues on Irish farms and solutions to lower losses

J. Humphreys<sup>1</sup>

#### Abstract

Agriculture in Ireland utilizes 63% of total land area and has a big environmental impact accounting for 70% of phosphorus and 82% of nitrogen in surface waters, and for 97% of ammonia, 81% of nitrous oxide and 86% of methane emissions to air. Phosphorus loss to water is Ireland's most serious pollution problem. The deterioration of water quality that has been evident since the 1970's has been halted and reduction targets for ammonia and greenhouse gas emissions from agriculture are being achieved. These achievements are largely attributable to declining ruminant livestock populations and declining inputs of manufactured fertilizers as a result of increasing emphasis on extensification of production practices in the Common Agricultural Policy during the past decade. Nevertheless, substantial improvements in water quality are needed by 2015 to meet the requirements of the EU Water Framework Directive. To meet this and a broad range of environmental targets and to comply with the Nitrates Directive a wide ranging set of regulations governing agricultural practices were implemented into law in 2006. These include general limits on stocking rates on farms of no greater than 170 kg ha<sup>-1</sup> of N in livestock manures applied mechanically or deposited by grazing livestock. There are periods between September and January when the application of fertilizers and manures are prohibited and minimum winter storage requirements for manures generated on farms of between 16 and 26 weeks depending on location and agricultural enterprise. The use of phosphorus is stringently curtailed; there are limits on phosphorus concentrations in soil as determined by a soil test and limits on imports of phosphorus onto farms, which generally cannot exceed exports from farms. These regulations are likely to make an important contribution to achieving environmental targets in Ireland, particularly the improvement in water quality required by the Water Framework Directive.

#### 3.1. Introduction

Agriculture in Ireland is estimated to be the origin of 70% of phosphorus (P) and 82% of nitrogen (N) in Irish inland surface waters (Toner *et al.*, 2005), and to be the source of virtually all (97%) of ammonia, 81% of nitrous oxide and 86% of methane emissions to air (DAF, 2007; DEHLG, 2007). These percentages reflect the scale of agriculture in Ireland which uses approximately 63% of total land area. Water quality in Ireland is high compared with other European countries (Nixon *et al.*, 2003) and targeted reductions in ammonia and greenhouse gas (GHG) emissions from agriculture are mostly being achieved.

#### 3.2. Water Quality

The Environment Protection Agency (EPA) has identified eutrophication of inland surface waters as Ireland's most serious pollution problem. Enrichment by P is recognised as the main cause of this eutrophication (Toner *et al.*, 2005). The European Union (EU) Water Framework Directive (WFD; European Parliament and Council, 2000) aims to protect waters with high quality status, prevent deterioration and restore degraded waters to good status by 2015. A recent report by the EPA indicates that 70% of rivers are classified as unpolluted and have satisfactory quality

---

<sup>1</sup> M.Agr.Sc. PhD, Teagasc, Moorepark Dairy Production Research Centre, Fermoy, Co. Cork, Ireland, e-mail: [james.humphreys@teagasc.ie](mailto:james.humphreys@teagasc.ie)

status. The majority (84%) of 421 lakes assessed (representing over 90% of lake surface area) exhibited algal development consistent with natural or near natural inputs of nutrients and were of satisfactory water quality status (Lucey, 2006). Of the 67 water bodies assessed from 20 estuarine and coastal areas only 40% were classified as unpolluted. Substantial efforts are needed to bring 20% of these waters to good status. Much of this pollution is attributed to non-agricultural sources. Reports suggest that decline in inland surface water quality evident since the 1970's has been halted, with no marked change in the quality of lakes in recent years and indications of improvements in some rivers (Flanagan & Toner 1972; Clabby *et al.* 1982; Toner *et al.* 1986; Clabby *et al.* 1992; Bowman *et al.* 1996; Lucey *et al.* 1999; McGarrigle *et al.* 2002; Toner *et al.* 2005; Lucey, 2006).

Most of the drinking water in Ireland is taken from surface reservoirs. Groundwater and springs account for approximately 16% of total drinking water supplies. There are few deep water tables and 98% of Irish aquifers are karst and fissured bedrock. Consequently, groundwater velocities are relatively fast (a few metres per day) and mixing of groundwater in the top 60 m occurs readily. Nitrate concentrations in Irish surface waters are well within the mandatory limits set for abstraction and drinking (Lucey, 2006). Currently, mean nitrate-N concentrations recorded in 301 sampling points representing the main groundwater resources in Ireland are 2.5 mg l<sup>-1</sup>. Concentrations greater than 5.6 mg l<sup>-1</sup> and 11.3 mg l<sup>-1</sup> were recorded in 23% and 2% of samples, respectively. Recent measurements represent a continuance of a decline in groundwater quality that has been apparent since the mid 1990's. In contrast, median nitrate concentrations in rivers appear to be levelling off, having peaked in the mid 1990s (Lucey, 2006).

### 3.3. Ammonia

Agriculture accounts for virtually all (97%) ammonia emissions in Ireland. The target ammonia emissions to be achieved by 2010 under the EU Directive on National Emissions Ceilings (European Parliament and Council, 2001) are 116 kilotonnes (kt). In 2005 ammonia emissions were 113 kt having declined from 130 kt in 1998 and hence were already compliant with the 2010 ceiling limit (DAF, 2007). This decrease has occurred due to declining ruminant livestock populations and declining fertilizer N use (Table 3.1). It was projected that ammonia emissions would decline to 102 kt by 2010. However, Ireland may shortly face a more demanding target of 83 to 89 kt to be achieved by 2020.

### 3.4. Greenhouse gasses

The agricultural sector is the single largest contributor to national GHG emissions, mainly methane and nitrous oxide, and accounted for 29% of national emissions in 2004 or 19.9 million tonnes (Mt) CO<sub>2</sub> equivalents, which is similar to emissions in 1990; 20.0 Mt CO<sub>2</sub> equivalents. Emissions from agriculture peaked in 2000 at 20.64 Mt CO<sub>2</sub> equivalents but have been falling since then due to declining ruminant livestock numbers and fertiliser N use (Table 3.1). While agriculture is achieving reduction targets outlined in the National Climate Change Strategy (NCCS; DEHLG, 2007), nationally emissions of GHG have increased from 55.6 Mt CO<sub>2</sub> equivalents in 1990 to 68.5 Mt CO<sub>2</sub> equivalents in 2004. This is higher than the target to be achieved for the period 2008 to 2012, which is an average of 63 Mt CO<sub>2</sub> equivalents per year.

### 3.5. Climate, soils, land use and farming in Ireland

Ireland has a total land area of just over 7 million ha. Agriculture utilises approximately 4.4 million ha. The climate of Ireland is subject to a maritime influence and is characterised by mild temperatures ranging between 5.1°C in January and 14.7°C in July, annual rainfall generally in the range of 800 to 1200 mm and distributed throughout the year, evapotranspiration averaging 460 mm per year, and hence, high net precipitation. Soils are generally of intermediate texture with a high moisture retention capacity. High net precipitation and high soil moisture retention capacity result in moist soil conditions in summer and wet conditions in winter. These soil and climatic conditions favour grassland farming because soil temperatures are generally sufficient

to allow grass growth right throughout the year, albeit at low rates during the winter, and soil moisture deficit generally does not impede grass growth during the summer.

Ninety per cent of agricultural area (AA; 4 million ha) is under grassland and this is mostly permanent grassland. Grassland products account for over 90 percent of the diet of ruminant livestock and beef, milk and sheep production account for 74% of gross agricultural output (GAO). Agricultural area under cereals (barley, wheat and oats) has been between 275 and 300 thousand ha since 1990 and cereals currently account for 3.0% of GAO. Agricultural area under other crops (for example, potatoes), fruit and horticulture is approximately 120 thousand ha and accounts for 5.7% of GAO. Pig and poultry production account for 6.0% and 2.7% of GAO, respectively. There are a total 130 thousand farms in Ireland (CSO, 2007) and farming was the sole occupation of 74 thousand or 56% of land-holders in 2005 (Connolly *et al.*, 2006). There were 22 thousand active milk producers in 2006, a reduction of approximately 1.5% compared with 2005, and these farms continue to be profitable with average family farm income (FFI) of approximately €38,400 (Connolly *et al.*, 2006). In contrast, direct payments in 2005 accounted for 125% of FFI on beef and sheep farms and 99% of FFI on tillage farms.

### 3.6. Lowering nutrient losses from Irish agriculture

There are a range of measures that are expected to lower losses of nutrients from agriculture to water and air. These include changes to the EU common agricultural policy (CAP) and declining ruminant livestock numbers (Table 3.1), regulations put in place during 2006 under the Nitrates Directive (European Council, 1991), the Rural Environmental Protection Scheme, and other policy measures such as conversion of agricultural land to forestry.

#### 3.6.1. Changes to the Common Agricultural Policy (CAP)

Over the last decade reforms of the CAP (for example Luxembourg Agreement in June 2003) have promoted greater extensification of agricultural production in the EU. As a consequence of these changes the number of sheep in Ireland in 2006 has declined to approximately 70% of that in 1998 in terms of the total population and of breeding ewes (Table 3.1). The number of cattle in 2006 has declined to 91% of that in 1998, although the number of beef cows has remained virtually unchanged at close to 1.2 million over the last decade (Table 3.1). The number of dairy cows has declined steadily as milk production per cow has increased and national output is limited by the national milk quota of 5150 million litres. The total population of cattle has continued to decline in recent years due to fewer dairy cows, fewer calves from the dairy herd, slaughtering at an earlier age and an increase of live exports to other (mostly EU) countries.

The average annual input of organic P in animal manures in 2004 was 16 kg ha<sup>-1</sup> AA, which declined from 21 kg ha<sup>-1</sup> in 1998. Input of manufactured fertilizer P was approximately 8.5 kg ha<sup>-1</sup> AA in 2006. High net precipitation and heavier textured soils lead to losses of P to water in runoff from fields and farmyards and, as pointed out above, this is considered to be Ireland's greatest environmental problem (Toner *et al.*, 2005). In contrast, the proportion of Irish soils that can be classified as medium to high risk of nitrate leaching is less than 10 percent (Gardiner and Radford, 1980). Low nitrate concentrations in surface and ground waters are attributed to (i) the average input of organic N in animal manures which was 103 kg ha<sup>-1</sup> AA in 2004, (down from 140 kg ha<sup>-1</sup> in 1998) (Figure 3.1), and the average annual input of manufactured fertilizer N was approximately 78 kg ha<sup>-1</sup> AA in 2006; (ii) grassland in Ireland has considerable capacity to take up N from the soil and uptake continues right throughout the year including the winter; (iii) Irish soils have high organic carbon contents (Brogan 1966; McGrath and Zhang, 2003), which along with moist soil conditions and moderate soil temperatures cause denitrification of nitrate in soils, most of which is lost as environmentally benign N<sub>2</sub> gas (Bailey, 1976; Sahrawat and Keeney, 1986; Weier *et al.*, 1993; Ryan *et al.*, 1998).

**Table 3.1:** Numbers of breeding cows and ewes, total cattle and sheep (thousands) and use of manufactured fertilizer nitrogen and phosphorous (thousand tonnes) in Ireland between 1990 and 2006 (CSO, 2007)

	Dairy cows	Beef cows	Total Cattle	Breeding ewes	Total sheep	Fertilizer	
						N	P
1990	130	731	6816	4227	8539	379.3	64.6
1991	1331	817	6912	4626	8888	370.1	62.6
1992	1278	889	6951	4745	8898	358.3	59.4
1993	1264	980	6982	4718	8627	378.0	61.5
1994	1261	1011	6997	4621	8404	404.8	60.0
1995	1256	1039	7034	4496	8332	428.8	62.4
1996	1266	1113	7314	4356	7888	416.9	61.9
1997	1252	1202	7533	4379	8132	379.5	53.7
1998	1234	1248	7640	4463	8312	432.0	49.9
1999	1201	1217	7387	4287	7926	442.9	50.5
2000	1178	1187	7037	4107	7555	407.6	49.3
2001	1183	1197	7050	3915	7330	368.7	42.7
2002	1164	1154	6992	3804	7210	363.5	41.9
2003	1156	1187	7000	3615	6849	388.1	43.8
2004	1156	1207	7016	3570	6777	362.5	42.7
2005	1114	1228	6983	3358	6392	352.2	38.6
2006	1109	1215	6916	3104	5973	342.1	36.9

### 3.7. EU Nitrates Directive Regulations

Regulations implementing the Nitrates Directive were put in place in Ireland in 2006 under Statutory Instrument (SI) 378, 2006. This SI applies to the entire national territory. These regulations set limits on stocking rates on farms in terms of the quantity of N from livestock manure that can be applied mechanically or directly deposited by grazing livestock on agricultural land. The limit is 170 kg ha<sup>-1</sup> year<sup>-1</sup> of N from livestock manure. There are also minimum requirements for slurry storage for the winter period being 16 weeks in the south of the country increasing to 22 weeks in more northern counties for ruminant livestock enterprises and 26 weeks for all intensive farming enterprises (pigs, poultry etc.) regardless of location. This storage capacity had to be in place by the end of 2008. There are closed periods during which manufactured fertilizers and livestock manures cannot be applied to land. For manufactured fertilizers the closed period for applications is between 15 September and 12 January in the south and between 15 September and 31 January in northern counties. For livestock manures the closed period is between 15 October and 12 January in the south and between 15 October and 31 January in northern counties.

Implementing closed periods for the applications of fertilizers and manures and minimum requirements for storage of manures during the high-risk winter period (high rainfall and low grass growth) is likely to substantially lower losses of nutrients from farms to water. A recent widespread survey (B. Hyde pers. comm.) indicates that between 60 and 70% of farms had adequate slurry storage facilities, however, there are no details available on dirty water storage at this stage. A detailed survey of dairy farms in 2005 (K. Mc Namara and M. Treacy pers. comm.) indicates that less than half (approximately 40%) had pollution control facilities adequate to meet all of the requirements of the above regulations.

Financial support to assist farmers to meet additional requirements for pollution control facilities is provided under the Farm Waste Management Scheme (European Council, 1999). The version of the scheme introduced by the Department of Agriculture and Food (DAF) in March 2006 provided a standard grant-rate of 60% for most of the country with 70% being available for the northern counties where there are requirements for longer periods of storage. The maximum eligible investment ceiling was €120,000 per holding. By the closing date for this scheme at the end of 2006, over 48 thousand applications had been received, which represents

approximately 37% of all farms. This compares with around 12 thousand successful grant applications in the period between 2000 and March 2006 when there was a lower rate (40%) of support available.

These figures give an indication of the scale of investment in pollution control taking place on farms at present. There is tax relief available to farmers who incur necessary capital expenditure for pollution control and who submit a nutrient management plan to the DAF (DAF, 2007). Since 2005 grant aid at 40% is available for farmers to purchase low ammonia emission 'trailing shoe' vacuum tankers for the application of slurry. Uptake of this element of the scheme has been slow.

The SI 378, 2006 sets out parameters for the use of manufactured fertilizer P on farms. The objective of these parameters is to achieve a zero balance on farms; imports of P onto farms (manufactured fertilizers, concentrates and other animal feeds, organic manures etc.) should not exceed exports of P (products, organic manures etc.) from the farm unless there is a need to build up the concentration of P in soils with very low or low soil P status. For grassland, soil P concentrations are divided into four categories: Indices 1 to 4 depending on the Morgan's (Na acetate + acetic acid, pH 4.8) soil P test (Morgan, 1941; Byrne, 1979). At lower indices (1 & 2) there are allowances in the SI 378, 2006 for additional P inputs for build up of soil P concentrations. For soils in index 3 (5.1 to 8.0 mg l<sup>-1</sup> soil) farm-gate inputs and outputs are expected to be in balance and for soils in index 4 (>8 mg l<sup>-1</sup> soil) inputs of manufactured fertilizers and imported organic manures are disallowed with the intention of creating a deficit of P causing soil P concentrations to decline into index 3 over time. The risk of losses of P by overland flow from vulnerable soils is low when soil P concentrations are in index 3 (Daly *et al.*, 2002; Kurz *et al.*, 2005a; Kurz *et al.*, 2005b; Jordan *et al.*, 2005).



### Fertilizer P use ('000 t)

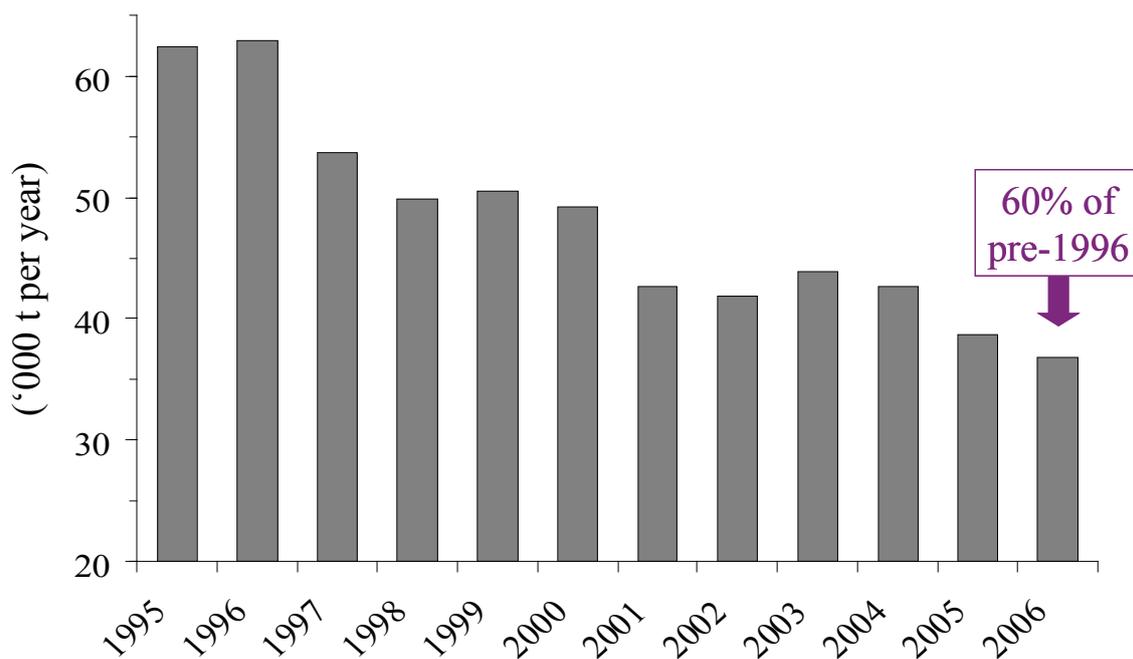


Figure 3.1 : Fertilizer P use decrease in Ireland.

The implementation of these regulations governing P use on farms is the culmination of a review of the national recommendations for P use on farms that commenced in the early 1990's motivated by concern about increasing incidences of eutrophication of inland surface waters. The initial consequence of this review was revised recommendations introduced in 1996. Prior to these 1996 recommendations manufactured fertilizer P use nationally was reasonably consistent from year to year at approximately 62 thousand tonnes (Table 3.1). Following the 1996 recommendations, national fertilizer P use fell to 54 thousand tonnes in 1997 and to approximately 50 thousand tonnes per year between 1998 and 2000. Since 2000 there has been a steady decline in fertilizer P use nationally to 36.9 thousand tonnes in 2006 due to further adjustments to the recommendations, rising fertilizer costs, increasing efficiency of P use on farms and falling livestock populations (Table 3.1). Fertilizer P use in 2006 was approximately 60% of pre-1996 levels (Figure 3.1). It is likely that there will be further reductions in fertilizer P use nationally following the implementation of the SI 378, 2006 because allowable rates under the SI are substantially lower than previous recommendations.

Under SI 378, 2006, there are also restrictions on inputs of N to grassland and other crops, which, in general, cannot exceed crop requirements. For grassland crops the requirement is dependent on stocking rate of grazing livestock. On the vast majority of farms (>90%) with stocking rates on grassland of less than 170 kg ha<sup>-1</sup> year<sup>-1</sup> of N from livestock manure these limits on fertilizer N use are close to current practices (Humphreys, 2007). However, at high stocking rates on grassland (>170 kg ha<sup>-1</sup> year<sup>-1</sup>) on mixed grassland and tillage farms and on derogation farms (see below) there are general limits on input of N in manures excreted by ruminant livestock of 250 kg ha<sup>-1</sup> year<sup>-1</sup> and on input of total N (livestock manures plus manufactured fertilizer) of 490 kg ha<sup>-1</sup> year<sup>-1</sup>. On these farms there is considerable pressure to increase the efficiency of N use in livestock manures recycled on farms and to lower input of manufactured fertilizer N.

Since 2000 Teagasc research and extension services have undertaken an education programme to increase efficiency and lower fertilizer N use on farms in anticipation of the pending regulations. This has been helped by escalating costs of manufactured fertilizer N; the cost of fertilizer N has almost doubled relative to farm-gate product prices during the last decade, and by declining livestock numbers. National use of manufactured fertilizer N in 1999 was 443 thousand tonnes and declined to 342 thousand tonnes in 2006; or to 77% of that in 1999 (Table 3.1) (Figure 3.2).

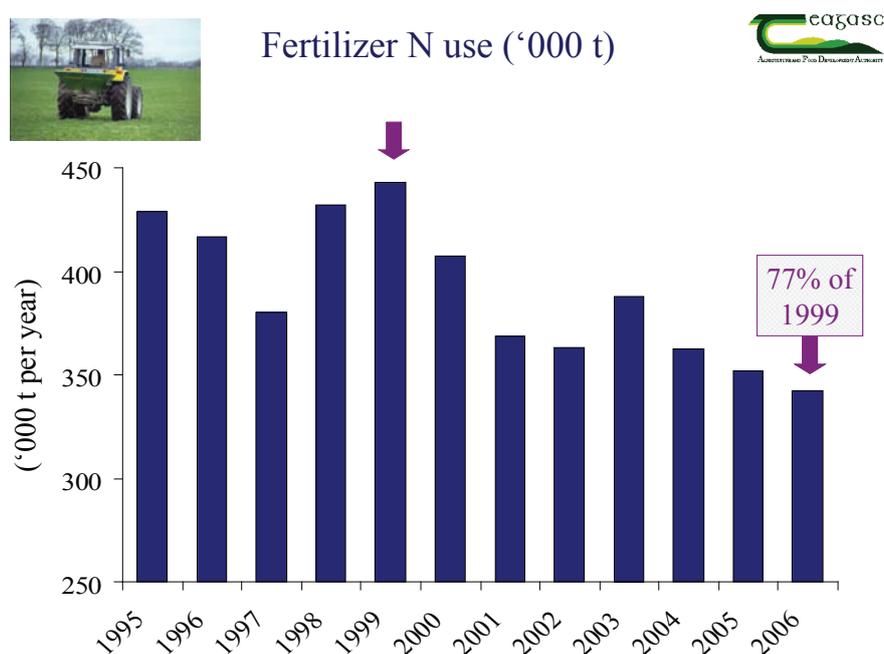


Figure 3.1 : Fertilizer P use decrease in Ireland.

### 3.7.1. Derogation

In November 2006, the EU Nitrates Committee approved Ireland's application for a derogation from the 170 kg ha<sup>-1</sup> year<sup>-1</sup> limit on N from livestock manures to allow grassland-based (mostly dairy) farmers to operate at up to 250 kg ha<sup>-1</sup> year<sup>-1</sup>. Limits to inputs of manufactured fertilizer N and total N on derogation farms have been outlined above. It is anticipated that no more than 10 thousand farmers will seek derogation, which represent less than 8% of all farms. It is anticipated that these farms will be subject to higher requirements for nutrient management and to higher levels of monitoring and inspection than non-derogation farms; however, the details of these aspects have not been published.

### 3.7.2. Rural Environment Protection Scheme

Farmers participating in the Rural Environment Protection Scheme (REPS; European Council, 2003) in Ireland receive payments in return for (i) establishing farming practices and production methods that take into account conservation, landscape protection and wider environmental problems; (ii) protecting wildlife habitats and endangered species of flora and fauna; (iii) producing quality food in an extensive and environmentally friendly manner. The REPS was first introduced in Ireland in 1994 and participation in the scheme by farmers increased steadily to 60 thousand representing approximately 45% of all farms in 2006. Farms involved in the scheme are subject to stringent nutrient management requirements and the input of manufactured fertilizers is lower on REPS than non-REPS farms (DAF, 2007). The introduction of this scheme in 1994 and increasing numbers of farmers joining the scheme since then have been partly responsible for the decrease in fertilizer P and N use outlined in Table 3.1. A new scheme was included in Ireland's draft Rural Development Programme for the period 2007–2013, which is generally similar to previous schemes. It is projected that the number of farmers participating in the scheme will increase to perhaps as high as 70 thousand, representing more than half of all farms by the end of the present decade (DAF, 2007).

## 3.8. Forestry

Forest cover in Ireland has grown from 480,000 ha in 1990 to 718,000 ha at the end of 2006. This increase has been encouraged by a strategic plan for the development of the forestry sector in Ireland, which was initiated in 1996 (DAFF, 1996). The overall target was to increase the area under forestry by an additional 20 thousand ha each year between 2001 and 2030, which would increase the national land area under forestry from 9% to 17%. However, actual plantings have fallen short of these targets. New areas planted were 8 thousand ha in 2006 compared with 15.5 thousand ha in 2001 and 21 thousand ha in 1996. The change in land use from ruminant livestock production to forestry provides a double dividend: a reduction of GHG emissions and sequestration of carbon from the atmosphere. Other non-timber benefits include recreation and leisure use, biodiversity and conservation. These non-timber benefits have been valued at over € 88 million per annum (Bacon, 2004). In the NCCS, it is estimated that the carbon sequestered by Irish forests will be worth €31 million annually for the first commitment period of 2008-2012 (DEHLG, 2007). Substantial public funds are currently available to support Ireland's forestry strategy. These include 100% grants covering the costs of establishment of plantations and annual premium payments over the following 20-year period. The Rural Development Programme 2007-2013 includes a 15% increase in premium payments (DAF, 2007).

## 3.9. Conclusions

Water quality in Ireland is relatively good by European standards and emissions of GHG's and ammonia from agriculture are meeting or exceeding reduction targets. Nevertheless there remains a need for a substantial improvement in water quality by 2015 to meet the requirements of the WFD. During the past decade the implementation of CAP in Ireland has had a major influence on land use and livestock densities and it is likely that it will continue to be an important factor influencing nutrient loads on farms and consequent losses to water, and in lowering

emissions of ammonia and GHG's from agricultural sources. Such anticipated changes include a greater number of farmers joining the REPS and additional agricultural land being converted from ruminant livestock production to forestry. The introduction of regulations in the SI 378 in 2006 was expected to have a big impact on nutrient losses from farms. At present there is substantial investment in pollution control facilities taking place on farms, which substantially increased the level of compliance required in the SI by the end of 2008. Having sufficient slurry and dirty water storage capacity on farms will be a major step towards lower losses because these manures can be applied at times of best crop response and least environmental risk.

This, combined with greater awareness, closed periods for the application of fertilizers and manures and limits on the use of manufactured fertilizers were expected to contribute to further reductions in nutrient loads on farms and lower losses from agriculture.

## Acknowledgements

The author gratefully acknowledges critical comments on the manuscript provided by T. Quinlivan, M. Sinnott, J. Nolan and P. Torpey, Department of Agriculture and Food, Kildare Street, Dublin 2 and L. Kinsella, Department of Agriculture and Food, Grattan Business Park Pavilion A, Stradbroom, Portlaoise, Co Laois, Ireland.

## References

1. Bacon P. (2004) A Review and Appraisal of Ireland's Forestry Development Strategy. Peter Bacon and Associates Economic Consultants, Ballyrane House, Killinick, Wexford. [www.agriculture.ie/publicat/publications2004](http://www.agriculture.ie/publicat/publications2004).
2. Bailey L D (1976) Effects of temperature and root on denitrification in a soil. *Canadian Journal of Soil Science* **56** 79-87.
3. Bowman J J, Clabby K J, Lucey J, McGarrigle M L and Toner P F (1996) Water Quality in Ireland 1991-1994. Environmental Protection Agency, Wexford. [www.epa.ie](http://www.epa.ie). EPA Publications Office, McCumiskey House, Richview, Dublin.
4. Brogan J C (1966) Organic carbon in Irish pasture soils. *Irish Journal of Agricultural Research* **5** 169-176.
5. Byrne E (1979) Chemical Analysis of Agricultural Materials. Teagasc, Johnstown Castle, Wexford. 194 pages.
6. Clabby K J, Bowman J J, Lucey J, McGarrigle M L and Toner P F (1992) Water Quality in Ireland 1987-1990. Environmental Research Unit, Dublin. EPA Publications Office, McCumiskey House, Richview, Dublin.
7. Clabby K J, Lucey J and McGarrigle M (1982) The National Survey of Irish Rivers. River Quality Investigations – Biological. Results of the 1980 and 1982 Investigations. An Forbas Forbartha, Dublin. EPA Publications Office, McCumiskey House, Richview, Dublin.
8. Connolly L, Kinsella A, Quinlan G and Moran B (2006) Teagasc National Farm Survey 2005. Teagasc, Oak Park, Carlow, Co. Carlow. 105 pages. [www.teagasc.ie/publications](http://www.teagasc.ie/publications).
9. CSO (2007) Principal Statistics in relation to Agriculture. Central Statistics Office, Skehard Rd., Cork, Ireland. [www.cso.ie](http://www.cso.ie).
10. DAFF (1996) Growing for the future: a strategic plan for the development of the forestry sector in Ireland. Department of Agriculture, Food and Forestry Dublin. Stationery Office. Dublin.
11. DAF (2007) Annual Review and Outlook for Agriculture and Food 2006/2007. Economics and Planning Division, Department of Agriculture and Food, Kildare Street, Dublin 2. 87 pages. [www.agriculture.gov.ie/publicat/publications2007](http://www.agriculture.gov.ie/publicat/publications2007).
12. Daly K, Mills P, Coulter B and McGarrigle M (2002) Modelling phosphorus concentrations in Irish rivers using land use, soil type, and soil phosphorus data. *Journal of Environmental Quality* **31** 590-599.

13. DEHLG (2007) Ireland: National Climate Change Strategy 2007-2012. Department of Environment, Heritage and Local Government. 59 pages. [www.environ.ie/en/Environment/Atmosphere/ClimateChange/NationalClimateChangeStrategy](http://www.environ.ie/en/Environment/Atmosphere/ClimateChange/NationalClimateChangeStrategy).
14. European Council (1991) Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources. *Official Journal of the European Union* **L 375** (31/12/1991) 1-8.
15. European Council (1999) Council Regulation (EC) No 1257/1999 on support for rural development from the European Agricultural Guidance and Guarantee Fund and amending and repealing certain Regulations. *Official Journal of the European Union* **L 160** (17/05/1999) 80-102.
16. European Council (2003) Council Regulation (EC) No 1783/2003 amending Regulation (EC) No 1257/1999 on support for rural development from the European Agricultural Guidance and Guarantee. *Official Journal of the European Union* **L 270** (21/10/2003) 70-77.
17. European Parliament and Council (2000) Directive 2000/60/EC establishing a framework for Community action in the field of water policy. *Official Journal of the European Union* **L 327** (22/12/2000) 1-73.
18. European Parliament and Council (2001) Directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants. *Official Journal of the European Union* **L 309** (27/11/2001) 22-30.
19. Flanagan P J and Toner P F (1972). The National Survey of Irish Rivers. A Report on Water Quality. An Foras Forbartha, WR/R1, Dublin. EPA Publications Office, McCumiskey House, Richview, Dublin.
20. Gardiner M J and Radford T (1980) Soil associations of Ireland and their land use potential. *Soil Survey Bulletin* No. 36. 142 pages. Teagasc, 19 Sandymount Avenue, Dublin 4.
21. Humphreys J (2007) Cutting back on fertilizer for grassland in 2007. *Proceedings of the Fertilizer Association of Ireland, Abbylax 2007*. **43** 25 pages. [www.fertilizer-assoc.ie/publications.htm](http://www.fertilizer-assoc.ie/publications.htm)
22. Jordan P, Menary W, Daly K, Kiely G, Morgan G, Byrne P and Moles R (2005). Patterns and processes of phosphorus transfer from Irish grassland soils to rivers – integration of laboratory and catchment studies. *Journal of Hydrology* **304** 20-34.
23. Kurz I, Tunney H and Coxon C E (2005a). The impact of agricultural management practices on nutrient losses to water: data on the effects of soil drainage characteristics. *Water Science and Technology* **51** 73 – 81.
24. Kurz I, Coxon C E, Tunney H, Ryan D (2005b). Effects of grassland management practices and environmental conditions on nutrient concentrations in overland flow. *Journal of Hydrology* **304** 35-50.
25. Lucey J (2006) Water Quality in Ireland 2005 – Key Indicators of the Aquatic Environment, pages 1-23. Environmental Protection Agency, PO Box 3000, Johnstown Castle Estate, County Wexford, Ireland. [www.epa.ie](http://www.epa.ie).
26. Lucey J, Bowman J J, Clabby K J, Cunningham P, Lehane M, MacCarthaigh M, McGarrigle M L and Toner P F (1999). Water Quality in Ireland, 1995-1997. Environmental Protection Agency, Wexford. [www.epa.ie](http://www.epa.ie). EPA Publications Office, McCumiskey House, Richview, Dublin.
27. McGarrigle M L, Bowman J J, Clabby K J, Lucey J, Cunningham P, MacCarthaigh M, Keegan M, Cantrell B, Lehane M, Clenaghan C, and Toner P F (2002) Water Quality in Ireland 1998-2000. Environmental Protection Agency, Wexford. [www.epa.ie](http://www.epa.ie). EPA Publications Office, McCumiskey House, Richview, Dublin.
28. McGrath D and Zhang C (2003) Spatial distribution of soil organic carbon concentrations in grassland of Ireland. *Applied Geochemistry* **18** 1629-1639.
29. Morgan M F (1941) Chemical Soil Diagnosis by the Universal Soil Testing System. Connecticut Agricultural Experimental Station Bulletin 450, Connecticut, USA.
30. Nixon S, Trent Z, Marcuello C and Lallana C (2003) Europe's Water: An indicator-based assessment. Topic Report No. 1/2003. 97 pages. European Environment Agency, Copenhagen.

31. Ryan M, Noonan D and Fanning A (1998) Relative denitrification rates in surface and subsurface layers of a mineral soil. *Irish Journal of Agricultural and Food Research* **37** 141-157.
32. Sahrawat K L and Keeney D R (1986) Nitrous oxide emission from soils. *Advances in Soil Science* **4** 103-148.
33. Toner P F, Bowman J J, Clabby K J, Lucey J, McGarrigle M L, Concannon C, Clenaghan P, Cunnningham P, Delaney J, O'Boyle S, MacCarthaigh M, Craig M, and Quinn R (2005) Water Quality in Ireland 2001-2003. Environmental Protection Agency, Wexford. [www.epa.ie](http://www.epa.ie). EPA Publications Office, McCumiskey House, Richview, Dublin.
34. Toner P F, Clabby K J, Bowman J J and McGarrigle M L (1986). Water Quality in Ireland. The Current Position. Part One: General Assessment. An Foras Forbartha, Dublin. EPA Publications Office, McCumiskey House, Richview, Dublin.
35. Weier K L, Power J N and Walters D T (1993) Denitrification and the dinitrogen/nitrous oxide ratio as affected by soil water, available carbon and nitrate. *Soil Science Society of America Journal* **57** 66-72.

## 4. Energy Use on Dairy Farms

J. Barnett<sup>1</sup>, J. Russell<sup>1</sup>

### 4.1. Introduction

The main types of energy used on dairy farms are electricity and fossil fuels (petrol, oil and diesel). Combined, these energy inputs can be a significant cost factor in milk and dairy product production. Energy inputs also contribute to the greenhouse gas emission profile of the dairy farming operations with the main emission being carbon dioxide.

Initiatives to reduce energy usage on dairy farms have a two-fold effect. Firstly reduced energy usage results in direct savings to the farmers through reducing the production costs. Secondly, energy reductions may also result in a reduced greenhouse gas emission footprint for the dairy sector, and as greenhouse emission taxes are introduced could also result in further cost savings for farmers.

This paper reports on the types of energy inputs to dairy farms, where the energy is consumed on the farm, and evaluates areas where energy savings can be made.

### 4.2. Farm Energy Sources

The main types of energy input to dairy farms are electricity and fossil fuels (oil, diesel and petrol). Energy use on dairy farms can be further characterised as being either direct uses or indirect (embedded) energy use (Wells, 2001).

Direct energy uses are those where the energy is consumed on the farm. Examples are (Wells, 2001):

- The use of electricity to heat water, for refrigeration, water pumping etc
- The use of diesel, petrol and lubricants in farm machinery.

Indirect energy uses are those energy uses where the direct energy use occurs outside the farm boundaries. The energy use is therefore embodied in the products used on the farm. Indirect energy inputs are (Wells, 2001):

- Energy used during the manufacture and transport of fertilisers,
- Energy used in the manufacture and transport of agri-chemicals (acid and alkali cleaners, bloat oil, zinc & magnesium, other animal remedies, herbicides, other chemicals),
- Energy use in the production and transport of seeds to the farm,
- Feed that was bought-in from outside the farm (grass & maize silage, balage, hay and straw, grains and meals, milk powder, molasses, etc),
- Energy used when grazing animals off the farm, and
- Any substantial purchases brought in for farm maintenance such as aggregate for road maintenance.

### 4.3. Total Farm Energy Consumption

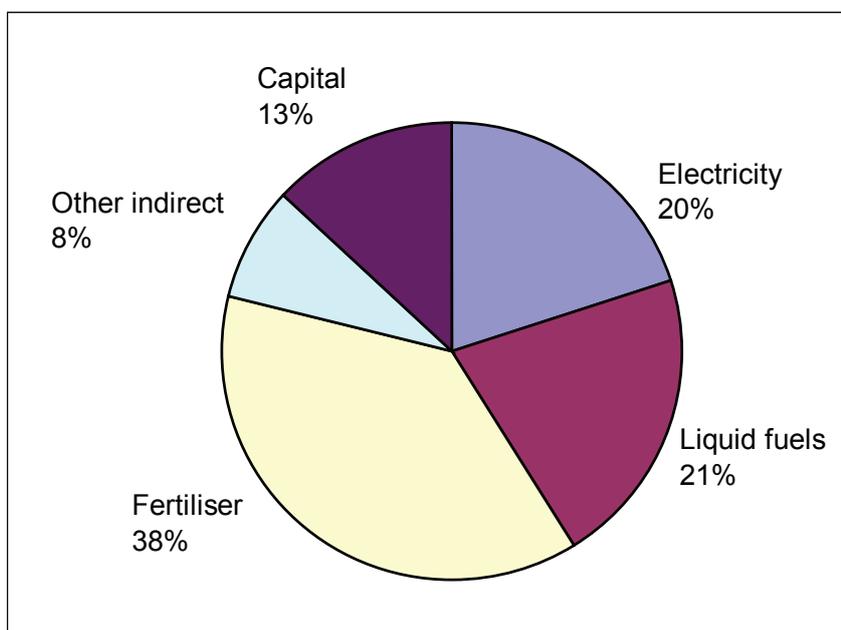
In New Zealand there have been two major studies of energy use on dairy farms (Wells, 2001; Hartman and Sims, 2006). In a survey of 150 farms Wells (2001) report the energy usage on an average dairy farm as 1.84 MJ/kg liquid milk with a range of 0.9-5.6 MJ/kg liquid milk found in their survey data. Wells (2001) recognised that farms that utilised irrigation had substantially different energy usage (1.79 MJ/kg liquid milk for non-irrigated farms compared with 2.79 MJ/kg liquid milk for irrigated farms).

Hartman and Sims (2006) surveyed 62 dairy farms and found the average total energy input was 3.9 MJ/kg liquid milk (range 3.0-5.4 MJ/kg liquid milk). Generally energy inputs were higher in the South Island of New Zealand where more energy was used for irrigation.

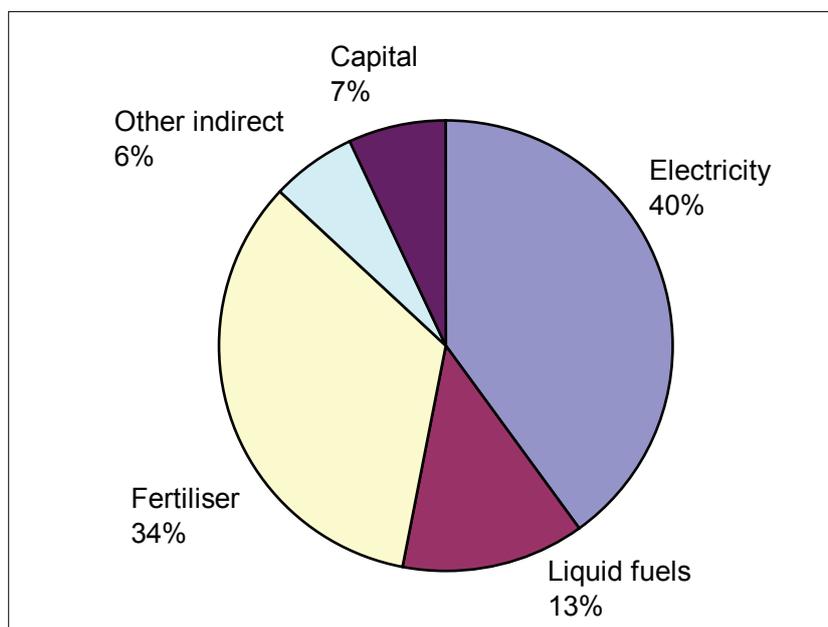
<sup>1</sup> Fonterra Co-operative Group Ltd, New Zealand, e-mail address: [jim.Barnett@fonterra.com](mailto:jim.Barnett@fonterra.com)

There have been few studies internationally of energy use on dairy farms. Refsgaard *et al.* (1998) report energy usage ranging between 2.88 and 3.63 MJ/kg liquid milk for conventional dairy farms and 2.16-2.92 MJ/kg liquid milk for organic dairy farms. Wells (2001) cites several other United States and European studies and concludes that on-farm energy usage is similar to that found in New Zealand.

The direct energy inputs to non-irrigated dairy farms were 41% of the total energy inputs while on irrigated farms direct energy inputs were 53% of the total (Figures 4.1 and 4.2 - Wells, 2001).



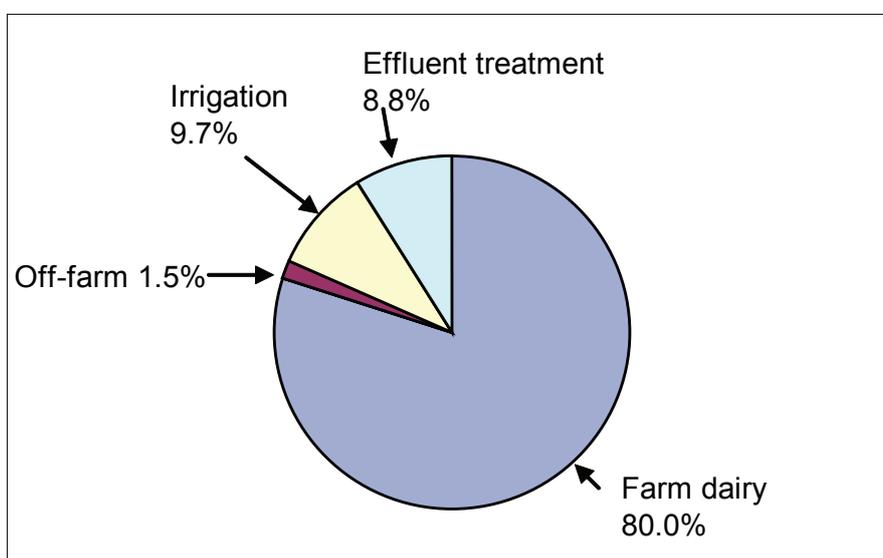
**Figure 4.1 :** Average energy inputs on New Zealand non-irrigated dairy farms.



**Figure 4.2 :** Average energy inputs on New Zealand irrigated dairy farms.

Carran *et al.* (2004) in a life cycle analysis of New Zealand dairy farms determined that 59% of the direct energy inputs to a New Zealand farm were from electricity and 41% were from fossil fuels. Approximately 97.2% of the fossil fuel usage is from diesel and 2.8% from petrol use.

Carran *et al.* (2004) analysed electricity usage on an “average” New Zealand dairy farm and showed that 80% of the electricity used on a farm was used in the farm dairy. Of the remainder 9.7% was used for irrigation pumping, 8.8% for farm dairy effluent treatment and small amounts (about 1.5%) attributed to off-farm grazing and off-farm forage production (Figure 4.3). Although the study by Carran *et al.* (2004) does not consider irrigated and non-irrigated farms separately, it does allow target areas for electricity usage reductions to be made. The areas to target to achieve the largest electricity savings are the farm dairy and, on farms where irrigation also occurs, irrigation scheduling and management.



**Figure 4.3 :** Farm direct uses of electricity on an “average” New Zealand dairy farm.

#### 4.4. Farm Dairy Energy Consumption

The major energy uses in the farm dairy are for water heating, vacuum pumping (and milking machinery), milk chilling (refrigeration), water pumping (wash-down and cleaning) and lighting (Hartman and Sims, 2006; CAENZ, 2007a). The farm dairy uses of electricity found in the Hartman and Sims (2006) survey are summarised in Table 4.1.

**Table 4.1:** Average energy usage in a survey of New Zealand farm dairies (Hartman and Sims, 2006)

	Range (kWh/cow/year)	Average (kWh/cow/year)
Water heating	20-75	51
Milk chilling	21-47	34
Milking machinery	14-42	29
Water pumping	14-46	29
Lighting	15-31	20

#### 4.4.1. Water Heating

To maintain high hygiene levels and good milk quality, water is heated, stored, and then used for cleaning the milking machinery and storage vats.

In the survey by Hartman and Sims (2006) water heating consumed between 20 and 75 kWh/cow/year (average of 51 kWh/cow/year). The high variability was caused by a number of factors including the level of insulation on storage cylinders, whether or not heat exchangers were used and the frequency of hot washing.

The farms that used the lowest amount of electricity for water heating were those that used once-a-day hot washing (20-25kWh/cow/year). Those farms that had additional insulation used 20-30 kWh/cow/year while those with heat exchangers used 30-40 kWh/cow/year.

The CAENZ (2007a) study found similar findings with considerable energy savings in the hot water system occurring with good leak repair and maintenance, additional insulation, checking thermostat operation, use of heat pumps, use of heat exchangers and replacing one in two hot washes with a cold wash.

#### 4.4.2. Milk Chilling

Storage of milk before transport to the processing facilities requires that the milk is chilled to less than 7°C. Hartman and Sims (2006) found that on average 34 kWh/cow/year was required for milk chilling. Lowest energy usage was found for those systems with insulated vats (22 kWh/cow/year) compared to 35 kWh/cow/year for non-insulated vats.

#### 4.4.3. Milking Machinery

The amount of energy used for vacuum and milk pump machinery ranged between 14 and 42 kWh/cow/year with an average of 29 kWh/cow/year (Hartman and Sims, 2006). Factors found to reduce energy use for milking machinery were once-a-day milking instead of conventional twice-a-day milking, and the use of variable speed drive technology on the vacuum pumps (Hartman and Sims, 2006; CAENZ, 2007a).

#### 4.4.4. Water Pumping

Water pumping is required in the farm dairy primarily for cleaning purposes. Hartman and Sims (2006) report that water pumping accounts for 13-46 kWh/cow/year with an average of 29 kWh/cow/year. The most significant factor affecting water pumping energy costs was whether or not once-a-day milking was practiced with higher energy inputs required for twice-a day milking and two wash-down periods.

#### 4.4.5. Lighting

Lighting costs in the farm dairy ranged between 15 and 31 kWh/cow/year with an average of 19.8 kWh/cow/year (Hartman and Sims, 2006). Farms that used energy-efficient, compact fluorescent light bulbs used significantly less electricity.

### 4.5. Options to Reduce Energy Usage and Costs

One of the main energy sources on New Zealand dairy farms is direct consumption of electricity with most of this being used either in the farm dairy or for irrigation. The operations within these areas therefore offer the greatest opportunity to reduce farm energy use and costs.

In New Zealand two studies have been undertaken investigating methods for reducing energy usage in farm dairies (Hartman and Sims, 2006 and CAENZ, 2006, 2007a). The major areas identified in these studies where savings can be made are summarised in Table 4.2.

Some of the operations described in Table 4.2 could potentially affect milk quality and milk yield (e.g. reducing the number of hot washes of the milking machinery and changing to once-a-day milking) and these options need to be considered carefully.

**Table 4.2:** Energy savings that can be made in farm dairies

Water Heating	Substitute a cold wash for every second hot wash Improved cylinder and pipe insulation Correct piping design Eliminating water leaks Correct setting of thermostats Heating water at the time it is required Change to once-a-day milking Optimise wash sequence Evaluate best pricing plans
Milk chilling	Improve vat insulation Investigate pre-cooling with water Investigate pre-cooling using chilled water (only if current plant is under-sized) Store off-peak electricity in a ice-bank or glycol cooling technology system Ensure cleanliness of heat transfer surfaces Maintain equipment Install a variable speed milk pump to smooth the milk flow through the pre-cooler
Milking machinery	Maintain and replace old equipment Control the vacuum level to suit the number of cows being milked Consider once-a-day milking
Water pumping	Consider changing to once-a-day milking Clean the yard using a "dry-clean" procedure and only wash at end of cycle
Lighting	Change to energy efficient, compact, fluorescent light-bulbs

#### 4.5.1. Water Heating

The main energy saving measures that can be made to the hot water heating system (Figure 4.4) are to ensure that the hot water cylinder and pipework are adequately insulated, that the thermostat is set to the correct temperature, and that leaks are eliminated. Additional savings can be made if the water heating utilises off-peak electricity at a lower electricity cost.

Opportunities exist for using heat pump technology to recover heat from the milk cooling refrigeration unit and using this to pre-heat the water entering the hot water cylinder. A system known as Mahana Blue™ has been used to preheat the water to 85oC (EECA, 2007). The heat pump operates at the same time as the vat chiller and produces a low flow of hot water that is used to refill the water cylinder over several hours.

**Figure 4.4 :** Insulated hot water cylinders.

### 4.5.2. Milk Chilling

As with water heating, the largest savings in milk chilling costs can be made by ensuring that the energy used in refrigeration is adequately stored. Therefore, adequate insulation of the milk vat is a cost effective way of reducing energy costs (Figure 4.5). Technologies such as the use of ice-banks and glycol cooling technology can utilise off-peak electricity to “store” refrigeration energy for when it is needed. Ice-banks store ice in a tank and the cooled water from the tank is used in the heat exchanger.

The glycol cooling technologies utilise a material that is stored in plastic spheres that changes phase on cooling. The energy used to achieve that phase change is stored within the material in the plastic spheres. Glycol transfers the “cooling” from the spheres to the heat exchanger, increasing the efficiency of milk cooling.



**Figure 4.4 :** Insulated hot water cylinders.

### 4.5.3. Milking Machinery

Installation of variable vacuum control (Varicac™) where the level of vacuum is matched to the number of cows being milked has reduced the electricity used by the milking machinery by 58-68% (Meridian Energy, 2007).

### 4.5.4. Lighting

Use of energy-efficient, compact fluorescent light bulbs can significantly reduce electricity usage for lighting.

### 4.5.5. Best Practice

Implementation of the best management practices in the farm dairy will produce an energy efficient farm dairy. The farm dairy energy usage will decrease from 163 to 92 kWh/cow/year, representing a saving of 43.6% (Table 4.3).

**Table 4.3:** Comparison of energy usage in the current “average” farm dairy compared to that achieved in an energy efficient dairy

	Current average (kWh/cow/d)	Energy efficient dairy (kWh/cow/d)
Water heating	51	22
Milk chilling	34	20
Milking machinery	29	15
Water pumping	29	20
Lighting	20	15
TOTAL	163	92

## 4.6. Alternative Energy Supplies

A number of “new” technologies for generating electricity (or energy) are available and should be evaluated as the energy supply and greenhouse gas mitigation strategies are progressively introduced. In this section we consider methane from manure, wind power, small-scale hydro-electric power, solar heating and bio-diesel. Although these methods will not, necessarily, reduce energy usage, they have significant potential for reducing greenhouse gas emissions from the dairy industry and may, in the longer term, reduce costs.

### 4.6.1. Methane Generation

The manure that is collected from dairy cows is a potential source of energy. Anaerobic digestion of manure converts the organic matter to methane gas that can be used as a fuel. A potential use would be for water heating (by direct combustion of the methane), or for electricity generation.

In countries such as New Zealand and Australia where cows spend most of the time grazing outside, only 10-20% of the manure can be collected for digestion. In contrast, where dairy cows are housed year-round nearly 100% of the manure can be digested. Our studies show that if only 10-20% of the manure is collected a minimum herd size of 1000 cows is required before methane generation is economic. When 100% of the manure can be collected the herd size at which manure digestion becomes economic is 250-300 cows. These conclusions have been supported in the studies by CAENZ (2007b). A typical on-farm methane digester is shown in Figure 4.6.

**Figure 4.6 :** Farm anaerobic digester.

#### 4.6.2. Wind power

Wind power is a renewable energy source. It is an appropriate technology in areas exposed to the prevailing wind direction and with high wind runs. A disadvantage of wind power is that it is not always windy and therefore power is not always available.

CAENZ (2007b) have evaluated wind records at two Southland, New Zealand dairy farms. They then estimated the likely amount of energy that would be produced by a 10 kW wind generator over the 10-month New Zealand dairy season. The study found the potential to generate about 6500 kW of electricity and estimated the payback period would be several decades. They concluded that small-scale wind energy will not be economic in the short to medium term unless special circumstances apply. A wind turbine is shown in Figure 4.7.



**Figure 4.7 :** Wind turbine.

#### 4.6.3. Hydroelectric Power

CAENZ (2007b) evaluated the use of small-scale hydroelectric power generation but concluded that very few dairy farms would have waterways with a flow or head capable of generating significant amounts of electricity.

#### 4.6.4. Solar Water Heating

Direct heating on water by the sun can be a useful way of reducing hot water heating costs. Pre-heating of the incoming water is widely practiced. CAENZ (2006) estimate that a suitably sized solar energy collection system could save 50% of the energy required to the heat hot water used in a typical farm dairy. A solar water heating system is shown in Figure 4.8.



**Figure 4.8 :** Solar water heating installed at a farm dairy.

A less sophisticated application of solar heating has been suggested by Barber and Pellow (2005). They suggest that the hot water cylinder should be sited away from the prevailing winds and on the sunny side of the milking parlour but give no further details as to the amount of energy that might be saved.

#### 4.6.5. Bio-diesel

Bio-diesel is a domestic, renewable fuel for diesel engines derived from natural oils and fats. Bio-diesel can be used in any concentration with petroleum-based diesel fuel in existing diesel engines with little or no modification.

Bio-diesel replaces some of the conventional diesel produced from fossil fuels (oil) and hence reduces greenhouse gas emissions.

In theory any oil or fat, including those produced as a by-product from the dairy industry, can be used as an ingredient to the bio-diesel process. Further research is required to progress this option further.

#### 4.7. Conclusion

Energy represents only 6-8% of the operating budget of a typical New Zealand dairy farm (Barber and Pellow, 2005). Therefore, energy savings are often given a low priority. However, as energy costs rise and greater incentive is given to reduce energy use and greenhouse gas emissions, it is likely that energy will receive greater attention.

This paper identifies many areas in which energy savings can be made, such as insulating hot water systems and insulating cooling and refrigeration plant through to changed management practices such as once-a-day milking and the use of cold water washes.

Further work is required to implement some of the savings discussed in this paper but as old plant is replaced best available technologies should be implemented.

## References

1. Barber, A. and Pellow, G. (2005). Energy use and efficiency measures for the New Zealand dairy farming industry. Report prepared for the New Zealand Climate Change Office by AgriLINK New Zealand Ltd. [http://www.agrilink.co.nz/Portals/agrilink/Files/Dairy\\_Energy\\_Efficiency\\_Stocktake.pdf](http://www.agrilink.co.nz/Portals/agrilink/Files/Dairy_Energy_Efficiency_Stocktake.pdf)
2. CAENZ (2006), Energy efficiency in dairy sheds- a preliminary report. <http://www.cowshed.org.nz/index.cfm/3,77,235/preliminary-report-nov06-v2.pdf>
3. CAENZ (2007a), Energy efficiency in dairy sheds <http://www.cowshed.org.nz/index.cfm/3,77,235/efficient-dairy-shed-project-profile-july-07.pdf>
4. CAENZ (2007b), Energy efficiency in dairy sheds – Interim report (summary). <http://www.cowshed.org.nz/index.cfm/3,77,235/dairy-flyer-june-07-red.pdf>
5. Carran, R.A., Ledgard, S.F., Wedderburn, M.E. and Jollands, N.A. (2004). A life cycle assessment of milk production on a New Zealand dairy farm. Report prepared for Dairy Insight, Wellington, New Zealand. <http://www.dairyinsight.co.nz/reports/10054-2.pdf>
6. EECA (Energy Efficiency and Conservation Authority) (2007) Gentle touch in the cow shed increases yield with less energy. <http://www.eeca.govt.nz/news/energywise-news/january-2006/features/energy-efficient-milk.html>
7. Hartman, K. and Sims, R.E.H. (2006). Saving energy on the dairy farm makes good sense. Proceedings of the 4<sup>th</sup> Dairy3 Conference held at Hamilton New Zealand. Centre for Professional Development and Conferences, Massey University, Palmerston North, New Zealand pp 11-22.
8. Meridian Energy (2007) Varivac. <http://www.meridianenergy.co.nz/YourFarm/Products/Varivac.htm>
9. Refsgaard, K., Halberg, N. and Kristensen, E.S. (1998) Energy utilization in crop and dairy production in organic and conventional livestock production systems. *Agricultural systems*, **57**(4), 599-630.
10. Wells, C. (2001) total energy indicators of agricultural sustainability: Dairy farming case study. Technical Paper 2001/3 prepared for the New Zealand Ministry of Agriculture and Forestry, Wellington, New Zealand. <http://www.maf.govt.nz/mafnet/rural-nz/sustainable-resource-use/resource-management/total-energy-indicators-of-agricultural-stability/total-energy-indicators-of-agricultural-stability.htm>

## 5. Pesticide consumption at farm level and residues in the environment and in milk

S. Bertrand<sup>1</sup>

### 5.1. Introduction

The relationship between environment and milk production can be seen from two perspectives: on the one hand, milk production has an impact on the environment (on air, soil and water), and on the other, the environment can have an impact on milk production, through environmental contaminants like pesticides, dioxins ...that may lead to residues in milk. Pesticides constitute an interesting issue because they concern both of these perspectives: the use of pesticides by dairy farmers has an impact on the environment, and milk can be contaminated with pesticide residues.

It is important to be aware that techniques for residual pesticides analysis are a lot more sensitive today. Thirty years ago, the detection limit was around 1 mg/kg. Today, the detection limit is under 0.001 mg/kg. This means that detection level has improved by a factor of 1000 in 30 years. As a result, interpretation can be very difficult in cases of the detection of very low residue levels. The publication of analytical results without an appropriate commentary can lead to negative publicity and even a crisis in consumer confidence. So today consumer concerns about pesticide residues in the environment and food are growing. As a result, there is more pressure with new regulations and more restrictions on the use of pesticides.

### 5.2. Pesticide consumption

#### 5.2.1. Pesticide classification and consumption in Europe

Pesticides are classified with a double classification: a chemically-based family classification (for example, organochlorine, organophosphorus, carbamates...) and a target classification (herbicides, fungicides and insecticides). The active ingredients of a family tend to have the same behaviour and characteristics. A commercial formula that is used by farmers on their fields is composed of one or more active ingredients, plus a solvent. Table 5.1 shows a few examples of well known active ingredients and their classification.

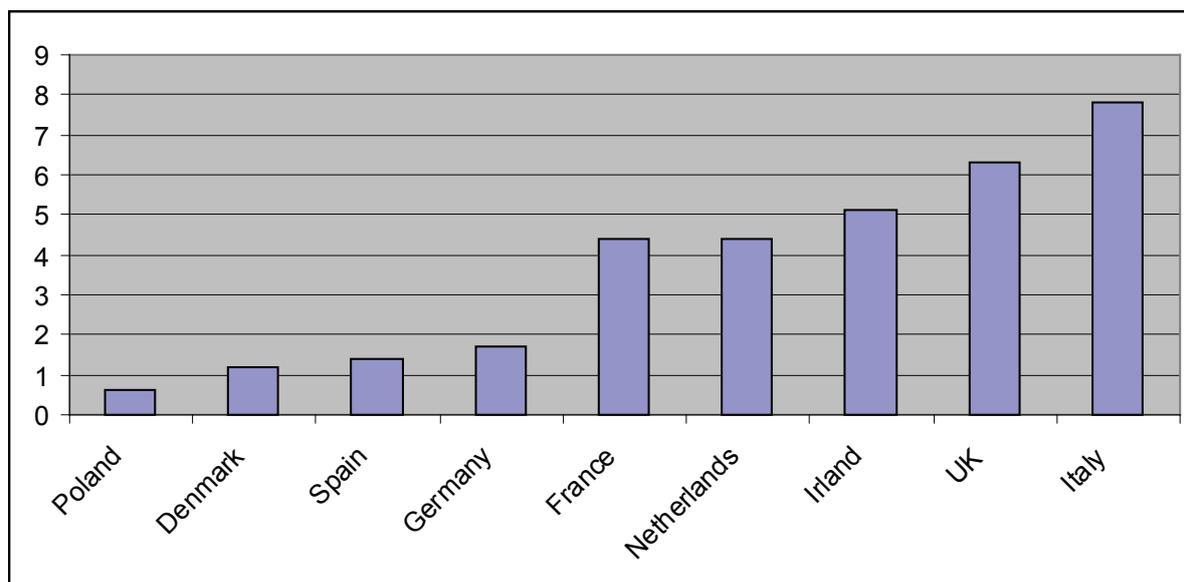
**Table 5.1:** Example of double classification (target/family) for well known active ingredients

	Insecticides	Fongicides	herbicides
Organo-chlorines	lindane dieldrine		
Organo-phosphorus	endosulfan malathion chorpiryphos		
Carbamates	carbofuran	thiram	asulam
Pyrethrinoids	cypermethrin deltamethrin		
Triazoles		tebuconazole epoxiconazole	atrazine
Strobilurines		asoxystrobine	
Ureas			isoproturon

<sup>1</sup> French Livestock Institute/French Dairy Association, 149 rue de Bercy, 75595 PARIS cedex 12 - France, e-mail: [sophie.Bertrand@inst-elevage.asso.fr](mailto:sophie.Bertrand@inst-elevage.asso.fr)

If we look at pesticide consumption in Europe, France used 71 600 t of pesticides in 2006, with more than 400 different active ingredients (UIPP, 2007 – ACTA, 2006). It is recognised that the pesticide pressure is quite high in France. Figure 5.1 shows the pesticide use for different European countries, in kg of active ingredient per hectare treated. Over the period 1992 /2003, however, a substantial change in pesticide use took place. Some countries limited their use by 60 % (Denmark, the Netherlands and Hungary), while in other countries a substantial rise has been observed, as much as by 52% (Poland, Greece and Portugal).

(source : OECD 2008)



**Figure 5.1** : Pesticide use for different European countries (2008) in kg of active ingredient/ha of crop.

### 5.2.2. Pesticide consumption in dairy farms

In fact, small quantities of pesticides are used on forage areas in dairy farms. In France there are 10 million ha of permanent pasture and 3 million ha of temporary pasture, which receive either very little pesticide or none at all. In addition 1.2 million ha of maize silage and 1.5 million ha of cereals (for animal feed) which receive 1 to 5 treatments per year. All these represent only 10% of the total pesticide volume used in France (the main consumers are vines, vegetables and fruit). The pesticide consumption in a dairy farm grows with the share of maize silage and crop in the arable area. A survey was conducted on 70 French dairy farms in 2006 by the French Livestock Institute (Bertrand, 2007). The results show that, on average, 2.3 kg of active ingredient is sprayed per ha treated, per year. This means 1 kg of active ingredient per ha of arable area per year, with 2 to 5 treatments per ha treated per year, on average. Each farm uses around 12 different active ingredients per year, and the 12 are not the same on each farm. So, in total on the 70 farms, 150 different active ingredients were identified. Herbicides represent the main use with 74% of the treatments, fungicides 14% and insecticides 9%.

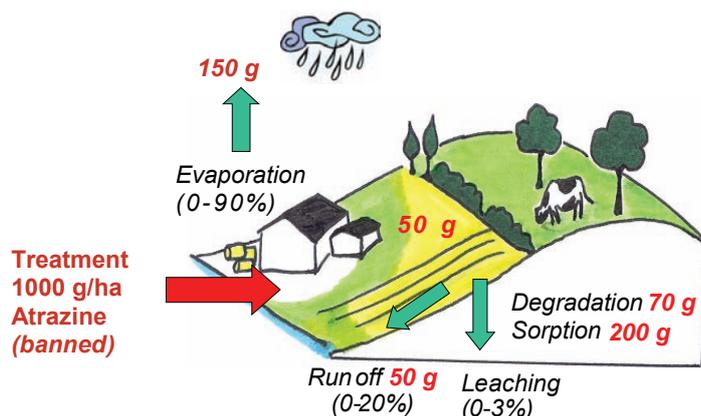
Not surprisingly, there is a lower use of pesticides on dairy farm systems based on pasture. The quantity of active ingredient used varies with the share of maize and cereals in the arable area (AA). When a farm has less than 20% of its AA in maize and cereals, it uses on average 500 kg of active ingredient per ha of AA per year. When a farm has more than 35% of its AA in maize and cereals, it uses around 2000 kg of active ingredient per ha of AA per year.

### 5.2.3. Pesticide residues in the environment and milk

#### 5.2.3.1. Pesticide behaviour in the environment

The active ingredient atrazine is banned today but it has been widely used on maize by dairy farmers as a herbicide. Its behaviour in the environment has been well studied and data are available. When a farmer sprayed 1000 g of atrazine on his field, only 50 g was fixed in the corn and 150 g was evaporated into the air. A quantity of 70g decomposed, 200 g was absorbed in the organic matter in the soil and the remainder was bound in the soil for a certain time. Around 50 g was lost through run off and leaching and could represent a threat to water quality (Figure 5.2). But the distribution of the quantities lost in the environment is very different for each active ingredient. It is recognised that 0 to 90% of an active ingredient can be evaporated, 0 to 20% can be lost by run-off and 0 to 3% can be lost through leaching. But whatever the active ingredient is, it is important to be aware that only 60 to 80 % of the applied amount reaches its target, the rest is lost in soil, air and water (Barriuso, 2004) (Farruggia, 2000) (Calvet, 2005)

### Pesticide behaviour in the environment



Only 60 to 80% of the applied amount reaches the target, the rest is lost in the air, soil and water

**Figure 5.2 :** Pesticide behaviour in the environment.

#### 5.2.3.2. Behaviour of pesticides in animals

A dairy cow can be exposed to pesticides through the air it breathes, the water it drinks and the forage it consumes. After ingestion, the active ingredient is mostly metabolised in the liver. Storage in fat and pesticide excretion through milk can lead to residues in milk and meat. The active ingredients that are soluble in water will be mostly eliminated through urine and faeces, but the substances that are more fat soluble will be eliminated mainly through milk. This greater or lesser fat solubility of an active ingredient can be estimated by what is called the Log P, which is the logarithm of the octanol-water partition coefficient. The log P is the prime indicator of fat solubility and so of the potential transfer to the milk. When log P exceeds 3, the compound would be designated as fat soluble.

The log P of the different metabolites needs to be determined as well. The mechanisms of degradation in animals can be very complicated. An active ingredient can be degraded in the animal body to several metabolites that can be more toxic and have a different behaviour from the source ingredient. An active ingredient, soluble in water, can be degraded in animals to a metabolite which is soluble in fat, for example.

The higher the log P, the more the substance is soluble in lipids. Table 5.2 shows a few examples of log P for well known pesticides. When log P exceeds 3, the substance has a potential of bioaccumulation. That is the case of long-banned active ingredients like aldrin, DDT, endosulfan and lindane. Log P can be negative for active ingredients that are very soluble in water, such as glyphosate (the active ingredient in Roundup), and this is the case for most herbicides.

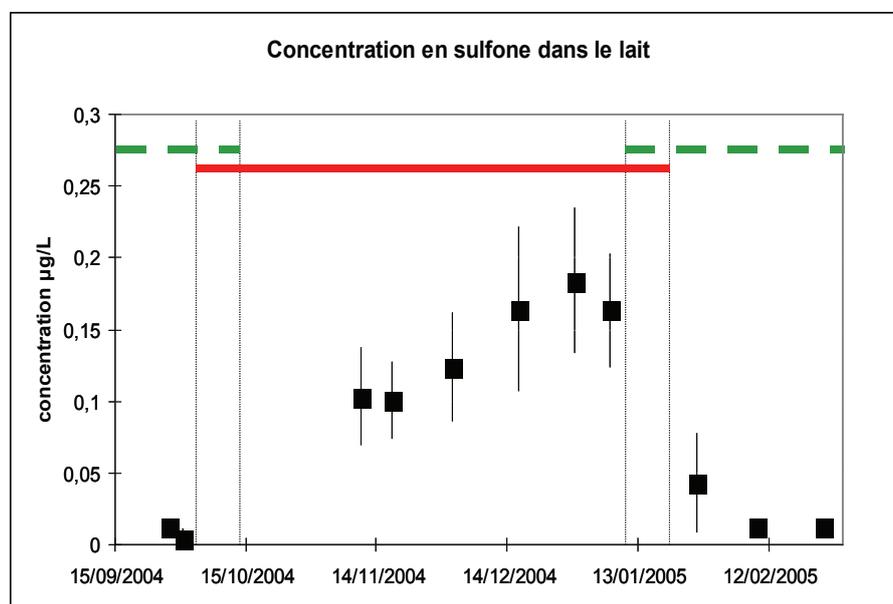
**Table 5.2:** Log P for well known active ingredients

Active ingredient	Log P
Aldrin	7.4
DDT	6.9
Endosulfan	4.74
Fipronil	4
Lindane	3.5
Malathion	2.75
Carbofuran	1.52
Nicosulfuron	-0.65
Propamocarbe	-2.6
Glyphosate	-3.2

The example of the imidacloprid can be used to illustrate these mechanisms. Imidacloprid is the active ingredient of the commercial formula Gaucho (a maize and sunflower insecticide). The use of pesticide may lead to significant residues in crops that may be fed to animals. The possibility of these residues transferring from the plant to food producing animals that may consume it needs to be addressed in registration applications. For the registration of imidacloprid, the firm Bayer had to undertake a trial on dairy cows to estimate the transfer of imidacloprid to milk. For the trial, different groups of cows were fed for 28 days with different doses of the active ingredient. When a cow consumes a dose of 5ppm, which is 50 times the MLR (maximum residue limit), 0.05 ppm is found in the liver, 0.03 ppm in the kidney and 95% of the dose is eliminated through urine and faeces. No residue can be quantified in the milk and the meat. The word "quantify" is important because it does not mean there are no residues present in milk. It means that scientists cannot quantify any residues – which is very different. The definition of the quantification limit (LOQ) is important in order to understand that subtlety. The LOQ is the lowest concentration of a residue that can be identified and quantitatively measured in a food sample using an analytical method that has been validated with specified accuracy and precision.

Fipronil is the active ingredient of the commercial formula Regent, a maize insecticide. An experiment was conducted in 2006 at the French Livestock Institute experimental dairy farm (Brunschwig, 2006). A group of 60 cows were fed with non-treated maize and then with fipronil-treated maize. The trial period lasted 6 months. Until October the cows were fed with maize without fipronil, and from October to February, they were fed with fipronil-treated maize. The results show that only the metabolite sulfone is detected in milk, and not the active ingredient fipronil. Figure 5.3 shows that from October to February, the presence of the metabolite sulfone was detected in the milk. But the red line is the LOQ (0.25): so the levels detected are under the LOQ. The MLR for fipronil is a lot higher than the LOQ, at 0,4. This means that the levels detected are considerably below the MLR. After one month of non-treated maize, the situation was back to normal, with no residues in the milk. However, even with non-treated maize, very low quantities of sulfone were detected. This can be explained by the fact that the two maize fields were side by side and so there could have been a light contamination from the treated field to the non-treated field.

(source French Livestock Institute)



**Figure 5.3 :** Sulfone concentration in milk.

These two examples highlight the fact that it is easy for there to be confusion between the presence of a residue and the health risk for the consumer. Pesticide residues can be found in milk, but the quantities detected are mostly below the MLR. The presence of residues below the MLR level does not mean a health risk for the consumer, given the state of scientific knowledge today. This means that, so far, nobody has demonstrated that quantities below the MLR pose a health risk.

However, it is important to highlight that doubts still exist about whether there is a potential link between very low levels of pesticides residues and an increased risk of cancer (INSERM, 2008).

Doubt also exists about the risks around chemical mixtures or pesticide cocktails. The presence of multiple different chemical residues in food raises new questions about the possible toxicological impacts of the mixture on the body.

#### 5.2.3.3. Results from government controls

In 2005 and 2006 in France, 100% of the samples tested contained no detectable residues (DGAL, 2005, 2006). In the UK in 2003, dieldrin was found in a sample of full fat milk (PRC UK, 2003). Dieldrin is a long-banned chlorinated insecticide, but very persistent in the environment. So it still represents a threat. It is important to highlight that sometimes in government controls, residues of banned organochlorine pesticides are found at low levels, because they are still present in the environment. The results are generally very good and reassuring but it is important to highlight that tests have only been made for the organophosphorus and organochlorine pesticides. None of the recent 150 active ingredients that have been identified in the 70 dairy farms surveyed by the French Livestock Institute, are currently being searched for (especially because analytical methods are not available for 'routine' controls in the national laboratory).

#### 5.2.3.4. Ways to limit contamination with pesticide residues

There are not many ways of limiting contamination from pesticide residues, apart from a really minimal use of the pesticides.

In France, more and more farms now have a classification of their fields with regards to their risk of contamination of surface water. The fields close to water courses, or on a slope, are classified as high risk and farmers should avoid using pesticides on them.

It is also compulsory in France, to keep a minimum of a 5 meter band of grass along water courses, to avoid direct contamination.

Farmers are encouraged to use the strict minimum dose of pesticides necessary . They are also encouraged to use non-chemical alternatives.

These different measures can limit the transfer of pesticides into water, but they will not eliminate them. To obtain really significant results, farmers need to go further, which means to move towards a less pesticide-dependent system. It means using agronomic forms of defence. The different agronomic tools available are well known. For example, thinking about the crop rotations in advance with the objective of avoiding the use of pesticides. It means choosing accurate seeding periods, selecting more resistant varieties, and to sow seed at a lower density. These last measures lead to a complete change in agricultural practice and this is quite a challenge for dairy farmers. More research is required to be done to provide a basis for approved strategies to propose to the farmers that minimise the use of pesticides and still guarantee a healthy crop.

## References

1. ACTA (2006), Index phytosanitaire ACTA.
2. Barriuso E. (2003), Estimation des risques environnementaux des pesticides, INRA.
3. Bertrand S.(2007), Enquête consommation de pesticides en élevage laitier, Institut de l'élevage, non publié.
4. Brunschwig P (2006), Evaluation de résidus de produits phytosanitaires, Pôle agronomique Ouest.
5. Calvet R. (2005), Les pesticides dans le sol, conséquences agronomiques et environnementales, Editions France Agricole, INRA.
6. DGAL/SDSPA, 21 juin 2004, Note de service, bilan des plans de contrôle 2003 des résidus chimiques dans les animaux et les produits d'origine animale, p 7, p 23
7. Farrugia A. (2000), L'eau et les herbivores, les chemins de la qualité, Institut de l'Élevage.
8. INSERM (2008), Résultat de l'expertise collective cancer et environnement.
9. OECD (2008). Environmental Performance of Agriculture in OECD countries since 1990, Paris, France, [www.oecd.org/tad/env/indicators](http://www.oecd.org/tad/env/indicators)
10. UIPP (2007), Union des industries des produits phytopharmaceutiques, [www.uipp.org](http://www.uipp.org)
11. PRC, Pesticide residues committee, 2003, pesticides residues monitoring : third quarter results July-September 2003, p 9, table 3.

## 6. Outcome from Edinburgh summit, Climate Change – the heat is on

J. Gilliland<sup>1</sup>, A. Fagerberg<sup>2</sup>, P. Gerber<sup>3</sup>, M. Gill<sup>4</sup>



### 6.1. Main conclusions from the IDF Dairy Farming summit on Climate Change

As we have seen earlier in this report, environmental issues at dairy farm level are very complex owing to the great diversity of dairy farming practices and contexts.

Dairy farmers today are facing two challenges: they need to produce more and better.

To achieve these challenges, the speakers at the summit agreed that research priorities should be:

- Timing of mineral N application
- Use of new crops and nitrification inhibitors
- Soil carbon storage and emission
- Manipulation of animal diet
- Improvement of national GHG inventories.

There is global awareness of the fact that dairy farming has a problem with greenhouse gases. And there is a common willingness to work on solutions which will have to differ from

<sup>1</sup> Farmer and former chairman of the Rural Climate Change Forum in Northern Ireland.

<sup>2</sup> Dairy Expert of De Laval.

<sup>3</sup> One of the main authors of the landmark FAO report, "Livestock's Long Shadow".

<sup>4</sup> Chief Scientific Adviser for Rural Affairs and Environment for the Scottish Government.

region to region. These solutions should make dairy farming a sustainable sector with a reduced carbon footprint in the future.

Two of the best solutions at this moment are bio-digesters and energy audits, but new solutions will surely appear. Experts expect that innovative farm management will play a key role. Trading of CO<sub>2</sub> rights (like in other industries), thereby using market forces to stimulate solutions could be a way to control greenhouse emissions from dairy farming. This was one of the suggestions that came up at the Summit.

On the other hand the cow is a highly efficient 'food processor'. She is one of the few species which can convert grass into healthy nutrition for humans: milk and meat. Otherwise millions of hectares of the grasslands in the world could not be used for human consumption. On those lands no other crop can grow. The world population is increasing. Grazing land occupies 3.4 billion hectares in the world. There is an absolute need to use this biomass which only ruminants can convert into high quality food for humans. We cannot look at livestock only in terms of a negative contribution to climate change: we also have to look at livestock in relation to the food security debate and appropriate land use. The issue is getting that in balance. There are 70 million new mouths to feed every year. At the same time prosperity in several regions in the world (China, Brazil, India etc.) is growing. The food consumption in those 'new' countries changes from starch to protein. Thus, much more milk and meat are needed (it needs to be doubled by 2050), but this causes more problems with greenhouse gases.

Here is the dilemma, in a nutshell: feeding the world versus the environmental problems.

How much the dairy sector contributes to the greenhouse gas emission is not known yet. At the conference the experts mentioned figures between two to five percent, depending on what they calculated. They expect to have more precise figures within a short time. But the sources of GHG emission in relation to livestock are now well-known.

The GHG emissions in relation to livestock are caused by:

- Land use and land use change (forest and other vegetation replaced by pasture and feed crop) and carbon release from soils: 36 percent (2.5 Giga tonnes CO<sub>2</sub> equivalent).
- Manure management, mainly through manure storage, application and deposition: 31 percent (2.2 Giga tonnes)
- Animal production: 25 percent (1.9 Giga tonnes)
- Feed production including fertilizer production: 7 percent (0.4 Giga tonnes)
- Processing and transport: < 1 percent (0.03 Giga tonnes)

Action is required because if, as predicted, the production of meat will double from now to 2050 we need to halve the impact per unit to achieve a mere status quo in overall impact. And technical options exist, for instance fermentation in a bio-digester, storing CO<sub>2</sub> in the soil and balanced feeding. When a dairy farmer intensifies and produces more milk per cow, he reduces the emission per litre, but this is only one part of the whole picture. The complete farm and all the inputs should be considered to avoid a shift of pollution. It cannot be done in the same way in all regions. And there is a tremendous difference between dairy farms. Different parts of the world have different abilities to respond to technological challenges.

Currently we do not have answers to all the questions being asked. Our innovation tool kit is only half full and needs to be supplemented with the products of a better funded and more sophisticated R&D programme. The politicians need to find a balance between the three parts of sustainability: economics, environment and social aspects to ensure long term sustainability.

Climate Change cannot be looked at in isolation! Farm solutions must be part of a much wider solution which also allows the World's population to be fed, watered and fuelled. The size of this challenge now needs a second "Green Revolution" in agricultural production, of a kind not seen since the 1950's and 60's. Agriculture should not be allowed to be seen as the problem. If we are to have a sustainable World population going forward, agriculture will be key in providing the ultimate solution, to feed, to provide clean water and to fuel the World, within a managed global but changing climate.

**For more information :**

[www.sustainabledairyfarming.com](http://www.sustainabledairyfarming.com)

## ENVIRONMENTAL ISSUES AT DAIRY FARM LEVEL

### ABSTRACT

The dairy sector worldwide is confronted with a triple challenge – how to feed an increasingly large human population, how to control the impact of dairy production on the global environment and, at the same time, to discover new ways of managing animal and milk production to achieve these aims. The papers in this IDF Bulletin provide an overall review of the interaction between milk production and the environment and possible measures to minimize the impact of each on the other, and illustrate the practical steps that can be and are being taken by the dairy sector in a variety of countries and in relation to specific environmental issues: air quality, soil quality, water quality, energy use, pesticide residues.

*Keywords: Animal production, air quality, biodiversity, climate change, energy use, environment, environmental management, environmental policies, land use, nitrogen, nutrient losses, nutrient management, pesticide residues, phosphorus, regulations, soil quality, water quality, water resources.*

40 pp - English only

Bulletin N° 443/2010 - Free of charge (electronic) - Date: 2010

# INTERNATIONAL DAIRY FEDERATION INSTRUCTIONS TO AUTHORS

## Submission of papers

Submission of a manuscript (whether in the framework of an IDF subject on the programme of work or an IDF event) implies that it is not being considered contemporaneously for publication elsewhere. Submission of a multi-authored paper implies the consent of all authors.

## Types of contribution

Monographs; separate chapters of monographs; review articles; technical and or scientific papers presented at IDF events; communications; reports on subjects on the IDF programme of work.

## Language

All papers should be written in English.

## Manuscripts

- Files to be sent electronically on CD-ROM, diskette or by e-mail.
- Final document in Word 2000 or later.
- All tables/figures included in final document to be sent also in separate Word, Excel or PowerPoint files, in colour format. Pictures to be sent in tif or eps format (resolution 300 DPI)
- All files to be named with author's surname plus title of paper/tables/figures.

## References

- References in the document to be numbered and placed between square brackets.
- Reference lists at the end of the document to contain the following:
  - \* Names and initials of all authors;
  - \* Title of paper (or chapter, if the publication is a book);
  - \* If the publication is a journal, title of journal (abbreviated according to 'Bibliographic Guide for Editors and Authors', published by The American Chemical Society, Washington, DC), and volume number;
  - \* If the publication is a book, names of the publishers, city or town, and the names and initials of the editors;
  - \* If the publication is a thesis, name of the university and city or town;
  - \* Page number or number of pages, and date.

Example: 1 Singh, H. & Creamer, L.K. Aggregation & dissociation of milk protein complexes in heated reconstituted skim milks. J. Food Sci. 56:238-246 (1991).

Example: 2 Walstra, P. The role of proteins in the stabilization of emulsions. In: G.O. Phillips, D.J. Wedlock & P.A. Williams (Editors), Gums & Stabilizers in the Food Industry - 4. IRL Press, Oxford (1988).

## Abstracts

An abstract not exceeding 150 words must be provided for each paper/chapter to be published..

## Address

Authors & co-authors must indicate their full address (including e-mail address).

## Conventions on spelling and editing

IDF's conventions on spelling and editing should be observed. See Annex 1.

## ANNEX 1 IDF CONVENTIONS ON SPELLING AND EDITING

In the case of native English speakers the author's national conventions (British, American etc.) are respected for spelling, grammar etc. but errors will be corrected and explanation given where confusion might arise, for example, in the case of units with differing values (gallon) or words with significantly different meanings (billion).

"....."	Usually double quotes and not single quotes
? !.....	Half-space before and after question marks, and exclamation marks
± .....	Half-space before and after
microorganisms.....	Without a hyphen
Infra-red.....	With a hyphen
et al.....	Not underlined nor italic
e.g., i.e.,... ..	Spelled out in English - for example, that is
litre.....	Not liter unless the author is American
ml, mg,... ..	Space between number and ml, mg,...
skim milk.....	One word if adjective, two words if substantive
sulfuric, sulfite, sulfate.....	Not sulphuric, sulphite, sulphate (as agreed by IUPAC)
AOAC <u>International</u> .....	Not AOACI
programme.....	Not program unless a) author is American or b) computer program
milk and milk product.....	rather than "milk and dairy product" - Normally some latitude can be allowed in non scientific texts
-ize, -ization.....	Not -ise, -isation with a few exceptions
Decimal comma.....	in Standards (only) in both languages (as agreed by ISO)
No space between figure and % - i.e. 6%, etc.	
Milkfat.....	One word
USA, UK, GB.....	No stops
Figure.....	To be written out in full
1000-9000 .....	No comma
10 000, etc. ....	No comma, but space
hours.....	ø h
second.....	ø s
litre.....	ø l
the Netherlands	

Where two or more authors are involved with a text, both names are given on one line, followed by their affiliations, as footnotes

for example A.A. Uthar<sup>1</sup> & B. Prof<sup>2</sup>

<sup>1</sup> University of .....

<sup>2</sup> Danish Dairy Board .....

IDF does not spell out international organizations

