1. End of Project Report

RMIS 5140: Projections of forestry as a competitor with mainstream agricultural enterprises and the consequent environmental implications

1.1 Summary

Background: Through its relationship with the Food and Agricultural Policy Research Institute (FAPRI), staff at the Rural Economy Research Centre (RERC) have developed a system of econometric models of the Irish Agriculture sector. The output from these models includes, amongst other things, projections of agricultural activity levels under different policy options. From an environmental perspective, information on future levels of agricultural activity are important since they can facilitate the calculation of aggregate national levels of emissions of various pollutants from agriculture. The project has also produced a model which makes projections of forestry planting.

Using per head and per hectare measures of emissions produced by environmental scientists, along with projections of agricultural activity levels, projection of total national level of emissions of greenhouse gases and ammonia can be produced under a baseline and under different agricultural policy scenarios.

Projections of forestry activity in terms of hectares planted, can also be derived using an economic model for forestry in Ireland which look at how trees compete with agriculture for land use. This allows for the calculation of the amount of carbon sequestered by forestry in Ireland, which can, at least partially, offset the effect of greenhouse gases (GHG) produced by agricultural activity. Ultimately this provides a measure of net greenhouse gas emissions.

Despite the continued loss of staff it was possible to devote some time to this project in 2004. Since there were no formal FAPRI-Ireland projections in 2004, it was decided that no new additional projections of GHG and Ammonia emissions would be produced in 2004.

Following a request for collaboration from the Department of the Environment, Heritage and Local Government, (DEHLG) a number of bilateral was arranged with the International Institute for Applied Systems Analysis (IIASA) in Austria. IIASA has an EU contract to produce country level models of Ammonia emissions for the whole of Europe. The purpose of the bilateral was to review the data and methodology being used by IIASA to calculate emissions of ammonia by agriculture in Ireland, and to review the data and methodology being used in RMIS project 5140. These bilaterals revealed a number of issues in the approach being used by IIASA which would need further investigation.

As an outcome of these bilaterals it was agreed that a further process of consultation would take place in Ireland involving, representatives from Teagasc (RERC and Johnstown Castle), the

Department of Agriculture and Food (DAF), the DEHLG and the Environmental Protection Agency (EPA). The final output of this consultation process was a report for IIASA on aspects of Ireland's ammonia emissions from agriculture which was submitted in July 2004.

Following a call from the DEHLG and the EPA, a request for formal co-operation by RERC in the provision of projections of greenhouse gas emissions by the agriculture sector was made by the DAF. This work is required so that Ireland can meet its reporting obligations under the Kyoto protocol.

During the project an invitation was taken up to present the methodology used in producing Ireland's GHG Emissions at a workshop hosted by the United Nations Framework Convention on Climate Change (UNFCCC) in Bonn.

Results: Under baseline policies (the Luxembourg CAP Reform Agreement), it is found that over the next 10 years, GHG emissions from Irish agriculture are projected to decline relative to existing levels. Potential WTO trade reforms that might become part of a future WTO agreement would lead to only modest additional reductions in GHG emissions by 2015.

In Ireland, increasing milk yields in the presence of a milk quota and the introduction of decoupled payments will reduce the number of dairy cows, other cattle and sheep. These livestock are the three leading contributors to GHG emissions from Irish agriculture. As a result of EU CAP reform (the decoupling of direct payments) and ongoing productivity improvements in agriculture, substantial reductions in methane and nitrous oxide emissions are possible, even in the absence of trade reform.

The dairy sector will remain the main source of agricultural GHG emissions in Ireland. This sector is projected to continue to produce at the maximum level allowed under the milk quota system. It is likely that it would require a greater degree of WTO reform than examined in this WTO scenario to further reduce emissions from the dairy sector.

Estimates for 2004 indicated that agriculture contributed over one-quarter of all Irish GHG emissions. Consequently, the reduction in emissions from Irish agriculture arising out of both the CAP reform and any future WTO trade reform should represent a significant contribution from the agricultural sector in meeting the Irish national Kyoto target of a maximum 13% increase in GHG emissions over the 1990 emissions levels.

Emissions of ammonia from Irish agriculture are projected to decline under both the baseline and the WTO reform scenario. Yet much of the decline projected under the WTO scenario is estimated to occur in any event under the baseline scenario. The impact of the WTO scenario on ammonia emissions only represents an additional 1% reduction in ammonia emissions from agriculture by 2015, relative to the 2015 baseline position.

It should be noted that projections in this project are produced at a national level. In the case of ammonia emissions there may be regional or local considerations that fall outside the scope of this model. For example, while it is anticipated that trade reform will lead to an overall lowering

of agricultural output in Ireland, it could lead to local-level intensification or extensification of production, which the national model is unable to capture.

The projections in this project have been produced under the IPCC Tier I basis, since this is the current level of detail allowed by the FAPRI-Ireland commodity model as presently structured. Future work will aim at redesigning aspects of the FAPRI-Ireland commodity model to allow a greater disaggregation of agricultural activity and enable emissions projections to be made on an IPCC Tier II basis.

1.2 Introduction

Relative to other EU member states and most other developed countries, Ireland is unusual in terms of the percentage contribution made by agriculture to national GHG emissions. Of the 68 Mt of GHG CO_2 equivalent produced in Ireland in 2004, it is estimated that 28% was contributed by Irish agriculture (Environmental Protection Agency, 2005). This figure reflects both the high degree of agricultural activity and relatively lower levels of other GHG sources (such as heavy industry) in Ireland. The emission of GHGs from Irish agriculture principally comes from animals but is also the result of agricultural practices such as the use of fertiliser and manure management. It is likely that policy-makers will seek to reduce GHG emissions below the levels projected in the NCCS report. In this regard they may consider the cost of reducing emissions from each sector in order to minimise the effect on the overall economy. There is thus a need to estimate GHG emissions from the various sectors of the economy, including agriculture.

This project projects the future level of GHG emissions under existing agricultural policies prevailing in the EU and then contrasts that outcome with projections made under an assumed WTO agreement, thereby capturing the potential impact of such a trade reform for GHG emissions from Irish agriculture.

In addition to concerns relating to GHG emissions, since the 1970s there has been growing international concern about air pollution. In the EU an objective of policy-makers is to formulate and implement strategies to improve air and water quality. To meet this objective, the control of emissions from a variety of industrial, commercial and agricultural sources is a key aim. With this in mind the European Council issued a Directive (No. 2001/81/EC) in 2001 that sets limits for each EU member state in terms of total emissions of specific gases. These limits are to be met by 2010.

Four categories of pollutants – sulphur (SO_2), nitrous oxides (NO_x), volatile organic compounds (VOCs) and ammonia (NH_3) – have been identified as being responsible for acidification and eutrophication of ground water and ground-level ozone pollution. The Directive allows EU member states to provide their own mechanisms to ensure that reduction targets are achieved. As part of the Directive EU member states will be required to report each year on their actual and projected future levels of emissions of these substances. National programmes are required to specify how national ceilings will be met. The Directive contained provisions for reviews in 2004 and 2008 to identify the progress being made and whether further actions are required.

Some of the pollutants mentioned above can be transported considerable distances through the air or in water, which means that pollution arising in one country may have an impact in another. Thus a coordinated international approach, which extends beyond the EU, is required to address the issue. Accordingly, in November 1999 EU member states together with Central and Eastern European countries, the US and Canada negotiated the UNECE Gothenburg Protocol to the 1979 Convention on Long Range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground Level Ozone (UNECE, 1999). The Gothenburg Protocol contains emission ceilings that are not as stringent as are those agreed by the European Council. Under the Gothenburg Protocol, Ireland agreed to reduce its NH_3 emission levels by 9% from those estimated for 1990. With regard to Irish agriculture's contribution to these forms of pollution, a number of consequences can be identified as below.

Eutrophication refers to the gradual increase in the concentration of phosphorus, nitrogen, ammonia and other plant nutrients in water ecosystems such as lakes. As the amount of organic material that can be broken down into nutrients rises, the productivity or fertility of such an ecosystem increases. Runoff from land may enter water systems containing, among other things, fertiliser and decomposing plant matter. This spillover can cause algal blooms (highly concentrated amounts of micro-organisms) to develop on the water surface, which then prevents the light penetration and oxygen absorption that is necessary for aquatic life. This process can be intensified when excessive amounts of fertilisers (as well as sewage and detergents) are prevalent. Ammonia is a major constituent of agricultural fertilisers, which contributes to the process of eutrophication.

Acidification can result from emissions of sulphur dioxide, nitrogen oxides and ammonia. Although sulphur is the biggest contributor to acidification, nitrogen compounds are also a significant source. When soil becomes acidified it can cause nutrients to leach, which then reduces soil fertility. Metals can also be released from the process, which can affect the micro-organisms that facilitate decomposition of organic matter in the soil and in turn affect birds, animals and humans. Tree damage such as leaf and needle losses has been linked to acidification and high concentrations of ground ozone.

We examine the level of ammonia produced by the various sub-sectors of Irish agriculture. We use economic projections for future levels of agricultural activity in conjunction with per unit estimates of ammonia emissions to calculate future levels of ammonia emissions from Irish agriculture

In this project we do not consider the issue of whether or not GHG or ammonia emissions from agriculture should be considered as a multifunctional output of the agricultural sector. The OECD has produced an analytical framework wherein the nature and definition of multifunctionality is discussed at length (OECD, 2001).

The rest of this report is divided into four further sections. Section 1.3 very briefly describes the methodology for the estimation of the impact of trade policy on the level of agricultural activity and in turn the effects of GHG and ammonia production. Section 9.2 outlines two states of the world for examination. The first, referred to as a baseline, examines agricultural activity and emissions generation under a continuation of existing (Uruguay Round) WTO trade policies and

the existing (Luxembourg Agreement) EU common agricultural policy (CAP). The second state of the world, a WTO reform scenario, alters trade policies (as a result of a hypothetical WTO agreement) to assess the impact on agricultural activity and emissions generation. The policy change considered under the WTO reform is also detailed in this section. The difference between emission levels under the two scenarios is an estimate of the environmental effects of the WTO reform. Section 9.3 presents the results for agricultural production, GHG and ammonia emissions under both the baseline and the WTO reform scenarios. The results are followed by some conclusions and areas for further work.

1.3 Method of analysis

The approach used here involves the use of two distinct modelling frameworks, which interact with each other to produce projections of the impact of trade policy reform on GHG and ammonia emissions. The first component is an econometric, partial-equilibrium commodity model and the second component is the satellite emissions projection models for both GHG and ammonia. For more details on the methodology employed see Donnellan & Hanrahan (2006).

1.4 Descriptions of the baseline and WTO reform scenarios

The method of reporting the effect of trade policy on GHG and ammonia emissions relies upon a comparison of two states of the world, one including, and the other excluding, the trade policy change under examination.

Baseline scenario. This scenario calculates the level of activity that would arise in the future under a base case set of agricultural policies. Projections of activity levels under the base case of agricultural policy are referred to as the baseline policy outcome.

The baseline projections of agricultural activity used in this section are drawn from the baseline outlined in Binfield et al. (2006), i.e. the CAP mid-term review and the GATT[1] Uruguay Round Agreement on Agriculture (URAA).[2] Projections of GHG emissions stemming from these agricultural projections are presented below.

Alternative scenario. This scenario calculates the level of activity that would arise in the future under alternative agricultural policies. Projections of activity levels under alternative policies are referred to as the alternate policy outcomes.

At the time of writing (December 2005), the outcome of the WTO Doha round negotiations is unknown. The WTO reform scenario formulated and analysed here is close to the current position of the EU within the Doha round (EU Trade Commissioner Peter Mandelson's offer of 28 October 2005). Under the WTO scenario, as defined in Table 1.1, the aggregate measure of support (AMS) is cut by 70% from the bound URAA levels. Under the export competition heading, the EU phases out its export subsidies over the course of 10 years. Also, in this WTO

[1] GATT refers to the General Agreement on Tariffs and Trade – the precursor to the World Trade Organisation.

[2] Note that the more recent reform of the EU sugar regime - Council Regualtion (EC) No 318/2006 - is not reflected in this analysis.

scenario, 50% of the cut in export subsidies is front-loaded on the first year (2007) with the remaining 50% phased out in equal instalments over the following nine years. Under the market access headings a cut in average tariffs of 60% is implemented with lower cuts in tariffs applying to sensitive products set at 25%. Beef and butter are designated as sensitive products for the EU and are subject to these lower tariff reductions. No other market access provisions (e.g. tariff-rate quotas or TRQs) are altered.

Under the WTO reform scenario analysed, the green and blue box classifications of current government support to agriculture are retained and unaffected by the changes proposed.

Table 1.1 WTO reform scenario

	Domestic support	**Export subsidies**	**Market access**
WTO scenario	70% reduction in the total AMS based on Uruguay round final bound levels with retention of green and blue boxes	Phased out over 10 years, with a 50% down payment in year 1 and 9 years of equal instalments thereafter	60% average cut in tariff lines, with a 25% minimum cut (to apply to products designated as sensitive)

Source: Authors' compilation.

The effect of the change in policy can be measured by the difference between the projections for the baseline and the WTO reform scenarios.

1.5 Results

Here the results for GHG emissions are presented under both the baseline policy and the WTO reform scenario. The results include a summary of the impact on agricultural production levels as well as details on GHG emissions.

1.5.1 Irish agricultural production: Baseline policy

Under baseline policies, livestock numbers in Ireland are projected to decline over time. The number of dairy cows would fall as a result of the quota limits on total milk production and genetic improvements that lead to dairy cows becoming more productive over time – thus the number of cows required to fill the quota would decrease. Dairy cows are by far the largest source of agricultural GHG emissions, on a per head basis, so this reduction would have a sizable effect on total Irish agricultural GHG emissions.

Under the baseline projection, the decoupling of agricultural policy as recently introduced in the EU will lead to a decrease in Irish beef cattle and sheep numbers over the period to 2015, since the policy will make it unprofitable for some producers to raise these animals. In Ireland, the baseline number of pigs and other animal categories is projected to remain relatively static over the projection period.

The total land area in agricultural use in Ireland will have declined slightly by about 1% under baseline policies by 2015 relative to the level in 2004. It is projected that there will be some changes in land use over the period, as there is a slight tendancy for area planted with cereals and root crops to shifts into use as pasture. Although animal numbers are expected to decline, the move towards more extensive livestock production will mean that the proportion of land devoted

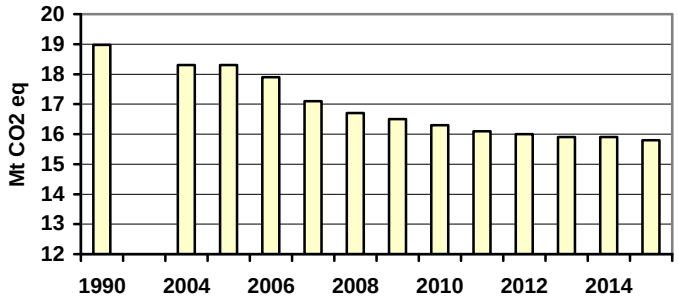
to pasture, hay and silage will not change markedly. Conditions attached to the receipt of the decoupled payments limits the extent to which land will move between these use categories.

1.5.2 GHG emissions from Iris h agriculture: Baseline policy

The baseline projections for total emissions from agriculture are presented in Figure 1.1. Overall, the baseline projections suggest that, with the introduction of decoupling as an agricultural policy, there will be a reduction in overall agricultural activity. Consequently, Irish agricultural GHG emissions are also set to decline. The reduction comes mainly through a decrease in the projected future numbers of cattle (both dairy and beef) and sheep. Total GHG emissions from Irish agriculture are projected to fall by approximately 14% by 2015 relative to 2004. Measured against a 1990 base, the decline by 2015 is projected to be over 16%.

Emissions must be reduced by 8% for the EU-15 as a whole, by the first commitment period. However, under the EU Burden-Sharing Agreement Ireland is committed to minimising its rate of increase in GHG emissions to 13% above the 1990 level agreed under the terms of the Kyoto Protocol. Strong economic growth has given rise to a significant increase in emissions in the non-agricultural sectors of the Irish economy since 1990, so the projected decrease in agricultural GHG emissions would represent an important contribution towards the attainment of Ireland's GHG emissions target. Projected emissions under the baseline scenario are summarised in Table 1.2.

Figure 1.1 Projections of GHG emissions from Irish agriculture – Baseline policy



Note: Totals represent CH_4 and N_2O (in $C0_2$ equivalents) from enteric fermentation, manure management and agricultural soils.

Source: FAPRI-Ireland Partnership Model (2006).

Table 1.2 GHG emissions by Irish agriculture from 1990 to 2015 – Baseline policy

Source category	Unit[a)]	1990	Baseline 2015	Change (%)
Methane (CH_4)	Gg	551.6	469.8	-14.83
Nitrous oxide (N_20)	Gg	23.9	21.3	-10.88
Total (CO_2 equivalent)	Mt	18.97	15.8	-16.71

[a)] Gg = gigagram (thousand tonnes); mt = million tonnes

Note: The $C0_2$ equivalent measure represents the change in the global warming potential of methane and nitrous oxide.

Source: FAPRI-Ireland Partnership Model (2006).

The next section outlines the results of the WTO reform scenario using the FAPRI-Ireland model. The consequent effects on GHG emissions under these alternate policy scenarios are presented.

1.5.3 Projections of agricultural activity: WTO reform scenario

It is projected that under the WTO reform scenario, milk quotas will continue to be filled in Ireland. Dairy cow numbers will decline at a slightly lower rate than indicated in the baseline, because the WTO reform scenario will lead to a reduction in milk prices that is greater than in the baseline. This outcome slightly impedes the growth in milk yields; as a corollary, it also slows the fall in cattle numbers.

Under the WTO scenario, there is also a further contraction in Irish beef cattle numbers as reduced exports (due to the elimination of export refunds) and increased imports (due to reduced import tariffs) lead to lower beef prices across EU member states including Ireland. Overall, cattle numbers under the WTO scenario are lower than in the baseline.

In the case of sheep, Irish prices and production also decline as imports from outside the EU increase (due to lower import tariffs). The number of pigs and other animal categories is projected to remain relatively static over the projection period under the WTO reform scenario.

Relative to the baseline, the WTO reform scenario leads to only minor changes in the allocation of Irish farmland to pasture, hay and silage, cereals and root crops. As indicated under the baseline projections, the conditions attached to the receipt of the decoupled payments will limit the extent to which land will move between use categories.

1.5.4 Projections for GHG emissions: WTO reform scenario

Since the WTO reform scenario suggests that cattle and sheep numbers fall appreciably, relative to the baseline levels, methane emissions from both enteric fermentation and manure management are expected to decline by a greater extent in this scenario than under the baseline. Emissions levels under the WTO reform scenario for methane, nitrous oxide and GHG equivalent emissions of CO_2 are illustrated in Table 1.3. Under the WTO reform scenario, by 2015 the total GHG emissions from agriculture are expected to decrease by 3.5 Mt of CO_2 equivalent (a decrease of almost 20%) relative to the position in 1990.

Table 1.3 GHG emissions by Irish agriculture from 1990 to 2015 – Luxembourg Agreement/EU WTO scenario

Source category	Unit[a)]	1990 Actual	2015 WTO reform scenario	Change (%)
Methane (CH_4)	Gg	551.6	456.9	-17.17
Nitrous oxide (N_2O)	Gg	23.9	20.9	-12.55
Total (CO_2 equivalent)*	Mt	18.97	15.3	-19.35

[a)] Gg = gigagram (thousand tonnes); mt = million tonnes

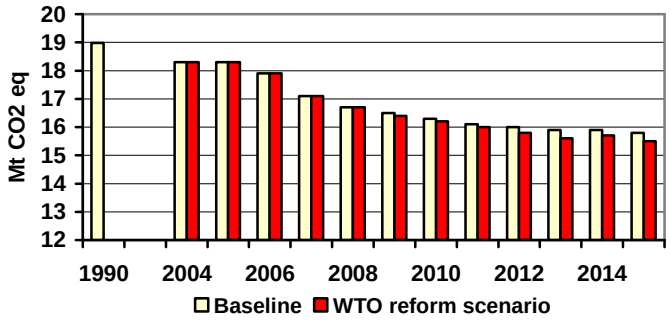
Note: The CO_2 equivalent measure represents the change in the global warming potential of Methane and Nitrous Oxide.

Source: FAPRI-Ireland Partnership Model (2006).

By contrast, the baseline analysis presented earlier projected a reduction of 3.2 Mt of CO_2 equivalent relative to the 1990 level (a decrease of over 16%). Under the WTO reform scenario the 2015 outcome represents a reduction in emissions relative to 1990 levels that is almost 3 percentage points below the reduction projected to occur in the baseline. This result suggests that the WTO reform examined here would deliver additional environmental benefits to those already anticipated under the baseline agricultural reforms taking place in the EU.

Figure 1.2 presents the projections for GHG emissions from Irish agriculture under the baseline and the WTO reform scenarios in CO_2 equivalent terms.

Figure 1.2 Projections of GHG emissions from Irish agriculture – Baseline and WTO scenarios



Note: Totals represent CH_4 and N_2O (in CO_2 equivalent) from enteric fermentation, manure management and agricultural soils.

Source: FAPRI-Ireland Partnership Model (2006).

1.5.5 Projections of ammonia emissions: Baseline and WTO reform scenarios

Apart from any environmental restrictions that might come into place, the type of agricultural policy pursued in the future will affect the level of agricultural activity and in turn the total level of ammonia emissions. The level of ammonia emissions can be projected under the baseline and WTO scenarios. The approach builds on earlier work (Behan & Hyde, 2003).

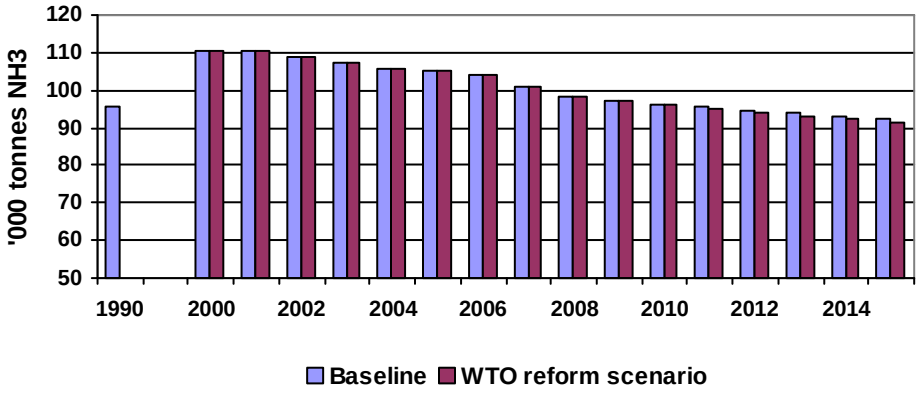
It is found that under both the baseline and the WTO scenarios emissions of ammonia are likely to decline relative to current levels. By 2015 it is projected that ammonia emissions from agriculture will have declined by 13% relative to the 2004 level. Despite the decrease this would still mean that the level of ammonia emissions from agriculture would be very close to the 1990 base year for the Gothenburg Protocol. Ireland's commitment under this Protocol is for a 9% reduction on the 1990 level of emissions of ammonia (a target level of 116,000 tonnes) in aggregate economy-wide terms by 2010. Projections of ammonia emissions are shown in Figure 9.3.

The reduction in emissions in the baseline stems from the decoupling of payments, which results in fewer beef cattle and sheep numbers. With milk production fixed by a quota, the continuing increase in milk yields per cow means that dairy cattle numbers are also reduced in the baseline.

Under the WTO reform scenario it is projected that there will be further reductions in beef cattle and sheep numbers relative to the levels projected in the baseline but the decline in dairy cattle numbers is in line with that of the baseline. Relative to 2004 the reduction achieved by 2015

represents a decline of 14%. The extent of the decline is only slightly (1%) greater under the WTO scenario compared with the baseline.

Figure 1.3 Projected ammonia emissions from agriculture – Baseline and WTO scenarios



Source: FAPRI-Ireland Partnership Model (2006).

The analysis here suggests that the effects on non-dairy sectors of EU and Irish agriculture of the WTO elements of the scenario analysed would be somewhat modest. The changes that arise under the scenario relative to the baseline in these sectors largely stem from policy changes in the Luxembourg Agreement. Nevertheless, more extensive trade reforms might have a more widespread impact on agriculture in the EU and Ireland. Results will also be sensitive to the future exchange rate between the euro and the US dollar.

1.5.6 Comments on the overall results

The overall results projected for both GHG and ammonia emissions suggest that the reductions in emissions foreseen over time will largely be arise due to CAP reforms rather than to international trade policy (WTO) reforms. Although this is the most obvious conclusion to make, it may also be slightly misleading. The motivations for reform of the CAP relate, to some degree, to pressures external to the EU – principally the need to make the CAP more compatible with a future WTO agreement. It is unlikely that the 2003 CAP reform would have taken the shape it did, had it not been for these WTO-related pressures. Therefore one could argue that the reductions in emissions projected under the baseline are also motivated by trade policy reform and not merely by changes to domestic policies.

1.6 Conclusions

This project projects some of the effects of recent reforms to EU agricultural policy (as a baseline) on the environmental/multifunctionality aspects of Irish agriculture. The analysis also provides projections of the potential effects of a WTO agreement on such measures in Ireland.

Under baseline policies (the Luxembourg CAP Reform Agreement), GHG emissions from Irish agriculture over the next 10 years are projected to decline relative to existing levels. Potential WTO trade reforms that might occur due to a future WTO agreement would lead to only modest additional reductions in GHG emissions by 2015.

In Ireland, increasing milk yields in the presence of a milk quota and the introduction of decoupled payments will reduce the number of dairy cows, other cattle and sheep. These kinds of livestock are the three leading contributors to GHG emissions from Irish agriculture. As a result of EU CAP reform (the decoupling of direct payments) and ongoing productivity improvements in agriculture, substantial reductions in methane and nitrous oxide emissions are possible, even in the absence of trade reform.

The dairy sector will remain the main source of agricultural GHG emissions in Ireland. This sector is projected to continue to produce at the maximum level allowed under the milk quota system. It is likely that it would require a greater degree of WTO reform than that examined in this WTO scenario to significantly reduce emissions from the dairy sector below the level projected in the baseline.

Estimates for 2004 indicate that agriculture was responsible for over one-quarter of all Irish GHG emissions. Consequently, the reduction in emissions from Irish agriculture arising out of both the CAP reform of 2003 and any future WTO trade reform should represent a significant contribution from the agricultural sector towards meeting the Irish national Kyoto first commitment period target of a maximum 13% increase in GHG emissions over the 1990 emissions levels.

Emissions of ammonia from Irish agriculture are projected to decline under both the baseline and the WTO reform scenarios. Yet much of the decline projected under the WTO scenario is estimated to occur in any event under the baseline scenario. The impact of the WTO scenario on ammonia emissions from agriculture only represents an additional 1% reduction by 2015, relative to the 2015 baseline position.

It should be noted that the projections in this project have been generated at a national level only. While this national focus does present an issue in the case of GHG emissions, in the case of ammonia emissions there may be additional regional or local considerations that fall outside the scope of this model. For example, while it is anticipated that trade reform will lead to an overall lowering of agricultural output in Ireland, it could lead to local-level intensification or extensification of production, which the national model is unable to capture. Such local level changes could have local level environmental implications concerning ammonia emissions that can not be measured by a non-local level study such as this.

The projections in this report have been produced under the IPCC Tier I basis, since this is the level of detail allowed by the FAPRI-Ireland commodity model as currently structured. Future work will aim at redesigning aspects of the FAPRI-Ireland commodity model to allow a greater disaggregation of agricultural activity and enable emissions projections to be made on an IPCC Tier II basis.

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