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DOMESTIC AND INTERNATIONAL ENVIRONMENTAL IMPACTS OF AGRICULTURAL TRADE LIBERALISATION

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**DOMESTIC AND INTERNATIONAL ENVIRONMENTAL IMPACTS
OF AGRICULTURAL TRADE LIBERALISATION**

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FOREWORD

This study is the result of analysis on linkages between agriculture, trade, and the environment undertaken as part of the work of the Joint Working Party of the Agricultural Committee and the Environment Policy Committee. It evaluates the environmental effects of agricultural trade liberalisation in the context of ongoing agricultural policy reform. In particular, it reports preliminary quantitative estimates of the impact of further agricultural trade liberalisation on the domestic and international environment.

The report provides a brief general overview of the impact of trade liberalisation on the environment, and then discusses trade induced *international* environmental impacts related to agriculture, such as greenhouse gas emissions from agricultural production, international transport of agricultural commodities, and the potential introduction of non-indigenous species alongside agricultural produce, as well as *domestic* environmental effects, including prospective changes in water and soil pollution from agriculture and the provision of agri-environmental amenities. A number of these effects are quantified by combining estimates from the OECD's commodity market and trade analysis model *Aglink* with information from the *Agri-environmental Indicators* database. Based on the qualitative and quantitative results from the analysis, policy approaches to address the interactions between agriculture, trade, and the environment are discussed. The study was carried out in the Policies and Environment Division of the Directorate for Food, Agriculture and Fisheries under the general supervision of Wilfrid Legg. While the study was prepared as part of the collaborative process in the OECD, the principal author of the report was Peter Walkenhorst.

The Secretary-General has agreed to declassify this document under his responsibility as recommended by the Committee for Agriculture and the Environment Policy Committee.

TABLE OF CONTENTS

DOMESTIC AND INTERNATIONAL ENVIRONMENTAL IMPACTS OF AGRICULTURAL TRADE LIBERALISATION

EXECUTIVE SUMMARY

Agricultural trade liberalisation has the potential to contribute to overall improvements in environmental performance. Further reductions of barriers to agricultural trade (a scenario assuming an extension of the Uruguay Round commitments until 2004) will have both positive and negative impacts on the environment. The direction and magnitude of these effects will depend on the trade liberalisation-induced changes in agricultural production patterns, the state of the environment, and the environmental regulations and policies in place to preserve and improve environmental quality. Given the considerable diversity of agricultural production systems, natural conditions, and regulatory approaches in OECD countries, the environmental impacts will vary between countries, regions, and locations. Indeed, many environmental effects are site-specific.

A reduction of trade barriers will influence the overall scale of agricultural activities, the structure of agricultural production in different countries, the mix of inputs and outputs, the production technology, and the regulatory framework. These adjustments, in turn, will impact on the international and domestic environment by increasing or reducing environmental harm and creating or destroying environmental amenities. International environmental effects include transboundary spill-overs, such as greenhouse gas emissions, changes in international transport flows, and the potential introduction of non-native species, pests and diseases alongside agricultural products. Domestic environmental effects include ground- and surfacewater pollution from fertiliser and pesticide run-offs, and changes in land-use that affect landscape appearance, flood protection, soil quality, and biodiversity.

This study illustrates the direction and magnitude of some of the environmental impacts by combining preliminary results on the commodity market impacts of agricultural trade liberalisation with agri-environmental indicators. The international environmental impacts indicate that projected medium-term increases in ruminant livestock numbers could lead to substantial increases in methane emissions in some OECD countries, which could warrant the attention of policy makers in the context of existing Kyoto Protocol commitments on greenhouse gas emissions.

With respect to domestic environmental impacts, the quantitative analysis suggests that agricultural prices and production intensity would decrease in countries that have had historically high levels of fertiliser and pesticide application, so that environmental stress in these countries would be relieved. Countries where increases in production intensity occur might be able to accommodate increased application rates of agro-chemicals relatively easily, as their historical levels of fertiliser and pesticide use tend to be low. Projections on the effects of further agricultural trade liberalisation on land use do not suggest substantial

changes in agricultural land. Yet, the analysis does not allow to derive firm conclusions on prospective changes in landscape appearance, soil and flood protection, and biodiversity, since the projections did not explicitly consider some environmentally sensitive areas, such as pastures and marginal agricultural land.

Under the assumptions of the scenario analysis, the environmental impacts of general economic developments are more important than those of further agricultural trade liberalisation, so that agri-environmental policies will need to be developed independently of trade policy reform. Environmental effects from changes in agricultural activities will most effectively be addressed through targeted policy measures that distort agricultural production and trade to the least possible extent. As far as transboundary effects on the environment are concerned, international co-operation, for example in the form of international environmental agreements, might be necessary to overcome the free-rider problem.

There are several issues at the interface of agriculture, trade, and the environment that warrant additional analysis. These include specific studies of the impact of further agricultural trade liberalisation on the environment at the regional level and on marginal agricultural land, taking the potential jointness of agricultural and positive and negative environmental outputs into account. Moreover, more explicit consideration of existing environmental regulations in the context of trade-induced changes in agricultural production patterns seems desirable, as well as an extension of the analysis to dynamic impacts of trade liberalisation, such as induced changes in production technology and farming systems. One issue for investigation in this context might be the impact of trade liberalisation on the local and regional concentration of livestock herds and associated problems of environmental pollution.

1. Background and policy issues

Furthering the integration of the agro-food sector into the multilateral trading system and facilitating the sustainable management of natural resources and the environment are two of the shared goals that OECD Agriculture Ministers endorsed during their March 1998 meeting in Paris. Ministers thereby acknowledged that the challenge in simultaneously pursuing trade liberalisation and environmental protection is to use a range of well-targeted policy measures which ensure that concerns for the state of the environment are met in cost-efficient ways, while avoiding distortions to production and trade. Developing mutually supportive environment and trade policies was seen as a central element of fostering sustainable agriculture. OECD Environment Ministers, meeting in April 1998, considered that economic globalisation, when combined with sound environmental and social policies, can provide a positive impetus to sustainable development. One of their shared goals included the strengthening of international co-operation in meeting global and regional environmental commitments by promoting efforts to ensure that environmental concerns are effectively integrated into the multilateral trading system.

Provided that governments implement effective environmental policies, trade liberalisation can have positive impacts on the environment by improving the efficiency of resource allocation, promoting economic growth, and mobilising resources for environmental improvements. But if all significant environmental costs are not internalised through appropriate policies, the increased economic activity from trade liberalisation might contribute to environmental problems. The quality of the environment appears to be especially sensitive to changes in agricultural production, as agriculture is an activity that requires large amounts of land and water, influences natural habitats and biodiversity, and shapes large parts of the rural countryside. However, agriculture is not the only production activity that impacts on the rural environment.

In practice, there might be potential for friction between agricultural trade liberalisation and environmental protection, as trade barriers for agricultural products remain high and accounting for environmental costs and benefits is often incomplete. The Uruguay Round Agreement brought agriculture more closely into the framework of the multilateral trading system and established a new set of rules on market access, export subsidies, and domestic support. The conditions under which agricultural products are traded improved and domestic agricultural policies were partially reformed. For example, the value of market price support in OECD countries decreased from $226 billion in 1991-93 to $180 billion in 1997-99 (in current US$), which was only partly offset by an increase in budgetary payments to farmers from $66 billion to $86 billion over the same time period. The average Producer Support Estimate (PSE) in the OECD dropped from 39 per cent in 1991-93 to 36 per cent in 1997-99 (OECD, 2000A). Despite this reduction in protection and transfers to agricultural producers, barriers to trade continue to be substantial and pervasive. For example, tariffs on agricultural products in industrialised countries are on average about ten times as high as those on manufactured goods (Josling, 1998). Some observers see this differential in protection reflecting in part the non-trade concerns that countries associate with agricultural activities.

At the same time, not all agricultural producers have appropriate incentives to take all the environmental costs and benefits of their activities into account when making production decisions, if there is an absence of an appropriate regulatory framework, inadequate information, or insufficient financial resources. Farmers do not always fully internalise the social costs they impose on the environment, such as causing pesticide and nutrient run-offs into the groundwater, nor do individual revenues always cover the costs of providing agri-environmental amenities, such as contributing to biodiversity and shaping rural landscapes. In such cases, the outcome in terms of agri-environmental performance can be economically sub-optimal.

With high levels of agricultural protection and incomplete environmental regulation or enforcement, a central policy issue for OECD countries is how to realise the efficiency gains from agricultural trade without compromising the quality of the environment. Are there environmental benefits from further agricultural trade liberalisation and how are they distributed? Can domestic policies address all the environmental risks of increased agricultural trade, or is international policy co-ordination required? Does agricultural trade liberalisation have a substantial impact on the state of the environment or are other factors more important? Are trade policy instruments effective means to achieve environmental objectives or are other policies more efficient?

Earlier work in the OECD reasoned that agricultural trade liberalisation is necessary to improve the state of the environment, but is not sufficient in itself (Ervin, 1997). Domestic policy responses might be needed where pollution hot-spots or amenity losses occur. The present paper aims to further the analysis by establishing distinctions between the domestic and international impacts of agricultural trade liberalisation, and by reporting some preliminary quantitative results from recent studies on the subject. Quantitative information on the effects of agricultural trade liberalisation on the environment, as derived from analysis using the OECD's *Aglink* model and *Agri-environmental Indicators* database, is still scarce and by no means conclusive, but it can provide some insight into the direction and magnitude of prospective outcomes that should be helpful to advance the policy debate.

The following section illustrates the linkages between agriculture, trade, and the environment as an overview for the subsequent discussion. Section 3 presents the analytical framework that is used to quantify the environmental effects of further agricultural trade liberalisation. Sections 4 and 5 then evaluate the international and domestic impacts of agricultural trade liberalisation in detail. Section 6 discusses policy approaches, and the final section 7 provides a summary of main results.

2. Linkages between agricultural trade and the environment

Even prior to the Uruguay Round Agreement on Agriculture (URAA), trade in agricultural products had increased. Between 1980-82 and 1990-92, agro-food imports of OECD countries (excluding intra-EU trade) expanded at an average annual rate of 3.0 per cent. During the same period, agro-food exports of OECD countries increased on average by 1.5 per cent annually (OECD, 1997a). Measures agreed to in the URAA as well as in regional trade agreements will have tended to further propel the volume of international agricultural commerce.

The reduction of barriers to trade will have both positive and negative effects on the environment. Several linkages between trade and the environment, comprising structural, scale, product, technology, and regulatory effects, can be distinguished (OECD, 1994). These are in many cases interlinked and to some extent overlapping. Some of them are international in nature, others are predominantly of domestic consequence, and a third type has effects in both the international and the domestic sphere. The latter case refers in particular to the improved specialisation of agricultural production brought about by trade liberalisation, which allows better use to be made of the available production resources, including environmental ones.

Improved resource allocation will also foster economic growth. Increased economic activity and rising incomes might put pressure on the rural environment by generating additional pollution (e.g. acid rain or run-off of agro-chemicals into groundwater) and stimulating consumer demand for agro-food products, thus possibly raising agricultural prices and triggering the expanded and intensified use of inputs in agriculture. On the other hand, economic growth will possibly mobilise resources for public projects, including perhaps environmental conservation programmes, and improved living standards might strengthen society's preferences for environmental goods relative to other goods, so that the political demand for environmental quality might increase and additional environmental protection measures might be implemented (Radetzky, 1992; Grossman, 1994; Runge, 1995). Moreover, trade liberalisation tends to be associated with increased flows of foreign direct investment and the transfer of new technology. The adoption of the latter often improves productivity and reduces pollution.

Changes in resource allocation due to agricultural trade liberalisation will not be confined to the agricultural sector, but also trigger adjustments in other parts of the economy. In some cases, production factors might be released from the agricultural sector and be employed in other sectors, while in others resources might move from other parts of the economy into agriculture. In a similar manner, liberalisation of international trade (and investment) for non-agricultural products and services will affect resource use in agriculture. The international and domestic environmental impacts of these resource shifts will depend on whether the agricultural or the non-agricultural uses of the production factors are more benign to the environment.

The characteristic of *international* environmental impacts of agricultural trade liberalisation is that although the source of the environmental impact might be national, the consequences are transboundary. Three categories of physical linkages between trade and the environment can be identified:

- *Transboundary spill-overs*: Trade liberalisation induced changes in domestic production patterns might have effects on the international and global environment. This concerns the emission of greenhouse gases (GHGs), but also issues like fertiliser and pesticide run-offs into rivers that cross into other countries, or losses of plant and animal species that reduce the world’s biodiversity. The overall environmental impact could be either beneficial or harmful.

- *Transport*: Agricultural trade liberalisation might result in changes in the volume of international freight, particularly sea transport. The majority of pollution associated with such shipments would occur in the international sphere and would affect common goods, such as fish and other marine organisms. Also, transport within exporting countries will tend to increase. On the other hand, domestic transport might decrease in importing countries, as consumption centres could possibly be supplied from nearby ports or other trade hubs instead of dispersed domestic production locations.

- *Introduction of harmful organisms*: Increased international commerce in agro-food products as a result of trade liberalisation will tend to open new pathways for the introduction of harmful organisms into trading countries. There have been a number of examples of exotic species entering a country and swiftly crowding out native species. However, the introduction of harmful species is not proportional to the volume of trade and in many cases not even associated with agricultural commerce.

Moreover, there can be non-physical international impacts from trade-induced changes in environmental quality *via* “option values”. People can attach values to environmental preservation in places distant from their home, even if positive outcomes of conservation activities are not subject to direct experience. Such option values are rooted in general preferences and ethical attitudes that consider the world-wide protection of biodiversity or valuable landscapes as an issue of preserving the natural heritage of mankind.

In addition to international environmental impacts, agricultural trade liberalisation will likely have consequences for the *domestic* environment. Like many other market and policy changes, a reduction in agricultural trade barriers will change the relative prices of products and the domestic patterns of agricultural production, which in turn might have an impact on the state of the environment (Anderson, 1992; Antle/Just, 1992). This impact will differ among countries, regions, and sectors, and with respect to different aspects of environmental quality, like water quality, soil erosion, or landscape appearance. Also, existing regulations can have a crucial effect on the environmental impact from trade-induced changes in agricultural production. In some cases, the outcome will be environmentally beneficial, in others it might lead to a worsening of the state of the environment:

- *Potential impact on pollution*: In the case of countries (or sectors within countries) where producer prices fall relative to the prices of production inputs as a result of trade liberalisation, the incentive is to reduce fertiliser, pesticide, and irrigation water use, which would diminish run-off into the groundwater and relieve environmental stress.[1] The opposite effects could be expected in countries (sectors) where prices rise so that production is intensified and expanded. Larger amounts of purchased production inputs, like agro-chemicals, might there be applied with potentially adverse consequences for the environment. If the trade-induced shifts in agricultural production are large, so could be the changes in environmental quality.

- *Potential impact on environmental amenities*: While increases in environmental harm are a concern in countries where production is likely to expand due to agricultural trade liberalisation, changes in the provision of environmental amenities are an issue predominantly expressed in countries where agricultural production is expected to decline. The output reduction might not just reduce the input intensity of agricultural practices, but might also lead to a reduction in agricultural land use with either beneficial or adverse consequences for landscape appearance, soil protection, and biodiversity.

In the following sections, both the international and the domestic environmental impacts of agricultural trade liberalisation are discussed in greater detail and with a forward looking perspective. Particular emphasis is thereby devoted to the quantification of likely effects using the different analytical tools available in the OECD Secretariat, such as the *Aglink* commodity market analysis model and the *Agri-environmental Indicators* database. Empirical quantification is helpful for an improved understanding of the issues surrounding agricultural trade liberalisation and the environment. In particular, the direction of some effects can not be determined by economic theory alone, the relative importance of individual effects is not known *a priori*, and the magnitude of the trade liberalisation induced changes needs to be compared with changes brought about by general economic and other developments (Anderson/Strutt, 1996).

However, the numerical results have to be interpreted with care, since the relationship between agriculture, trade, and the environment is complex, depending on such location-specific and often scientifically not fully explored factors like the assimilative capacity of the natural environment. Also, the pressures on the environment from changes in agricultural production will tend to differ according to the country-specific environmental regulations in place. Any estimate of prospective environmental impacts from agricultural trade liberalisation is hence subject to considerable risk. Nevertheless, deriving quantitative estimates of the likely environmental impacts of agricultural trade liberalisation might help to focus and advance the policy debate. They might in particular contribute to differentiate between important and marginal issues and to outline the elements that need to be taken into account when making policy decisions regarding the environmental effects of further agricultural trade liberalisation.

1. In a general equilibrium framework, the impact of price changes for a commodity can be ambiguous. For example, a fall in the producer price for wheat may reduce the polluting input-use for that commodity. However, the relative price of other commodities, such as maize, increases, so that resources will flow into the production of that product, and if the latter is more polluting, overall environmental harm could increase.

3. Framework for quantitative analysis

Trade liberalisation changes the relative prices of previously protected and unprotected inputs, goods and services. Improving market access, reducing market price support, and scaling down export subsidies will tend to lower the prices of the protected products on the domestic market. If trade liberalisation occurs on a multilateral basis, the price reduction effect will be mitigated to some extent by an increase in world market prices. At the same time, the higher world market prices will benefit producers in countries with no or only low levels of protection.

The change in relative prices will trigger adjustments in production and consumption patterns. Where prices on the domestic market rise, producers will tend to expand their output by increasing the use of production inputs. Conversely, in countries where prices fall, producers will try to devote a part of their production factors to alternative, more profitable uses. Corresponding changes, although in opposite directions, will occur on the consumption side.

The production effects of agricultural trade liberalisation will vary within countries. The diversity of natural conditions and economies of scale in agricultural operations could lead to divergences between trade-induced production changes in different regions. Estimates of production developments at the national level do not take this spatial heterogeneity into account. The use of location-specific detail would yield more precision, but the data requirements for such analysis often prove prohibitive.

Despite the lack of regional specificity, results from aggregate models can help to determine the relative importance of different factors and the overall magnitude of adjustment, and thereby highlight potential agri-environmental problems that might require further investigation. For example, if aggregate analysis predicts an overall increase in polluting activities, the development of regional pollution “hot-spots” is more likely than in the case of an aggregate reduction of the particular activity. Considering limitations imposed by data and modelling constraints, the central aim of the subsequent analysis (based on results of trade liberalisation scenarios described in the Annex) is to test the ability of quantifying prospective environmental pressures for demonstration purposes.

4. International environmental impacts

In the case of transboundary or global environmental harm from increased agricultural trade, a free-rider problem, stemming from the fact that national environmental programmes are not sufficient to ensure that the environmental problems are fully addressed, might lead to inefficient outcomes. Some countries might be tempted to avoid the costs of environmental programmes by not participating in efforts to address the transboundary externalities in the hope that others will take the necessary action. However, such free-riding raises the costs of abatement for other countries and might induce the latter also to stop their efforts to contain or reduce international environmental harm. In the end, no country might take action to protect the international environment. Hence, international solutions in the form of multilateral or plurilateral environmental agreements, such as the Kyoto Protocol on greenhouse gas emissions, would be called for to contain or reduce potential harm to the common environment.

Moreover, some environmental problems might be most cost-effectively contained through border measures rather than domestic environmental policies. In particular, control and inspection measures are less costly if carried out at gateways such as border posts, instead of at dispersed farming locations.

The discussion in this section assesses trade-induced impacts on the international environment with respect to transboundary spill-overs (in particular GHG emissions), transport activities, and the introduction of harmful organisms.

4.1 Transboundary spill-overs

Agricultural trade liberalisation will trigger changes in agricultural production, which might lead to increased cross-border spill-overs and possibly aggravate environmental problems at the international and global level. Examples of by-products of agricultural production that could potentially cause environmental harm include emissions of GHGs, nutrient and pesticide run-offs into waterways that flow into the open sea and damage fish stocks, and deforestation that reduces not only local soil fertility but also global biodiversity. In all these cases the *source* of the environmental harm is at the national level, but the *consequences* are international.

The liberalisation of agricultural trade might help to reduce negative spill-overs or augment positive transboundary effects. For example, reduction of fertiliser and pesticide application in countries or regions that used to apply large quantities of these agro-chemicals might reduce the leaching of nitrates and pesticide residues into rivers that flow across borders. On the other hand, further agricultural trade liberalisation could lead to a worsening of the state of the international and global environment, if aggregate output of products that cause transboundary spill-overs rises as a result of increased specialisation according to comparative advantage, corresponding reductions in production costs, and induced economic growth. For example, one might expect from economic theory that international beef market liberalisation will shift beef production from high to low cost suppliers, leading to a reduction in average production costs. This might trigger an expansion of beef production and possibly also of the world's (methane emitting) cattle herd. The magnitude of the change in cattle numbers and GHG emissions depends on the demand and supply impacts of trade liberalisation, substitution possibilities between different livestock products, and agricultural technologies, such as feeding systems, in producer countries.[2]

Agriculture in OECD countries contributes on average about 7 per cent to total GHG emissions (measured in carbon dioxide equivalents), which are major factors in global warming and climate change. The main agricultural sources of GHG emissions are livestock production, fertiliser use, fossil fuel combustion, biomass burning, and wetland rice cultivation. Livestock farming including manure management contributes nearly two-thirds of the total agricultural emission for the OECD countries as a whole, with methane emissions from enteric fermentation in ruminant animals accounting for about half of the agricultural total.

Results from commodity market analysis using the *Aglink* model indicate that under the assumptions of a baseline scenario output of beef and milk in OECD countries is expected to increase by 2.7 and 8.2 per cent between 1995-97 and 2004, while sheepmeat production is projected to decline by 2.5 per cent in the medium term (Table 4.1). However, developments in individual countries diverge considerably. For example, beef output in Korea is projected to decline by more than 20 per cent over the period, while production in Hungary is expected to increase by more than 34 per cent. Some of these divergences in trends might be related to the fact that countries are at different stages in the beef cycle, whereby farmers in some countries are increasing their livestock herds while others are in a destocking phase. In non-OECD countries, in particular in China, considerable expansions of output of ruminant livestock products are expected. Aggregate output change is projected to be positive and exceed that in the OECD area in percentage terms.

Aglink trade liberalisation analysis suggests that an extension of the URAA commitments until 2004 would, compared with the baseline scenario, lead to a small reduction in beef, milk, and sheepmeat output

2. A trade-induced change in the pattern of beef production can entail beneficial or adverse environmental impacts in areas other than GHG emissions. For example, the decrease in the intensity of livestock production in high support countries might lead to a reduction of manure and nutrient run-offs.

in the OECD as a whole (Table 4.1). The production impact on individual countries would vary, though. In some countries, such as Canada and Korea, both beef and milk output would decline as a result of more liberalised trade, while in other, for example Mexico and Poland, production of the two commodities is projected to increase. Many other OECD countries show differing directions of change for individual outputs.

Table 4.1. Impact of an extension of the Uruguay Round commitments on beef, milk, and sheepmeat output, 1995-97 to 2004 (per cent)

	Beef			Milk			Sheepmeat		
Country	Change in Output w/o URAA extension	Change in Output with URAA extension	Impact of URAA extension	Change in Output w/o URAA extension	Change in Output with URAA extension	Impact of URAA extension	Change in Output w/o URAA extension	Change in Output with URAA extension	Impact of URAA extension
Australia	9.4	9.4	-0.1	37.0	37.2	0.2	-7.0	-7.0	0.0
Canada	17.0	16.7	-0.2	7.8	4.8	-3.0	..	..	..
EU-15	-5.1	-5.6	-0.5	-2.1	-2.1	0.0	0.1	0.0	-0.1
Hungary	46.9	46.7	-0.2	7.8	7.8	0.0	..	..	..
Japan	-1.6	-2.0	-0.5	10.8	10.8	0.0	..	..	..
Korea	-8.9	-9.2	-0.3	5.3	5.2	-0.1	..	..	..
Mexico	6.5	6.6	0.1	37.5	37.5	0.1	..	..	..
New Zealand *	12.9	13.0	0.1	33.5	33.2	-0.4	-2.1	-2.2	-0.1
Poland	15.4	15.6	0.2	21.9	22.2	0.3	..	..	..
USA	-0.3	-0.3	0.0	9.0	8.9	-0.1	..	..	..
Argentina	10.8	11.4	0.6	20.7	21.3	0.6	..	..	..
China	57.1	57.1	0.0	40.8	40.8	0.0	61.9	61.9	0.0
Other countries**	30.3	31.6	1.3	26.5	27.1	0.5	..	..	..
OECD countries	2.7	2.5	-0.2	8.2	8.0	-0.1	-2.5	-2.6	-0.1
Non-OECD	26.4	26.7	0.4	26.9	27.5	0.5	61.9	61.9	0.0
Total	11.3	11.3	0.0	16.1	16.3	0.1	29.7	29.6	0.0

* Due to data irregularities the projections for sheepmeat in New Zealand are misleading (see note to annex table A1). **) Countries which were included for the trade liberalisation scenario include Brazil, Paraguay, Chinese Taipeh, and Uruguay for beef; and Africa, non-OECD Asia (except China), non-OECD Europe, and Latin America (except Argentina) for milk. .. not calculated.
Source: OECD Secretariat.

In non-OECD countries, output of ruminant livestock products is projected to rise as a result of further agricultural trade liberalisation. Aggregating across all the OECD and the non-OECD countries that have been analysed, milk output would increase slightly, while beef and sheepmeat production are projected to stay largely unchanged. Hence, even though the analysis of the beef and sheepmeat markets did not take all producer countries into account, the analysis highlights the possibility that production decreases in OECD countries, induced by trade liberalisation, might be offset by increases in production outside the OECD area. In addition, the model results suggest that the aggregate production impact of an extension of the URAA until the year 2004 is not of major importance relative to other factors, such as technological progress. For example, an extension of the URAA would add only 0.1 percentage points to the underlying growth in world milk production of 16.1 per cent between 1995-97 and 2004.

The analytical result from the projections that aggregate ruminant livestock production will increase considerably, but that further agricultural trade liberalisation will lead to only minor increases in world output, does not necessarily imply that emissions of GHGs will rise in proportion to these production changes. Three additional factors have to be considered that are related to the productivity of livestock, farming technology, and the size of national animal herds.

First, technical progress will tend to increase the productivity of livestock over time, so that more milk and meat can be produced from fewer animals. An increase in output of livestock products does, therefore, not necessarily require an increase in animal herd size. Since parts of a ruminant's feed intake and methane gas emission is related to self-maintenance of the animal rather than the production of milk and meat, higher productivity animals tend to have relatively lower GHG emissions per unit of marketed output.[3] Moreover, the composition of an animal herd with respect to age and species influences overall GHG output. For example, young animals tend to generate less methane through enteric fermentation than mature ruminants.

Second, agricultural practices change over time. The use of animal feed diets that are less intensive in carbohydrates and hence generate fewer methane emissions could become more widespread, for example because of feed price developments that favour such a change. Conversely, a switch to more carbohydrate-intensive diets, such as through increased reliance on grass-based feeding systems in which the carbohydrate to protein ratio is more difficult to control than in in-door feeding systems, would augment GHG emissions from livestock.

Third, the geographical changes in ruminant livestock production due to differing rates of domestic production growth and trade liberalisation might lead to an overall increase in GHG emissions. In general, the highest rates of production growth and the largest trade-induced expansions of output for beef, sheepmeat, and dairy products are expected for countries, including developing countries, with relatively low yield levels and often carbohydrate-intensive animal feed diets. For example, the production of one kilogram of butter in North America, a production region with high milk yields and animal feed diets relatively low on carbohydrates, is associated with the generation of about 12 kilograms of carbon dioxide equivalent, while in Oceania, where milk yields are lower and animal feed rations more carbohydrate intensive, about 29 kilograms of GHGs would be emitted per kilogram of butter.[4] Hence, a trade-induced shift of milk production from Canada to Australia, for example, might be associated with an increase in GHG emissions, if feeding practices in the two countries remain unchanged. However, more research on the GHG impact of animal feeding diets over the whole life-cycle seems to be required, in particular concerning the use of energy inputs of non-grass animal feed diets, the methane problems associated with large-scale manure concentrations, and the carbon sink function of pastures.

The impact of agricultural trade liberalisation on global emissions of GHGs can at this stage not be evaluated with sufficient accuracy through the *Aglink* model, because of the latter's currently incomplete coverage of non-OECD countries and the missing coverage of possible changes in animal feeding diets and farming techniques. However, the results from the baseline and trade scenario analysis can provide some insight into the contribution of agriculture to the fulfilment of individual countries' commitments on GHG reductions agreed to at the third Conference of the Parties to the UN Framework Convention on Climate Change held in Kyoto in December 1997. Annex B of the Protocol of the conference contains pledges to reduce total anthropogenic emissions of GHGs in the target period 2008-12 by 5 per cent.

3. However, it should be noted that a shift to higher-productivity livestock might have adverse consequences for environmental quality in other areas, for example if livestock production gets locally more concentrated or if marginal pastures are no longer used.

4. The calculations are based on data submitted by national authorities to the United Nations Framework Convention on Climate Change (UNFCCC). However, information on greenhouse gas emissions is subject to a considerable margin of error and should be interpreted with caution.

Table 4.2 shows the GHG reduction commitments that individual OECD countries have agreed to, as well as the share of agricultural GHG emissions in the countries' total and the projected changes in ruminant livestock numbers with and without agricultural trade liberalisation. The livestock herd size can be taken as a proxy for GHG emissions from beef cattle, dairy cows, and sheep, if the composition of the livestock herd and animal feed diets can be assumed to stay constant over the projection period. The *Aglink* estimates show diverging trends in livestock numbers across countries. The projected changes over the period 1995-97 to 2004 range from an increase in ruminant livestock (dairy cow equivalents) from 22 per cent in New Zealand, to a decline by 30 per cent in Korea.[5] For some countries, notably Australia, the European Union, and Hungary, the projected change in livestock numbers and methane emissions is consistent in proportion to the Kyoto Protocol requirements. For example, in the European Union the number of ruminant livestock and methane emissions are expected to decrease by nearly 11 per cent, while the EU's overall commitment requires a reduction of at least 8 per cent. Hence, methane emissions from livestock would in principle not provide a major obstacle to meet the Kyoto Protocol commitments in the European Union.

Table 4.2. Impact of an extension of the Uruguay Round commitments on livestock numbers (1995-97 to 2004), share of agriculture in greenhouse gas emissions, and Kyoto Protocol greenhouse gas commitments of OECD countries (per cent)

Country	Change in number of ruminants* w/o URAA extension	Change in number of ruminants* with URAA extension	Impact of URAA extension	Share of agriculture in national GHG emissions, 1993/95	Kyoto Protocol commitments, 1990-2008/12
Australia	-1.0	-0.9	0.1	20.7	+8.0
Canada	7.3	7.0	-0.3	4.6	-6.0
EU-15	-10.7	-11.1	-0.4	9.1	-8.0
Hungary	-7.4	-7.3	0.1	5.9	-6.0
Japan	6.2	6.2	0.0	1.7	-6.0
Korea	-30.2	-30.0	0.1	..	..
Mexico	1.5	1.5	0.1	..	..
New Zealand	21.9	21.9	-0.1	57.8	0.0
Poland	1.2	1.4	0.2	5.2	-6.0
USA	0.2	0.1	-0.1	4.4	-7.0

*) in dairy cattle equivalents: 12.5 sheep or 2.083 beef cattle are taken to produce as much methane as one dairy cow. .. not calculated.
Source: OECD (2000c), OECD Secretariat.

However, the projections point to some potential problems in some OECD countries. In New Zealand, for example, livestock numbers are expected to increase by 22 per cent, while the country is committed to keep its GHG emissions constant at their 1990 level. Moreover, GHG emissions from livestock and other agricultural sources in New Zealand account for almost 58 per cent of the country's total, so that very large GHG reductions in non-agricultural sectors would be required to offset the increases in livestock emissions. Further agricultural trade liberalisation is projected to reduce the livestock herd size in New Zealand marginally, so that meeting the Kyoto Protocol commitments will be slightly facilitated.[6] Similar

5. In some countries, such as Hungary, beef and milk production is projected to increase (see Table 4.1), while ruminant livestock numbers are projected to decline. This divergence in trends of production and herd size reflects expected increases in livestock productivity. For example, productivity of milk production in Hungary is expected to increase by almost 30 per cent over the projection period (from 4 900 kg of milk per cow during 1995-97 to 6 250 kg in 2004).

6. The strong increase in New Zealand's ruminant livestock herd might be cyclical, and the number of livestock might decrease between the end of the *Aglink* projection period in 2004 and the start of the Kyoto

positive effects of an extension of the URAA on GHG emissions are projected for the European Union and the USA, which have committed themselves to the sharpest reductions in GHGs among the OECD countries.

Yet, the impact of agricultural trade liberalisation on livestock inventories and GHG emissions is of relatively minor importance when compared with underlying economic trends. For all countries analysed, the changes in ruminant livestock numbers in the baseline scenario are much bigger than the differences between the baseline and the trade liberalisation scenarios.

Even though methane emissions from ruminant livestock account for more than half of the GHG emissions in OECD agriculture, other sources, which might also be affected by agricultural trade liberalisation, have to be considered in addition. For example, the expected overall increase in grain production in OECD countries will tend to lead to a rise in fertiliser consumption with an associate increase in GHG emissions. However, the linkages are difficult to quantify, not least because some natural processes, such as resorption and release of GHGs in soils, are as yet not well understood.

4.2 Transport

Since most environmental resources affected by increased transboundary transport are not subject to multilateral control and protection, the risks of environmental degradation might rise with more international commerce. Countries or regions along major international trade routes will be particularly concerned.

Increased international trade will affect the pattern and volume of transport. The changes apply to trade in both agro-food and other products. Trade liberalisation might reduce domestic transportation in importing countries as consumption centres could possibly be supplied from nearby ports or other trade hubs instead of dispersed domestic production locations, with the magnitude of the effect depending on the organisation of the distribution system.[7] On the other hand, international freight and internal transport in exporting countries will tend to increase. Average transport distances will likely grow, even though enhanced flows of products between neighbouring countries might in some cases replace shipments from more distant export locations. The overall effect on the environment depends on the relative changes in domestic and international transport, average transport distances, and the composition of freight carriers. Long-range international commerce will likely use trains and ships more frequently than short-range domestic traffic, which tends to rely to a greater extent on trucks. Moreover, if transport shifts from countries with strict environmental standards to countries with less stringent regulations, overall environmental harm might increase, and *vice versa*.

Developing a complete energy and air pollution balance of agricultural trade liberalisation would require considering not only the transport-related consumption of energy, but the entire production-cycle, including, for example, the energy used for producing the fertiliser and pesticide applied or for heating animal barns and producing concentrated grain-based fodder. The savings from production in energy-extensive systems might compensate for higher use of transport energy. Yet, general conclusions on the energy-efficiency of different production plus transport systems are difficult to derive, as the eco-efficiency of agricultural production methods varies widely across commodities, farming practices, and locations.

Protocol target period in 2008, thereby reducing methane emissions and potential difficulties in meeting the country's GHG commitments.

7. In particular, if due to trade liberalisation, a decentralised national distribution system is replaced by a more centralised one, transport needs could increase.

The volume of international transport might be reduced, if trade liberalisation leads to a reduction in tariff escalation. In many countries, agricultural commodities are subject to higher rates of border protection at each successive stage of processing. For example, the tariff on cotton thread, as a percentage of the border price, tends to be higher that that for raw cotton, and that on wheat flour might be higher than the one on grain. A reduction in such tariff escalation might encourage more processing to take place in countries that have mainly been exporters of the raw commodities. As processed food products are generally lighter and less voluminous than agricultural raw materials, increased processing close to the farming location will tend to reduce transport needs.

Transport affects the environment by augmenting air pollution, GHGs, noise, water pollution, accidents, land conversion, and habitat fragmentation. The magnitude of the environmental impact depends on the mix of transport modes. With respect to air pollutants, for example, shipments by truck are more damaging to the environment than transport by train or ship (Table 4.3). The evaluation of other types of environmental impacts is more difficult to undertake and the ranking of transport systems is less clear (OECD, 1997b).

Table 4.3. Ranges of air emission rates for trucks, trains, and ships (grams per tonne-km)

Pollutant	Truck	Train	Ship
CO	0.25 - 2.40	0.02 - 0.15	0.018 - 0.20
CO_2	127.00 - 451.00	41.00 - 102.00	30.00 - 40.00
HC	0.30 - 1.57	0.01 - 0.07	0.04 - 0.08
NO_x	1.85 - 5.65	0.20 - 1.01	0.26 - 0.58
SO_2	0.10 - 0.43	0.07 - 0.18	0.02 - 0.05
Particulates	0.04 - 0.90	0.01 - 0.08	0.02 - 0.04
VOC	1.10	0.08	0.04 - 0.10

Source: OECD, 1997b.

Empirical studies on the effects of trade liberalisation on freight movement show a positive but relatively small contribution of increased transport activities to environmental stress (Box 4.1). The adverse effects are mitigated to some extent by a switch from truck haulage to transport by trains and ships, which is less harmful in terms of air pollution.

In comparison, economic growth for reasons other than trade liberalisation will likely lead to greater increases in international transport and related environmental stress. Macro-economic projections of changes in transport of internationally traded goods suggest increases by 71 per cent between 1992 and 2004 (OECD, 1997b). The strongest expansion in transport activities is expected for manufactured products, including intermediate goods used as inputs into manufacturing, while movements of agricultural and mineral commodities will tend to increase to a lesser extent.

Box 4.1. Effects of Uruguay Round commitments on European freight movements in 2004

In 1996, the OECD Secretariat and the Dutch institute NEA analysed prospective changes in average transportation distances and volumes in western Europe resulting from Uruguay Round trade liberalisation commitments (OECD, 1997c). The study combined information on the quantities of commodities that arrived in or departed from European seaports and data on the distances the freight travelled inside the EU-12, Austria, and Switzerland in the base year 1992, with estimates of the Uruguay Round trade liberalisation effects, as derived from Global Trade Analysis Project (GTAP) model simulations. Agro-food products were one of the 12 commodity groups considered.

The results show a modest overall increase by about 3 per cent in transport volume between 1992 and 2004 and insignificant changes in average transport distances (Table Box 4.1). However, the effects of trade liberalisation on transport intensity were more pronounced for agro-food products, where above-average increases in volumes and distances by 4 per cent and 1 per cent, respectively, were projected.

Table Box 4.1: The effect of trade liberalisation on transport activities in western Europe

	1992		2004		
Product category	Volume ('000 t)	Distance (unit km)	Volume (v) (% of '92)	Distance (d) (% of '92)	Activity (v*d) (% of '92)
Agricultural products, live animals and food	134 188	354	104	101	105
Building materials and non-metallic minerals	174 770	427	99	100	99
Coal and coke	131 678	328	105	100	105
Crude oil	396 264	485	100	100	100
Petroleum and gas	88 198	319	105	100	105
Lumber and wood	14 856	433	103	100	103
Paper and paper manufactures	18 021	441	102	100	102
Chemicals and fertilizers	44 409	382	109	100	109
Primary metals and fabricated metal products	39 469	486	108	100	108
Textiles, apparel and footwear	6 345	444	157	97	152
Transport equipment	14 607	488	107	101	108
Other consumer goods and machinery	19 734	474	107	100	107
TOTAL	1 082 539	409	103	100	103

Source: OECD (1997b).

Additional analysis on changes in the modes of transport within western Europe showed an increase in freight movements by train and ship by 22 per cent and 3 per cent, respectively. On the other hand, road haulage was projected to fall by 2 per cent over the period 1992 to 2004.

4.3 Introduction of non-indigenous organisms

The reduction of barriers to agricultural trade will increase the volume of international commerce and open up new trade pathways. Such an expansion in the international exchange of goods increases the probability that non-indigenous species, as well as pests and diseases, will be introduced into importing countries through shipments of agricultural produce. In some cases the non-indigenous organisms could turn out to be environmentally harmful. Exotic weeds might, for example, compete with the native flora for light, water, and nutrients, and ultimately drive the latter out.

In the USA, an estimated 50-75 per cent of major weeds are non-indigenous, as well as about 40 per cent of insect pests afflicting agriculture and forestry. For example, the invasions of the leafy spurge and the Andean pampas grass on US western rangelands and in Hawaii, respectively, have led to a deterioration of pasture quality. The economic damage from exotic species in the USA during the period 1906-91 has been estimated to amount to more than $97 billion in 1991 US dollars (US OTA, 1995).

The population of non-indigenous species does not grow in a linear way and is not necessarily proportional to trade. Instead, there seem to be spurts of species proliferation due to social, technological, and other factors. A proliferation peak in the United States, for example, occurred during the mid-1970s. This spurt may have been related to soldiers returning home from the war in Vietnam with exotic species, intentionally or unintentionally. Given the importance of non-trade factors for the proliferation of exotic species, it seems difficult to quantify the impact of increased agricultural trade due to trade liberalisation on the number of non-indigenous species entering a country.

US authorities have passed a number of statutes, regulations, and judicial decisions to limit the damage from harmful non-indigenous species. Other OECD countries, such as Australia and New Zealand, have also implemented measures, such as quarantines, to guard against damages from the introduction and proliferation of harmful organisms. The Sanitary and Phytosanitary Agreement, which was part of the outcome of the Uruguay Round trade negotiations, allows governments to restrict trade in order to protect human, animal, and plant health. Restrictions have to satisfy a number of criteria, though: they must be transparent, based on scientific risk assessment, provide a level of protection equivalent to international standards or a level that is scientifically sound, and have to ensure equal treatment between all imports and domestic products.

While increased international commerce due to further agricultural trade liberalisation might increase the risk of introduction of exotic species, a reduction in tariff escalation could have the opposite effect with benefits for the environment. If tariffs on processed food products in importing countries would fall relative to tariffs on agricultural raw materials, a larger share of overall processing might be carried out in the raw material producing country. Fewer agricultural products might be shipped between countries, reducing the potential for pests and diseases to be passed from one country to another.

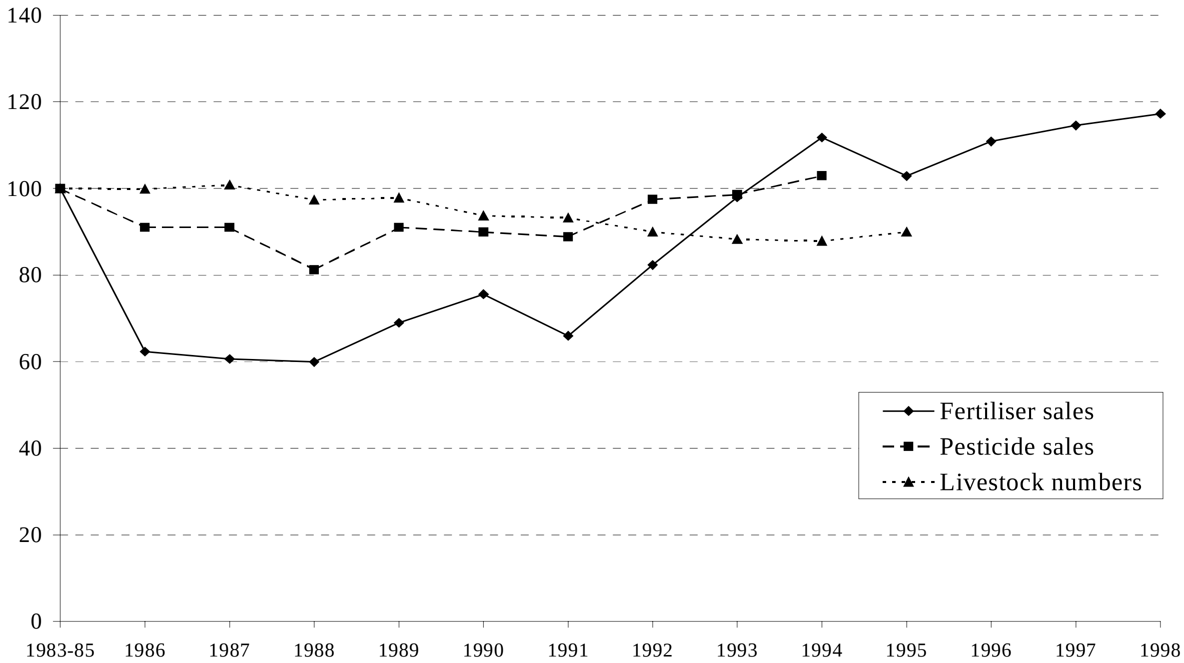
5. Domestic environmental impacts

The domestic environmental repercussions of production changes due to trade liberalisation are site-specific and sometimes ambiguous. In the case of countries where producer prices would fall following agricultural trade liberalisation, the incentive for fertiliser, pesticide, and irrigation water use is reduced, which is likely to diminish run-off and groundwater contamination and, in general, relieve environmental stress (Ribaudo/Shoemaker, 1995; Tobey/Reinert, 1991; Box 5.1). Also, marginal land might drop out of production and in some cases allow for the regeneration of valuable wildlife and natural habitats. In some other cases, land idling — specifically if it concerns land that has been cultivated over centuries — could similarly cause environmental loss from flood damage, increased soil erosion, loss of biodiversity, and degraded landscapes, even though there are techniques available to reduce the likelihood of adverse consequences.

Box 5.1: The impact of farm support reductions on the environment: the case of New Zealand

In 1984, New Zealand embarked on a large-scale agricultural policy reform programme. Output price assistance for agricultural products was eliminated, fertiliser and other input subsidies were abolished, and tax concessions for farmers were withdrawn. Total support to agricultural producers as measured by the PSE dropped from 17-18 per cent in the early 1980s to 3 per cent in the mid-1990s. The reduction of support led to a temporary decrease in the use of fertiliser and pesticides, as well as to a de-stocking of livestock herds (Figure Box 5.1). Since the early 1990s, favourable price developments, economic growth, and in particular the significant expansion of horticultural production have triggered an increase in the use of agro-chemicals again.

Figure Box 5.1: Livestock numbers, and fertiliser and pesticide use in New Zealand, 1986-98
(1983-85 = 100)



Note: Livestock numbers are expressed in breeding ewe equivalents.
Source: New Zealand Ministry of Agriculture and Forestry.

Fertiliser use remained well below pre-1984 levels for several years and only in 1993 and 1994 returned to the level of the early 1980s. Pesticide use also decreased after 1984, though less than the fall in fertiliser application, because pesticides had not been subsidised. Subsequently, pesticide use varied but has gradually increased since the early 1990s to reach near 1984-levels by 1994. In the livestock sector, the overall reduction in animal numbers was accompanied by a marked change in the composition of the national livestock herd. Triggered by the reduction in subsidies as well as low wool prices on the world market, the number of sheep in New Zealand fell from 70 million in 1983 to 49 million in 1995. In contrast, beef and dairy cattle numbers increased over the same time period from 4.5 million to 5.2 million heads and from 3.1 million to 4.1 million heads, respectively. Since subsidies to beef and dairy were also reduced in 1984, the increases in beef and dairy cattle were triggered by factors not directly related to policy, such as world market price developments for dairy products and inputs.

The opposite effects could be expected in countries where production is expanded. Larger amounts of variable production inputs, like agro-chemicals, would likely be applied per hectare and additional land might be taken into production (Abler/Shortle, 1992). The question whether and to what extent more intensive production methods will be harmful for the environment depends partly on the initial level of production input use and the relative scarcity of production factors and environmental amenities. If historically only relatively small quantities of agro-chemicals have been used in crop production, a well managed increase in variable production inputs might still be easily accommodated without causing spill-overs into groundwater, for example. Moreover, if land is abundant, increasing agricultural acreage will tend to leave still ample space for a diverse wildlife to prosper. Also, vast land resources imply the existence of large stretches of rural and natural landscapes, so that some change in the latter's composition might still preserve a diversity of landscape-types to provide environmental and recreational amenities. Land-rich countries with low production intensities will, therefore, tend to be less susceptible to environmental damage from an expansion of agricultural output than countries with high population densities and intensive agricultural production systems.

Moreover, there might be impacts of further agricultural trade liberalisation on the spatial distribution of agricultural production with consequences for the volume of domestic transport and related environmental effects. Some OECD countries set guaranteed administered prices for agricultural commodities that are uniform across the country. The result is that production tends to be stimulated in locations remote from demand centres compared with the level that would be produced in these same areas were prices to reflect internal transport costs. More liberal trade in agricultural commodities could in such cases lead to production and consumption patterns that correspond more closely to regional supply and demand conditions, and possibly lead to smaller environmental impacts associated with transport.

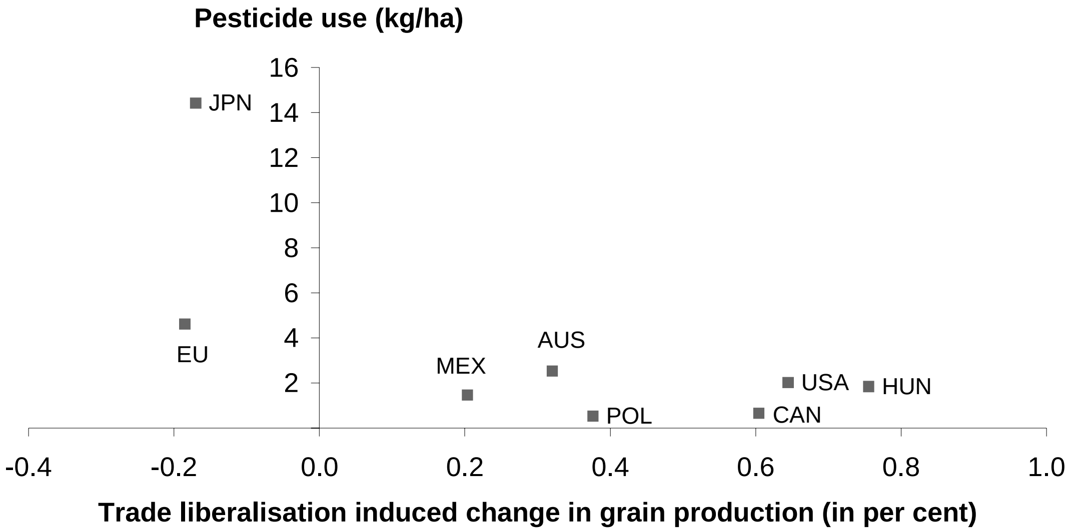
5.1 Potential impact on pollution

The results reported in Tables 3.1 and 3.2 can be used to derive inferences on the domestic environmental impact of further agricultural trade liberalisation by combining commodity output projections with information from the OECD's *Agri-environmental Indicators* database, which contains detailed estimates for pesticide use and nutrient balances. Since the application of pesticides and fertilisers is closely related to the level and intensity of agricultural production, inferences on potential environmental stress from pesticide and nutrient leaching into the groundwater can be made.

For example, a comparison between levels of pesticide use per hectare of arable land in the mid-1990s and the projected grain output changes of an extension of the Uruguay Round commitments until 2004 shows a negative relationship between pesticide application rates and trade-related production changes (Figure 5.1).[8] Reductions in grain output compared with the baseline scenario without further trade liberalisation are expected in countries that historically had relatively high levels of pesticide application. On the other hand, increases in grain production are projected for those countries with relatively less pesticide-intensive production systems.

8. Ideally, the data on pesticide use would be accompanied by information on the toxicity, persistence, and mobility of different pesticides. Indicators on pesticide risk are currently being developed by the OECD Working Group on Pesticides (Environment Directorate), but no results are available to date.

Figure 5.1. Levels of pesticide use per hectare of agricultural land 1995-97* in relation to the projected grain production effects by 2004 of an extension of the Uruguay Round commitments

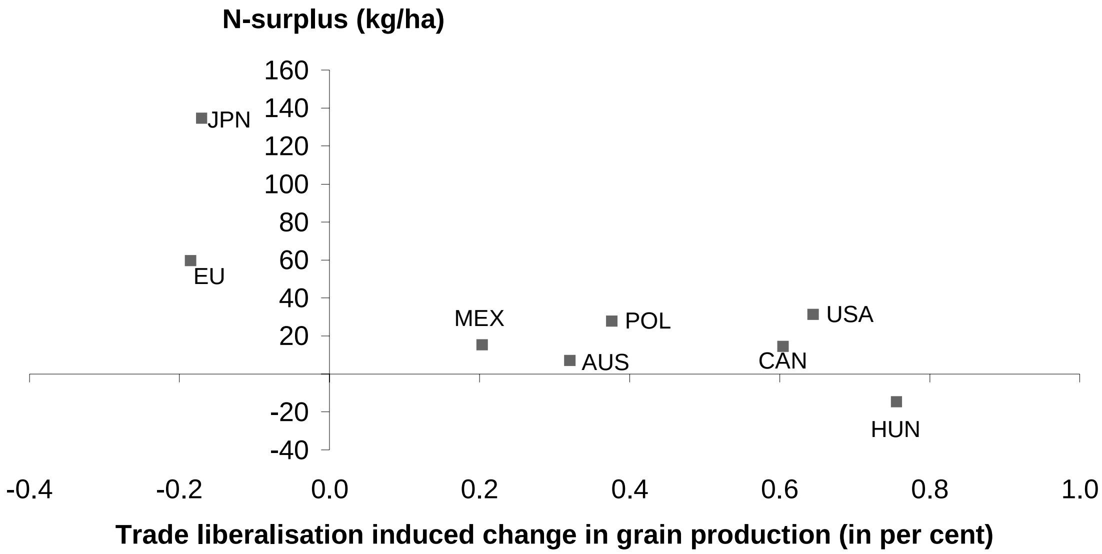


Note: *) or latest three-year period available. The graphical relationship between pesticide use and trade liberalisation induced changes in grain production does not imply a causality between the parameters. Grain production comprises production of wheat, coarse grains, and rice. Agricultural land includes arable land and permanent cropland. Total pesticide consumption in the respective countries is related to agricultural land not comprising pasture, even though some pesticide might in reality have been used on meadows and other grassland. The inaccuracy should, however, not systematically distort the underlying relationship between pesticide application rates and trade-induced output expansion. Also, ideally the pesticide used on grains, instead of total pesticide use, should be related to trade liberalisation induced changes in grain production, but corresponding data that is comparable across countries is not available.
Source: OECD (2000c), OECD Secretariat.

A similar relationship between pesticide use and grain production changes induced by trade liberalisation can be found between nitrogen surplus and projected changes in grain production due to trade liberalisation (Figure 5.2). Countries where nitrogen surpluses per hectare of agricultural land are high are projected to experience a reduction in grain output as a result of an extension of the URAA. Conversely, those OECD countries with relatively low N-surpluses (or even deficits) also tend to be the ones where grain production is expected to increase as a result of further trade liberalisation. These results are confirmed by recent studies that found positive relationships between agricultural support and fertiliser use (Lewandrowski *et al*., 1997).

The impact of agricultural trade liberalisation on output levels and the environment will differ between sub-sectors, depending on the initial level of protection and production, changes in world market prices, and the production methods for different commodities. In general, air, water, and soil pollution associated with agricultural production will change in the same direction as output (Box 5.2). However, in the longer term this linkage between production and pollution might be weakened, if new pollution-reducing production technologies were to become available.

Figure 5.2. Nitrogen surplus per hectare of agricultural land in 1995-97 in relation to the projected grain production effect by 2004 of an extension of the Uruguay Round commitments



Note: The graphical relationship between nitrogen surplus and trade liberalisation induced changes in grain production does not imply a causality between the parameters. Grain production comprises production of wheat, coarse grains, and rice. Agricultural land includes arable land, permanent cropland, and pasture.
Source: OECD (2000c), OECD Secretariat.

Changes in livestock production, particularly in intensively produced pork and poultry output, might prove to be especially sensitive from an environmental point of view. Medium-term growth rates for pork and poultry are projected to be among the highest of all agricultural commodities in the OECD area (Table 3.1). Output of other livestock products, except sheepmeat, is also expected to rise. Environmental harm might ensue, since livestock production is a major source of nitrogen surpluses. The latter are in turn a precursor of nitrate leaching into the aquatic environment, especially if the amount of animal waste is large compared with the available agricultural land on which it can be spread. Nitrate related risks to the environment comprise the contamination of drinking water resources, eutrophication of surface and coastal waters, and acidification of soils and water.

Table 5.1 shows medium-term projections for the amount of nitrogen contained in livestock waste. The projections are derived by multiplying the numerical production estimates from *Aglink* livestock projections (see Tables 3.1 and 3.2) with country and commodity specific coefficients on the N-content of animal waste from the *Agri-environmental Indicators* database, and aggregating across commodities. It is assumed that the age and species composition of the beef cattle, dairy cow, pig, broiler, layer chicken, and sheep herd as well as animal feed diets stay unchanged over the projection period. A baseline and a trade liberalisation scenario, simulating an extension of the URAA beyond the year 2000, are compared with the quantity of N in animal waste in 1995-97.

Box 5.2: General equilibrium analysis of the trade and environment links in Mexican agriculture

Analysis undertaken in the OECD Development Centre has investigated the effects of trade liberalisation on emission levels from 22 agricultural sub-sectors in Mexico (Beghin *et al*. 1997). The analysis considered a gradual unilateral elimination of border tariffs, which for most agro-food products in the base period 1989 ranged from 10 to 25 per cent, until 2010. A general equilibrium model was used for the analysis to assess the relative contribution of agriculture to total pollution emitted by all sectors.

The results indicate that unilateral trade liberalisation would lead to a decrease in agricultural output for most products, especially staple crops (Table Box 5.2). Moreover, the level of emissions would generally change in the same direction as output. Pollution from pig production is the exception, which is projected to increase despite a reduction in output. The authors attribute this result to a change in the composition and quality of animal feed. Overall, pollution from agricultural sources would fall or grow more slowly as a result of trade liberalisation than emissions from the manufacturing and service sectors.

Table Box 5.2: Impact of trade liberalisation on production and pollution in Mexico (in %)

Sub-sector	Production change	Toxic water pollutants	Toxic soil pollutants	SO_2	NO_2
Maize	-24.2	-24.1	-23.6	0.0	20.0
Rice	1.9	2.2	0.0	-1.5	-2.4
Wheat	-6.0	-5.7	-5.7	-21.1	-25.0
Beans	-20.4	-20.3	0.0	-17.5	-17.5
Sorghum	-18.4	-18.0	-18.0	-20.0	0.0
Barley	-19.0	-18.5	0.0	-54.2	-50.0
Soybeans	-47.3	-47.0	-46.5	25.0	0.0
Oilseeds	2.0	9.1	0.0	0.0	0.0
Sesame	1.0	0.0	0.0	11.1	0.0
Cotton	0.8	1.7	0.0	0.0	0.0
Sugar	-1.7	-1.3	0.0	0.0	0.0
Coffee	14.0	14.5	0.0	7.7	0.0
Tobacco	2.7	2.3	0.0	25.0	0.0
Cocoa	0.3	0.0	0.0	0.0	0.0
Sisal	-1.1	0.0	0.0	6.0	6.1
Other crops	1.4	2.3	1.9	4.9	4.9
Beef	0.2	1.2	0.5	1.8	3.0
Pork	-0.2	0.7	0.4	0.0	20.0
Other meats	-1.4	-0.8	-0.7	5.6	4.5
Poultry	1.8	3.1	2.4	40.0	33.3
Honey	19.6	0.0	0.0	0.0	-33.3
Other agr. products	-4.7	0.0	0.0	1.6	2.6
Total agr. products	-3.5	-8.3	-2.3	1.7	1.7
Manufacturing	3.7	1.3	0.6	4.9	5.0
Services	2.9	6.7	3.7	8.6	8.7

Source: Beghin *et al*. (1997).

Further simulations with the model revealed that modest pollution taxes would be sufficient to contain trade-induced emission increases in the economy. Strong complementarities between different pollutants were found. For example, a tax on water pollutants would not only lead to a decrease of toxic emissions into the groundwater, but also reduce soil pollution.

It should be noted that Mexican agricultural policy was radically reformed in the early 1990s as a consequence of joining NAFTA.

The results indicate that the amount of nitrogen from livestock in all OECD countries covered, except Australia, the European Union, and Korea, would increase (Table 5.1). These results hold for both the baseline scenario as well as the scenario simulating an extension of the Uruguay Round commitments. However, further agricultural trade liberalisation would in most countries tend to reduce the amount of nitrogen from animal waste. The exceptions are Mexico and Poland, where an extension of the URAA commitments is expected to increase the amount of nitrogen from livestock compared with the baseline.

Table 5.1. Impact of an extension of the Uruguay Round commitments on nitrogen quantity in livestock waste, 1995-97 to 2004

	N from animal waste in 1995-97	N from animal waste w/o URAA extension	N from animal waste with URAA extension	Impact of URAA extension	N from animal waste w/o URAA extension	N from animal waste with URAA extension	Impact of URAA extension
	'000 t of N	'000 t of N			Per cent change in N		
Australia	2 501.7	2 477.6	2 476.6	-0.9	-1.0	-1.0	0.0
Canada	1 234.9	1 382.5	1 378.3	-4.2	12.0	11.6	-0.3
EU-15	7 921.9	7 912.7	7 883.9	-28.7	-0.1	-0.5	-0.4
Hungary	127.0	150.0	149.6	-0.4	18.1	17.8	-0.3
Japan	762.2	778.5	776.2	-2.2	2.1	1.8	-0.3
Korea	311.4	293.7	293.5	-0.2	-5.7	-5.8	-0.1
Mexico	1 775.0	2 127.5	2 129.2	1.7	19.9	20.0	0.1
New Zealand	1 390.7	1 497.5	1 496.6	-0.9	7.7	7.6	-0.1
Poland	540.0	608.3	608.7	0.3	12.7	12.7	0.1
USA	10 171.6	11 238.1	11 241.4	3.2	10.5	10.5	0.0
Total	26 736.6	28 466.5	28 434.0	-32.5	6.5	6.3	-0.1

Source: OECD Secretariat.

Changes of agricultural production over time will not only affect the available nitrogen from livestock but, through increases or decreases in crop production, also the nitrogen uptake by agricultural plants. Table 5.2 reports on medium-term projections with respect to the nitrogen uptake by grain and oilseed crops. These estimates were derived in a similar way as the N-content in manure figures in Table 5.1, i.e. by combining commodity market projections from the *Aglink* model with information on country and crop-specific rates of nitrogen uptakes from the *Agri-environmental Indicators* database.

Triggered by an increase in grain and oilseed production, nitrogen uptake by agricultural crops is expected to increase in most OECD countries during the period 1995-97 to 2004. The exceptions are Japan and Korea, where N-uptake is projected to fall. Japan is thereby the only country analysed where the amount of nitrogen from livestock waste is expected to rise in the medium term, while N-uptake from grain and oilseed crops is projected to decrease. As a result, the "organic" N-surplus is expected to increase compared with the average in 1995-97 (Table 5.3). Larger N-surpluses also occur in those countries where growth in nitrogen from livestock waste is faster than increases in the uptake through crops.

Table 5.2. Impact of an extension of the Uruguay Round commitments on nitrogen uptake by grain and oilseed crops, 1995-97 to 2004

	N-uptake in 1995-97	N-uptake w/o URAA extension	N-uptake with URAA extension	Impact of URAA extension	N-uptake w/o URAA extension	N-uptake with URAA extension	Impact of URAA extension
	'000 t of N	'000 t of N			Per cent change in N		
Australia	585.3	614.9	616.8	1.9	5.1	5.4	0.3
Canada	1 731.3	1 765.0	1 772.5	7.5	1.9	2.4	0.4
EU-15	4 125.6	4 274.0	4 271.9	-2.1	3.6	3.5	-0.1
Hungary	327.1	454.5	459.7	5.3	39.0	40.6	1.6
Japan	240 .8	230.4	230.0	-0.4	-4.3	-4.5	-0.2
Korea	145.3	137.3	..	..	-5.5	..	..
Mexico	543.5	618.2	619.6	1.4	13.7	14.0	0.3
New Zealand	15.3	17.1	..	..	11.9	..	..
Poland	440.0	503.9	506.1	2.2	14.5	15.0	0.5
USA	8 266.6	9 058.7	9 090.1	31.8	9.6	10.0	0.4
Total	16 420.8	17 674.1	17 721.7	47.5	7.6	7.9	0.3

Note: .. not calculated.
Source: OECD Secretariat.

Table 5.3. Impact of an extension of the Uruguay Round commitments on the nitrogen balance between N from livestock manure and N-uptake by grain and oilseed crops, 1995-97 to 2004
('000 t of N)

	N-surplus* in 1995-97	N-surplus* w/o URAA extension	N-surplus* with URAA extension	Impact of URAA extension
Australia	1 916.5	1 862.7	1 859.8	-2.9
Canada	-496.4	-382.5	-394.2	-11.7
EU-15	3 796.3	3 638.7	3 612.1	-26.6
Hungary	-200.1	-304.5	-310.2	-5.7
Japan	521.4	548.1	546.2	-1.9
Korea	166.1	156.4	..	..
Mexico	1 231.5	1 509.3	1 509.6	0.3
New Zealand	1 375.4	1 480.4	..	..
Poland	99.9	104.4	102.6	-1.8
USA	1 905.0	2 179.4	2 150.8	-28.5
Total	10 315.8	10 792.4	10 712.4	-80.0

Note: N-surplus does only include N from livestock manure and N-uptake through grain and oilseed crops, but excludes, for example, N from non-organic fertiliser and N-uptake through sugar crops or pasture. .. not calculated.
Source: OECD Secretariat.

Further agricultural trade liberalisation is expected to lead to a decrease in organic nitrogen surpluses (or an increase in deficits) compared to the baseline scenario in almost all OECD countries. The exception is Mexico. However, the overall impact of an extension of the URAA on nitrogen balances is very small relative to the initial nitrogen surpluses/deficits in 1995-97. The change in the organic nitrogen balance is less than 3 per cent for all countries analysed.

The rise in organic nitrogen surpluses in Mexico does not necessarily imply increased environmental stress. Any changes in the amount of organic nitrogen available might be offset by opposite changes in non-organic fertiliser use. For example, if livestock production increases, farmers might substitute nitrogen from animal waste for non-organic fertiliser, so that the overall nitrogen balance might change little. The degree of substitutability between organic and non-organic nitrogen thereby depends on technological and geographical factors. Manure is generally used for basic fertilisation before crop planting, while non-organic fertiliser can also be applied into growing stocks of crops using precision spreaders. The *technical difficulties* of spreading livestock manure in a similarly well targeted and crop friendly manner as non-organic fertiliser will tend to limit the possibility of substituting organic for non-organic fertilisers.

The sometimes large *geographical distances* between centres of livestock production and crop growing areas are another factor that reduces the potential to accommodate increasing N-surpluses in livestock intensive regions. Since transport of manure is time and cost-intensive, a regional balance between the availability of livestock waste and their disposal might be difficult to attain. Since livestock operations tend to be increasingly concentrated in particular regions or locations, the potential for local nutrient surpluses and associated risks to the aquatic environment is augmented. It is hence more likely that environmental problems might emerge at the regional rather than the national level.

Technical progress has favoured a continuously increasing specialisation of livestock farmers and an increase in average herd size. These developments have taken place across all types of livestock operations despite differing levels of producer support, which for some livestock commodities, such as milk, are relatively high, while for others, including pork and poultry, is relatively low. For example, the number of pigs in western Germany decreased between 1990 and 1997 by 2.5 per cent, but the number of farmers holding pigs decreased by about 40 per cent, implying an increase in average herd size by more than 60 per cent. In parallel, the share of pigs held in the state with the largest pig population, Lower-Saxony, increased slightly from 32 to 33 per cent of total holdings in Germany. So despite a decrease in pig numbers at the national level, the consolidation of holdings has meant that pig production has been getting more concentrated at the farm level and, to a lesser extent, in the main producer region. Similar developments can be observed in other OECD countries.

Locally increasing livestock densities might not only create environmental problems because of point-source emissions of water and air pollutants, but large-scale livestock operations might also trigger adjustments in cropping patterns in the surrounding area that have adverse effects on the state of the environment. For example, the expanded and intensified cultivation of some crops, such as maize, in order to produce fodder for livestock herds, might make cropland more vulnerable to soil erosion. Also, the variety of crop species in the region might fall, with detrimental consequences for biodiversity and landscape appearance.

Further agricultural trade liberalisation might accelerate the local and regional concentration of animal herds by removing impediments to structural change in the livestock sector. In previously protected markets, the trade-induced fall in output prices might have adverse impacts on farm incomes and force livestock farmers to increase their animal holdings to make up for reduced per-unit profits through increased output. Alternatively, livestock farmers could partly or entirely switch to other agricultural or non-agricultural activities to maintain sufficient income. Overall, the benefits from economies of scale and specialisation that larger production units can reap will tend to lead to an increase in the average size of livestock holdings. A similar increase in production scale is likely to occur in countries that experience an increase in livestock margins as a result of trade liberalisation. It is generally easier and less costly for livestock farmers to enlarge an existing operation than for newcomers to enter the sub-sector with a new average-sized production unit. So again, economies of scale will tend to favour a concentration at the farm level.

But agricultural trade liberalisation might also induce a further concentration at the regional level. Liberalised trade will tend to both foster competition and facilitate technology transfer. Those livestock producers with well co-ordinated relationships to upstream and downstream enterprises and access to high-quality extension services will tend to be best placed to exploit new opportunities in a more globalised market. Regional clusters with several feed suppliers and livestock processors and specialised advisory services in the vicinity might prosper. This will particularly be the case for pig and poultry operations, for which production does not have a strong link to spatially dispersed farmland.

On the other hand, further agricultural trade liberalisation might to some extent relieve livestock-related stress on the environment. For example, as a result of policy reform some farmland might be released from set-aside programmes and could be used for the spreading of manure, so that the amount of nitrogen from livestock waste per hectare decreases. Also, the reduction of trade barriers might remove distortions between different animal feeds, with implications for the structure of the livestock sector. For example, some centres of pig and poultry production in the European Union developed in the vicinity of ocean ports, because of access to cheap grain substitutes from abroad. Tapioca, for example, is imported into the European Union at zero tariffs, while grains are subject to substantial tariff rates, pushing up their domestic price level. Hence, by reducing the cost advantage of grain substitutes over grains, agricultural trade liberalisation will diminish the incentive for pig and poultry operators to locate in areas with easy access to grain substitutes and possibly lead to a greater dispersion of livestock production. However, the overall effect of further trade liberalisation on regional clustering of livestock operations is difficult to quantify, so that given current knowledge it is not possible to assess the magnitude of the consequences for regional nutrient balances and potential environmental stress.

5.2 Potential impact on environmental amenities

While potential increases in environmental harm are primarily a concern in countries where trade liberalisation is expected to induce an increase in agricultural production, the possible loss of environmental amenities is an issue particularly in countries where agricultural production is likely to shrink. Many environmental amenities, such as landscape appearance and biodiversity, are related to whether and how intensively land is used for agricultural purposes. Marginal agricultural land is thereby often of particular value, since the low production intensity with limited application of agro-chemicals helps to sustain a variety of plant and animal wildlife that co-exists with agriculture. Moreover, marginal agricultural land is frequently situated at the fringe of non-agricultural areas, where it can play an important role for the eco-system as well as for recreational purposes.

Further agricultural trade liberalisation will tend to change the input/output price ratios which in turn induce adjustments in agricultural practices. In previously protected markets, less input-intensive farming methods will likely become more prevalent and agricultural output per hectare will tend to fall. This drop in production could have adverse consequences for the provision of those environmental amenities that are jointly produced with agricultural output. If the degree of jointness between agricultural and environmental outputs is high, i.e. if it would be very difficult to provide the environmental amenities without agricultural production, environmental amenities might be lost. Conversely, if similar environmental services could easily be provided through non-agricultural activities, the risk of losing environmental benefits from rural amenities due to agricultural trade liberalisation will likely not be a major concern. Moreover, in some cases environmental amenities, which are by-products of agricultural production, can also be provided through non-agricultural means. Targeted policies aimed at directly encouraging the provision of environmental amenities might be more transparent and efficient than indirectly through agricultural price support, even though potentially higher administration and transaction costs would have to be taken into account. For example, bushes and trees might be kept from developing on pastures either through grazing by farm animals or by mowing the meadows from time to time, thus keeping the landscape “open”. Hence, whether environmental goods are produced jointly with agricultural commodities is often a function of how and where commodities are produced.

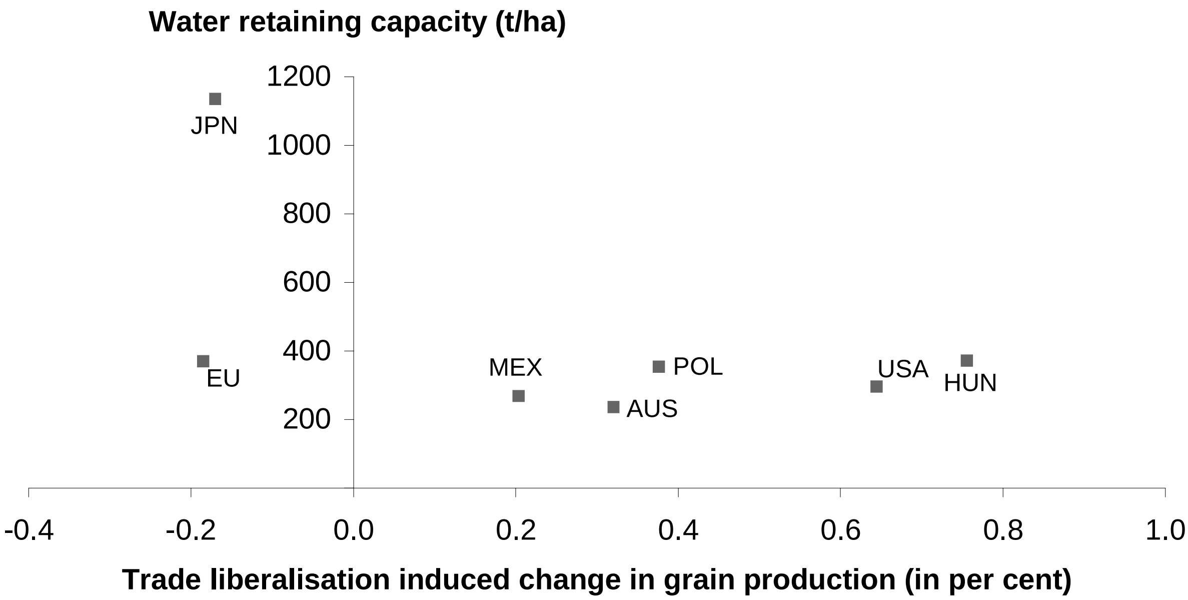
The linkages between agricultural trade liberalisation and environmental amenities tend to be especially pronounced on marginal agricultural land. If agricultural prices fall, farmers might find it no longer profitable to produce on marginal land, so that the latter might be left idle. Agri-environmental benefits and amenities associated with agricultural production might be lost on this land. Yet, as the overall agricultural production intensity is reduced, parts of the former agricultural “production core”, which might have been farmed using relatively large quantities of production inputs and might have been relatively poor with respect to environmental amenities, might turn into marginal, environmentally highly valuable land. Hence, the loss of landscape and biodiversity amenities from idling some agricultural land might be partly or fully offset by improvements in the environmental value of some other agricultural land. However, the regeneration of landscape and biodiversity amenities in both quantitative and qualitative terms will require time and in some cases it might not at all be possible to replace the loss of environmental amenities from the conversion of some marginal agricultural land into non-agricultural land through increases in the environmental value of some other agricultural land. For example, if agricultural production in mountainous areas contributes to land conservation by reducing soil erosion or increasing water retaining capacity, ceasing agricultural activities in these areas as a consequence of trade liberalisation might create or exacerbate environmental problems (Box 5.3). However, targeted payments for the construction and maintenance of dams in mountainous areas might be able to ensure the provision of sufficient water retaining services to the same extent and possibly with a smaller effect on agricultural production and trade than the present system of market price support that encourages intensive rice farming.

Moreover, the environmental quality of idle land will depend on site-specific environmental conditions and might not necessarily be inferior to agricultural land. For example, if a stable natural pasture develops on the land that has dropped out of agricultural production, the land might not be more susceptible to soil erosion than under cropping, and with environmental policies that encourage land conservation in place, sediment loss might actually decrease. Also, even though idle land will likely provide a different type of habitat and support a different set of animal and plant species than agricultural land, overall biodiversity might not necessarily be reduced. Indeed, land left idle could be developed for environmental purposes, such that it becomes a haven for threatened species, for example. Alternatively, targeted measures could enhance environmental amenities on idle land for tourism and recreation purposes, where the proximity to population centres would make such a reorientation of land use desirable. More generally, the use of farmable land should be oriented towards long-term sustainability, which in some cases might suggest the preservation of historical patterns of agricultural production, while in others a switch to alternative uses might be desirable.

Box 5.3: Agricultural production and land conservation: water retaining capacity in Japan

Rice farming in mountainous areas in Japan might be a case where trade liberalisation induced changes in land use could possibly lead to a reduction of land conservation services provided by agriculture, according to research by Japanese analysts. Figure Box 5.3 shows that water retaining capacity in Japanese agriculture plays a more important role than in other OECD countries. This reflects the characteristics of rice paddy fields which are surrounded by dykes that hold back rainwater. If in this situation a reduction of grain production occurs, as projected from further agricultural trade liberalisation, the idling of some rice paddy fields in mountainous areas with potentially adverse consequences for weed control, water retaining capacity and flood control might ensue.

Figure Box 5.3: Water retaining capacity per hectare of agricultural land in 1993/94 in relation to the projected grain production effect by 2004 of an extension of the Uruguay Round commitments



Note: The graphical relationship between water retaining capacity and trade liberalisation induced changes in grain production does not imply a causality between the parameters. No complete data sets on water retaining capacity covering all OECD countries are available, and the information in the figure is based on estimates by the Japanese authorities. To obtain these estimates, technical coefficients that were derived for Japan are applied across all countries analysed, even though they might not have been validated for these other OECD countries.

Source: Japanese Ministry of Agriculture, Forestry and Fisheries.

A first step towards assessing the magnitude of the potential environmental problems from land-idling would involve the quantification of the impact of further agricultural trade liberalisation on agricultural land use. Table 5.4 reports results from *Aglink* baseline and trade liberalisation scenarios regarding agricultural land use, as measured by area harvested.

Table 5.4. Impact of an extension of the Uruguay Round commitments on land use, 1995-97 to 2004
(in per cent)

	Change in area harvested* w/o URAA extension	Change in area harvested* with URAA extension	Impact of URAA extension
Australia	14.5	14.8	0.3
Canada	2.4	2.5	0.0
EU-15	-2.8	-2.8	0.0
Hungary	9.9	10.1	0.2
Japan	-8.3	-8.4	-0.1
Korea	-6.7	-6.7	0.0
Mexico	0.8	1.0	0.2
New Zealand	..	..	..
Poland	4.3	4.6	0.3
USA	4.1	4.6	0.4
Total	3.0	3.3	0.2

*) area harvested for wheat, coarse grains, rice, and oilseeds. .. not calculated.
Source: OECD Secretariat.

The results indicate that both in the baseline scenario and in the case of an extension of the Uruguay Round commitments on agricultural trade liberalisation until 2004 area harvested would increase in most analysed OECD countries. The exceptions are the European Union, Japan, and Korea. Moreover, further agricultural trade liberalisation would only have a modest impact on agricultural land use, with the projected changes ranging from minus 0.2 per cent to plus 0.4 per cent. Japan is thereby the only country for which a significant reduction in area harvested as a result of an extension of the URAA was projected. However, the *Aglink* model scenarios did not cover some OECD countries, such as Norway and Switzerland, with relatively large quantities of agricultural land in marginal areas. Further analysis would be needed to investigate and quantify the potential impact of trade liberalisation on agricultural land use and environmental amenities in these countries. Also, additional investigations are required to evaluate the effects of trade liberalisation on pasture land, which is not covered in the *Aglink* projections, and to analyse possible changes in farming practices might have to be taken into account. For example, pasture that serves for cattle-grazing will have a different environmental value from grassland that is harvested mechanically to feed cattle indoors.

While the impacts of an extension of the Uruguay Round commitments on land use are relatively small, the general trend points to an increase in area harvested in many OECD countries. With an increase of 10-15 per cent, the expansion of agricultural land use is projected to be most pronounced in Australia and Hungary. Such substantial rates of agricultural expansion might lead to the encroachment of farmers on environmentally fragile land, such as wetland or highly erodible land. Taking such land into agricultural production might lead to the loss of environmental amenities (e.g. loss of species diversity on former wetland) or increased environmental harm (e.g. soil erosion). The extent to which OECD countries are exposed to these risks from increased agricultural land use depends on country and site-specific circumstances, as well as on the environmental policies in place. For example, if environmental policies put constraints on farming practices on environmentally fragile land, as is frequently the case in OECD countries, no significant environmental harm might result from extending the use of land for agricultural purposes.

The *Aglink* projections on agricultural land use do not cover non-OECD countries. Yet, judging from trends in past years, agricultural land use can be expected to increase in many developing countries. Further agricultural trade liberalisation, which will likely lead to higher world market prices and thus stronger agricultural production incentives in low-support countries, might further contribute to the conversion of non-agricultural into agricultural land. If such a change in land use involves large-scale deforestation and encroachment on fragile eco-systems, such as rainforests, considerable environmental damage with possibly global consequences might ensue (Giordano, 1994; Chichilnisky, 1996). Wildlife species might be lost, soil quality might be severely damaged, and GHG emissions from forest fires might be augmented. Further research will be needed to assess the environmental risks involved.

In addition to an overall expansion or contraction of agricultural land use in different countries, further agricultural trade liberalisation will also affect the composition of agricultural production and thus agricultural habitats and the appearance of rural landscapes. In some countries, support to agriculture has traditionally been highly unequal across commodities, so that farmers have concentrated on the production of only a few, highly supported crops (Runge, 1993). Further agricultural trade liberalisation and the reduction of differentials in commodity support might lead to more diverse cropping patterns with possibly positive effects on biodiversity and landscape appearance. However, any changes in crop rotations and the relative shares of crops in production depend on the initial levels of support to the different crops, and in some cases the reduction of support due to trade liberalisation might lead to the increased cultivation of a few dominant crops, even though the empirical evidence from past trade liberalisations (e.g. in New Zealand) suggests that concerns relating to the possible emergence of local monocultures might be overstated.

Overall, the impact of further agricultural trade liberalisation on environmental amenities, such as wildlife habitats and biodiversity, is site-specific. As regards the aesthetic features of rural landscapes, valuation is highly subjective and hence difficult to assess. The development of agri-environmental indicators and the underlying datasets is not sufficiently advanced yet to allow for appropriate impact evaluations and cross-country comparisons. To date, developments with respect to particular amenity-indicators are often only meaningful within country-specific circumstances. Further conceptual background work will hence be necessary before quantitative results on the linkages between agriculture, trade, and environmental amenities can be derived.

6. Policy approaches to address the interactions between agriculture, trade, and the environment

Agricultural trade liberalisation, provided effective environmental policies are implemented, can enhance the overall quality of the environment through improved resource allocation, which will tend to augment economic growth and thus potentially mobilise resources for other societal interests, including perhaps environmental conservation programmes. Further environmental benefits could result from a trade-induced shift in agricultural production from countries in which farmers currently use large amounts of purchased inputs to countries where farming practices are less input intensive and hence potentially less harmful to the environment. Yet, environmental harm from fertiliser and pesticide run-offs into the groundwater is not necessarily proportional to application rates, and the eco-efficiency of intensive production systems in terms of emissions per unit of output can in some cases be higher than that of extensive ones.

However, in the case of increased international spill-overs from agricultural production national environmental policies are not likely to be sufficient. International co-operation and co-ordination might be necessary to contain negative effects on the international environment. International environmental agreements are one type of institutional mechanisms to contain transboundary and global environmental problems (Barrett, 1994). Examples with relevance for agriculture include the Montreal Protocol banning methyl bromide, which was suspected of damaging the ozone layer, and the Kyoto Protocol, in which signatory countries agreed to contain or reduce their GHG emissions in order to slow down global climate change.

The quantitative analysis showed that trends and trade effects concerning the size of ruminant livestock herds, which represents the main agricultural source of GHGs, differ substantially among OECD countries. Livestock numbers in some Member countries are projected to increase considerably in the medium term, thereby potentially causing problems for the respective countries in meeting their Kyoto Protocol commitments. In order to contain and possibly reduce their GHG emissions from agriculture, countries could promote the adoption of farming technologies and practices that reduce the amount of emissions per animal. Possible means to achieve lower emission rates include changes in feeding diets, animal species, and manure management. Trade policy instruments seem inappropriate to contribute to a global reduction in GHGs, since the quantitative estimates indicate that further agricultural trade liberalisation will only have a relatively small effect on livestock numbers and agricultural GHG emissions.

Where border measures, such as inspections and quarantines, are used to contain harm from the introduction of exotic species, care needs to be taken in the design of the measures so that they do not turn into technical barriers to trade. Where trade restrictions are established, they should be transparent, based on scientific risk assessment, provide a level of protection equivalent to international standards or a level that is scientifically sound, and have to ensure equal treatment between all imports and domestic products.

Negative effects on the domestic environment from trade-induced changes in agricultural production patterns will most effectively be addressed through targeted domestic policy measures. Where existing environmental policies seem insufficient, new measures may have to be introduced. In some cases, however, frictions between environmental and trade policy objectives might arise. This could particularly be the case in situations where agricultural and environmental goods and services are jointly produced, so that environmental measures might have an effect on agricultural production and trade. One way to minimise potential conflict with international trading partners would be to design domestic environmental measures such that they distort trade flows to the least possible extent. Such a policy design would help to achieve high levels of domestic environmental quality without compromising the benefits from expanded international trade in agricultural products.

The quantitative results from the *Aglink/AEI* scenarios indicate that the environmental effects from an extension of the Uruguay Round commitments on agricultural trade liberalisation until 2004 will be only modest in comparison with the changes in agricultural production brought about by technical progress and general economic development. This points to the need to develop domestic environmental policies complementary to trade policy reforms. For example, research and training programmes might promote technical progress with respect to the environmental efficiency of farming processes in order to match the technological advances on the production side.

The analysis in this paper focused largely on OECD countries, while non-OECD members will also be affected by further multilateral liberalisation of agricultural trade. Environmental policies in developing countries, in particular, might not be well established enough to effectively regulate and contain the possible increases in the use of agro-chemicals that might result from potential trade-induced increases in agricultural output (Lutz, 1992). In addition to domestic impacts on environmental media, such as water and soil quality, global environmental problems might worsen, if, for example, GHG emissions increase as livestock herds grow or if biodiversity is reduced in the case of rainforests being converted into farmland (Boyce, 1996). Preventive policy strategies might consist of increased efforts to reach international agreements on global environmental issues and to foster know-how transfers from developed to developing countries in the area of environmentally friendly farming technologies.

7. Concluding remarks

The preceding discussion and analysis outlined the linkages between agriculture, trade, and the environment, highlighted distinctions between international and domestic environmental impacts of agricultural trade liberalisation, and quantified trade induced effects on agricultural production patterns and environmental quality. There are a number of general results concerning the linkages between agricultural policy, trade, and the environment:

- Like many other policy changes, agricultural trade policy reform will have both positive and negative impacts on the environment. The direction and magnitude of the effects will depend on the state of the environment and on the production impacts of further agricultural trade liberalisation, as well as on the environmental regulations in place.

- The trade-induced production changes will vary between countries and commodities (and between regions within countries). Indeed, the results from *Aglink* commodity market projections show that no country will experience only increases or only decreases across all commodities. The environmental effects associated with agricultural commodity production will tend to be similarly diverse.

- Any estimate of the prospective international and domestic environmental impacts of further agricultural trade liberalisation depends on the underlying assumptions. In particular, different environmental effects can be expected if more wide-ranging reductions in trade barriers would occur than under the assumed extension of the existing URAA liberalisation commitments. Also, the impacts of trade-induced production changes on individual regions within OECD countries might differ substantially from those at the national level.

International environmental impacts of agricultural trade liberalisation refer to transnational or global environmental effects whose sources are national, but whose consequences are transboundary. Examples of international environmental impacts include international transport, which might impact on marine life; greenhouse gas emissions, which are suspected of contributing to global climate change; and species diversity. Moreover, some inspection and control activities are likely to be most cost-effective if carried out at the border.

- Trade liberalisation-induced growth in the world's output of livestock products and related increases in the size of the total ruminant livestock herd might lead to some rise in GHG emissions, although the effect is projected to be small. In addition, geographical changes in production patterns with shifts in livestock production from countries with protein intensive feeding diets to others with more carbohydrate-intensive diets might further augment total methane emissions, even though additional research on the relative level of GHG emissions of different feeding systems is needed. In any case, the trade-induced effects are relatively small compared with the overall trends in livestock numbers, which indeed might create problems for some OECD countries with respect to meeting their Kyoto Protocol commitments on GHG emissions.

- Increased agricultural trade is projected to augment the overall volume of transport, and change its structure and pattern, with international freight and shipments in exporting countries likely to rise while the volume of domestic shipments in importing countries might decline. The adverse impacts of intensified transport activities on the environment might be mitigated by a change in the composition in types of freight carriers, since long-range international transport uses environmentally relative benign trains and ships more frequently than short-range domestic traffic, which relies to a greater extent on more pollution-prone trucks.

- Further agricultural trade liberalisation might open new pathways for the introduction of exotic species. In order to avoid and contain harm to the domestic environment from these non-indigenous plants and animals, a number of OECD countries implement border measures, such as quarantine controls.

In contrast to international environmental impacts, the scope of *domestic environmental effects* of further agricultural trade liberalisation is limited to individual countries, or even regions within countries. A reduction in agricultural trade barriers will change the relative prices of products and the domestic patterns of agricultural production, which in turn can have an impact on the state of the environment. In some cases, the outcome will be environmentally beneficial, in others it might lead to a degradation of the state of the environment through increased pollution or loss of environmental amenities.

- Agricultural trade liberalisation is projected to lead to increased grain production in countries which currently use relatively small amounts of pesticides and have low nitrogen surpluses per hectare of agricultural land, and which therefore might be able to cope with increased production intensity without causing substantial environmental harm. Conversely, countries with high pesticide application rates and high N-surpluses are expected to experience trade-induced decreases in grain output and corresponding reductions in environmental stress. Also, at the national level, organic nitrogen surpluses are projected to fall in most OECD countries as a result of an extension of the URAA commitments. At the regional level the impact is unclear. However, it should be noted that the environmental impact of pesticide and fertiliser application depends on site-specific characteristics like climate and soil type.

- The loss of environmental amenities as a result of land idling is not projected to become a major problem, as agricultural land use is expected to increase in most OECD countries following further agricultural trade liberalisation. However, the quantitative analysis did neither cover pasture land nor some OECD countries with relatively large areas of marginal agricultural land. Hence, drawing firm conclusions from the analysis on changes in land use seems premature. Moreover, the impacts of agricultural trade liberalisation on soil and water resources other than fertiliser and pesticide contamination were not analysed in the study, so that possibly effects on soil erosion or changes in groundwater levels were not covered.

The environmental impacts of further agricultural trade liberalisation have to be seen in the context of general economic and other developments:

- The *Aglink* projections indicate that production changes due to technical progress and general economic development are in general much more pronounced than those brought about by an extension of the URAA commitments on agricultural trade liberalisation.

- Given current trends in world population and income growth, global demand for food will increase in the long term, while less agricultural land might be available to produce it from. Unless technological progress and improved management skills allow agricultural output to grow without increases in the use of purchased production inputs, higher levels of agricultural production might, for example, increase run-offs of agro-chemicals into the aquatic environment. Hence, beyond the year 2004, i.e. the end of the time horizon in this study, pressures on the environment might increase further, independent of agricultural trade policy reform.

The earlier discussion suggests a number of preliminary policy responses to address the environmental effects of further agricultural trade liberalisation:

- International environmental impacts of agricultural trade liberalisation are most appropriately addressed through international co-operation, because of the free-rider problem. International environmental agreements are one type of institutional mechanisms to contain transboundary and global environmental problems.

- Where border measures, such as inspections and quarantine controls, are used to prevent or control damage caused by non-native species, pests and diseases, the measures need to be designed in a way that does not turn them into technical barriers to trade. Governments can restrict free trade in order to protect human, animal, and plant health, if the restrictions are transparent, based on scientific risk assessment, provide a level of protection equivalent to international standards or a level that is scientifically sound, and ensure equal treatment between all imports and domestic products.

- Negative effects on the domestic environment from trade-induced changes in agricultural production patterns will most effectively be addressed through targeted domestic policy measures. Where new environmental policy measures are necessary, they should be designed in a way that they are least trade-distorting and to avoid conflict with international trading partners. In this context, further analytical work might be necessary to clarify the production and trade effects of policy measures in case of jointness of agricultural and environmental outputs.

- As the environmental impacts of general economic and other developments could be relatively more important than those of further agricultural trade liberalisation, agri-environmental policies need to be developed in parallel to agricultural trade policy reforms. Yet, even if the agri-environmental impacts of further agricultural trade liberalisation are relatively small, they may be significant at the regional level, and special attention of agricultural and environmental policy makers might have to be devoted to avoiding the emergence of "problem hot-spots".

There are several unresolved issues that might warrant further research:

- Additional scenarios of agricultural trade liberalisation could be considered, including comparisons between the environmental impacts of a scenario without agricultural trade liberalisation (pre-URAA state) and a scenario reflecting the URAA liberalisation commitments (the baseline scenario in the present paper). Moreover, the scenario analysis could possibly be complemented with first empirical findings in Member countries on the environmental effects of the URAA.

- The coverage of environmental effects could be broadened by incorporating the impacts of further agricultural trade liberalisation on agro-industry (and other sectors), as well as the effects of trade liberalisation in other sectors on agriculture.

- The analysis might benefit from empirical work that quantifies the linkages between agriculture, trade, and environment in pastoral agriculture and at the regional level, perhaps focusing on semi-natural areas and sites of high environmental value. Subsequent research could also cover in more depth the impact of trade liberalisation on issues like concentration of livestock herds that have been identified in this study as potential environmental "problem-hot-spots".

- The analysis could be extended to comprise dynamic impacts of trade liberalisation, such as induced changes in production technology and farming systems.

- A more explicit consideration of existing environmental regulations in the context of trade-induced changes in agricultural production patterns might be desirable, since the legal and regulatory framework can have a significant influence on the production response of farmers and their environmental performance.

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ANNEX:
Scenario Description and Commodity Market Projections

A.1 The Aglink model

The *Aglink* model is the OECD's tool for forward-looking commodity market policy analysis.[9] Calibrated with information from questionnaires completed by Member countries on an annual basis, the model is used for projections of medium-term commodity market developments, as well as for the simulation of particular policy scenarios. *Aglink* takes commodity interrelations into account, covers the most important agricultural and trade policies, and allows for the endogenous determination of national and world market prices.

Recently, *Aglink* has been used to evaluate the effects of further agricultural trade liberalisation (OECD, 1999). One scenario investigated the impact of extending the Uruguay Round commitment up to 2004, i.e. beyond the end of the current implementation period for most OECD countries in 2000.

In a *baseline model run*, which serves as a reference set of outcomes, URAA commitments on market access, bound tariff rates, and export subsidies are held constant for most OECD countries at their year 2000 values through to 2004. Because of their developing country status in the WTO, Korea, Mexico, and Turkey have until 2004 to implement their URAA commitments and the resulting adjustments in tariff rate quotas, tariff rates, and export subsidies over the period 2000-04 are included in the baseline scenario.

In the *trade liberalisation scenario*, the proportional annual rates of change applied during the URAA implementation period 1995-2000 were continued through to 2004 for all developed OECD countries. Hence, agricultural tariffs were assumed to be reduced annually by 6 per cent of the level obtaining during the base period average 1986-88 (corresponding to the total tariff cut of 36 per cent to be realised during the six-year Uruguay Round implementation period). Tariff-quotas were assumed to be filled, and where imports historically exceeded tariff-quota levels, above quota imports were modelled. Budget expenditure on export subsidies was assumed to fall every year by 6 per cent of the base period average, while subsidised export quantities were taken to fall annually by 3.5 per cent of their base period average levels (corresponding to the total cut in quantities exported with subsidies of 21 per cent to be realised during the six year Uruguay Round implementation period). The improvements in market access and reductions in export subsidies were assumed to trigger corresponding decreases in domestic support to agriculture, so that no explicit modelling of further reductions in the Aggregate Measure of Support (AMS) was undertaken. It should be noted that the *trade liberalisation scenario* does not refer to a complete abolishment of all trade measures concerning agricultural products.

A comparison with the results from the *baseline* and the *trade liberalisation scenarios* then allows quantification of the impacts of an extension of the URAA on agricultural production, consumption, prices, and trade. Since the *baseline scenario* includes a representation of existing commitments for trade barrier reduction under the URAA, the comparison with the *trade liberalisation scenario* does not yield the effects of agricultural trade liberalisation, but rather the ones of *further* agricultural trade liberalisation.

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9. The OECD countries that are covered in Aglink are Australia, Canada, the European Union, Hungary, Japan, Korea, Mexico, New Zealand, Poland, and the USA, while the agricultural markets of the Czech Republic, Iceland, Norway, Switzerland, and Turkey are not explicitly modelled.

A.2 Commodity market projections and agricultural trade liberalisation analysis

According to projections from the *Aglink* model's baseline scenario, output of most agricultural commodities in the OECD in 2004 will be higher than average production during 1995 to 1997 (Table A.1). The commodities with the strongest growth in the medium term are projected to be poultry and oilseeds. The widespread rise in agricultural production will likely lead to increased usage of production-related inputs, such as fertilisers and pesticides. This expanded application of agro-chemicals might cause additional environmental stress, unless improvements in farm management practices or the development of more environmentally benign fertilisers and pesticides compensate for the higher levels of usage.

Compared with general trends in commodity production, the magnitude of the effects of an extension of the URAA commitments would be of relatively minor importance (Tables A.2 and A.3). For most countries and commodities, the changes in agricultural production would be less than one per cent compared with the baseline scenario. Output of all agricultural products, except wheat and coarse grains, would decline in the OECD area.[10] However, the direction and magnitude of the trade impact varies between countries and agricultural sub-sectors. Indeed, there is no country that would experience agricultural output increases or decreases across all commodities as a result of further agricultural trade liberalisation.

Table A.1. Projection of agricultural production changes, "baseline scenario", 1995-97 to 2004
(in per cent)

	Wheat	Coarse grains	Rice	Oil-seeds	Pork	Poultry	Beef	Milk	Eggs	Sheep-meat
Australia	13.8	-3.8	30.3	206.0	18.3	41.1	9.4	37.0	0.6	-7.0
Canada	4.0	-1.2	..	22.9	15.0	18.4	17.0	7.8	9.9	..
EU-15	18.5	0.3	15.6	-2.5	9.3	18.7	-5.1	-2.1	-3.1	0.1
Hungary	42.7	42.4	0.0	58.5	29.2	15.0	46.9	7.8	2.5	..
Japan	5.4	-47.7	-9.1	1.6	-5.8	-1.3	-1.6	10.8	2.1	..
Korea	-8.9	19.8	-6.0	-1.6	-5.1	5.1	-8.9	5.3	0.5	..
Mexico	8.9	18.1	24.6	29.7	35.3	42.6	6.5	37.5	36.7	..
New Zealand *	18.8	10.6	..	..	14.5	40.8	12.9	33.5	4.4	-2.1
Poland	25.3	9.3	..	47.6	7.9	61.0	15.4	21.9	31.4	..
USA	6.5	19.5	10.3	20.6	17.3	33.4	-0.3	9.0	14.7	..
Total	13.7	13.0	-0.1	19.5	12.6	29.3	2.7	8.2	10.9	-2.5

Note: .. not calculated.
*) Due to data irregularities the projections for sheepmeat in New Zealand are misleading. More recent analysis indicates positive production developments between 1995-97 and 2004 (see OECD, 2000b).
Source: OECD Secretariat.

10. The (marginal) decrease in the output of livestock products in low support countries, such as Australia, is triggered by increases in world market prices for grains and animal feed that outweigh the liberalisation-induced increases in livestock prices.

The projections are consistent with production forecasts of national authorities, and indeed are based on the latter. Moreover, the results have been scrutinised by experts from Member countries and were published as trade reform scenarios in the 1999 edition of the *OECD Agricultural Outlook* report (OECD, 1999). This report also contains a comprehensive documentation of the economic and policy assumptions used for the projections. However, the trade liberalisation scenarios are currently being further refined, in particular with respect to issues of tariff quota extension, so that the reported projections should be regarded as preliminary. Also, some recent policy changes, such as the EU's Agenda 2000 reform, were not incorporated in the modelling analysis, since the decision on implementation of the reform proposals was taken after the finalisation of the analysis. Given the preliminary nature of the scenario results, there is a margin of error and the projected production changes should hence be viewed with a certain degree of caution.

Table A.2. Impact of an extension of the URAA on agricultural production until 2004, "trade liberalisation scenario"

(percentage difference in agricultural production in 2004 from the baseline scenario)

	Wheat	Coarse grains	Rice	Oil-seeds	Pork	Poultry	Beef	Milk	Eggs	Sheep-meat
Australia	0.5	0.2	0.0	-1.7	-0.3	-0.9	-0.1	0.2	-0.1	0.0
Canada	1.1	0.1	..	-2.2	0.0	0.1	-0.2	-3.0	0.0	..
EU-15	0.7	-1.1	-0.2	0.0	-0.7	-2.0	-0.5	0.0	0.2	-0.1
Hungary	2.5	0.2	0.0	0.0	-0.4	-0.8	-0.2	0.0	-0.6	..
Japan	0.0	0.0	-0.2	0.0	-0.9	-0.1	-0.5	0.0	-0.1	..
Korea	..	..	..	..	0.1	-0.2	-0.3	-0.1	-0.2	..
Mexico	0.2	0.2	0.0	0.3	0.0	0.0	0.1	0.1	-0.8	..
New Zealand	..	..	..	..	-0.1	7.9	0.1	-0.4	-0.2	-0.1
Poland	0.5	0.4	..	-1.3	-0.2	-0.7	0.2	0.3	-0.4	..
USA	1.5	0.6	-0.1	-0.2	0.1	0.1	0.0	-0.1	-0.3	..
Total	0.9	0.1	-0.1	-0.3	-0.4	-0.6	-0.2	-0.1	-0.1	-0.1

Note: .. not calculated, as production level is taken as exogenous in *Aglink.*

Source: OECD Secretariat.

Table A.3. Impact of an extension of the Uruguay Round commitments on the number of beef and dairy cattle, 1995-97 to 2004 (in per cent)

	Beef-cattle			Dairy-cattle		
Country	Change in Numbers w/o URAA extension	Change in Numbers with URAA extension	Impact of URAA extension	Change in Numbers w/o URAA extension	Change in Numbers with URAA extension	Impact of URAA extension
Australia	21.0	21.1	0.1	7.5	7.6	0.2
Canada	15.6	15.5	-0.1	-6.6	-7.2	-0.6
EU-15	4.2	2.6	-1.6	-14.4	-14.6	-0.1
Hungary	235.0	235.0	0.0	-15.6	-15.5	0.1
Japan	..	..	..	6.2	6.2	0.0
Korea	-44.0	-43.9	0.1	-6.3	-6.2	0.2
Mexico	..	..	..	1.5	1.5	0.1
New Zealand	..	..	..	21.9	21.9	-0.1
Poland	215.5	215.5	0.0	0.9	1.1	0.2
USA	3.7	3.6	-0.1	-5.9	-6.0	-0.1
Total	7.1	6.8	-0.3	1.6	1.6	-0.1

*) .. not calculated.

Source: OECD Secretariat.

A.3 Agri-environmental Indicators

The estimates of trade-induced changes in agricultural production can be seen as indicators of prospective pressures on the environment. This information can be linked to data on the state of the environment contained in the OECD's *Agri-environmental Indicators* (AEI) database in order to aggregate environmental effects in physical terms across crops and/or livestock, such as in the form of nutrient balances or quantity of pesticide used. For example, the AEI database on nitrogen balances holds detailed information on the number of different livestock, the area and yield of different crops, and the amount of non-organic fertiliser, as well as technical coefficients that link livestock numbers to the amount of nitrogen in animal waste or harvested quantities of crops to N-uptake. These data can be used to project the environmental impact of trade-induced changes in agricultural production.

A further step would be to aggregate across different environmental indicators to obtain an overall figure for the environmental impact of further agricultural trade liberalisation. However, such aggregation would risk reducing transparency as information on some particular dimension of environmental quality would be hidden in the aggregate. Also, there are conceptual issues, such as the degree to which a deterioration in one dimension of environmental quality could be offset through improvements in another one, which would have to be resolved. Anyway, actual data that would allow to link "physical" to "monetary" indicators, which could be used for aggregation purposes, are missing. Hence, an aggregation of environmental impacts and a cost/benefit analysis of agricultural trade liberalisation in monetary terms is not possible at this stage.

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