THE ENVIRONMENTAL IMPACTS OF TRADE LIBERALISATION AND POTENTIAL FLANKING MEASURES

Stage I of a Report to Defra

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1 EXECUTIVE SUMMARY

1.1 Introduction and context

The Institute for European Environmental Policy (IEEP) and GHK Consulting Ltd (GHK) have been commissioned by Defra to examine the environmental impacts of aspects of trade liberalisation and to identify appropriate flanking measures to address them. The study is intended to provide a relatively rapid survey of the potential environmental effects of aspects of trade liberalisation, based on existing published literature for a selection of different commodities and sectors.

The study is organised in two stages:

- Stage 1 focuses on case studies of agricultural commodities – dairy, sugar, vegetables, cotton and poultry;
- Stage 2 will examine the wider impacts of liberalisation in certain non-agricultural sectors.

The study is a desk-based exercise focused primarily on the literature and selected interviews with specialists and stakeholders. It has not been possible within the timescale and budget available to undertake any original research or fieldwork. This final report presents the findings of Stage 1 of the study.

For Stage 1, five agricultural commodities were chosen in collaboration with Defra. The intention was to include a selection which illustrated both temperate and tropical products, including those of importance for both developing and developed countries, and capable of throwing light on different aspects of liberalisation. Commodities that are the subject of active negotiations at present were given some priority.

1.2 Method of approach

The current study is concerned with predicting the expected future environmental effects of current and expected future trade liberalisation scenarios. The analysis has proceeded in two stages, the first forecasting the likely impacts of trade liberalisation scenarios on production and trade, and the second combining these predictions with knowledge of the environmental effects of changes in patterns of production and trade, in order to assess the potential environmental impacts of liberalisation.

This study has sought to review as wide a range of modelling studies as possible for each of the five commodities, in each case summarising key findings and identifying common themes.

Although environmental impacts differ between commodities and production areas, the most important trade-related environmental issues appear to include:

- Expansion of the agricultural land area at the expense of natural habitats through clearance,
- Substitution between different forms of agricultural land use (e.g. pastures and arable land), between crops (e.g. citrus and sugarcane), and changes in production systems (extensive and intensive),

- Changing pressures on natural resources from commodity production and processing, especially on water and soil,
- Shifts of production between areas with lower and higher environmental and/or animal welfare standards;
- Losses of or increases in agricultural habitats that provide certain environmental benefits
- Abandonment, or scaling back of existing agricultural land management through, for example, contraction of livestock production in marginal areas of the EU;

Adequate information on the production dynamics and environmental characteristics of some commodities was difficult to obtain, and the environmental impacts of trade liberalisation on developing countries was especially difficult to gauge. Most studies of liberalisation concentrate on acute socio-economic effects. The more serious limitations encountered in relation to analysis of environmental impacts of the commodities included the following:

- Lack of references on the more precise environmental effects of different production systems and commodities,
- Uncertainties about the consequences of changes in production where changes are predicted in crop area or intensity,
- Uncertainties about the effects of decreases in production,
- Uncertainties about the spatial distribution of trade liberalisation effects. Predictions of changes in output are often made at a national level, while an adequate analysis of environmental impacts usually requires greater spatial resolution;
- Uncertainties about the production methods that are going to be employed where output levels increase;
- A tendency in the literature to give relatively little consideration to potential changes in production methods and technology over time.

It is recognised that secondary and tertiary impacts resulting from adjustment in production systems and land uses over time can be significant in environmental terms but these are difficult to capture other than in detailed case studies.

1.3 The Environmental Impacts of Trade Liberalisation

For most of the commodities, the study has been able to draw on a body of evidence relating both to the environmental impacts of production, and the expected broad impacts of trade liberalisation on patterns of production and trade. However, there are significant limitations to this literature and some significant gaps are apparent. While there have been several studies of the effects of liberalisation of trade for some commodities – particularly those where intervention is greatest such as sugar, cotton and dairy – the evidence base is much thinner for others, such as poultry and vegetables. Evidence of the environmental impacts of production in different countries and settings is also variable and incomplete, particularly for certain commodities in certain parts of the world. For example, evidence of the environmental impacts of poultry systems in developing countries is, at best, patchy.

In attempting to predict environmental impacts on the basis of projected changes in output at a national or more local level, some major uncertainties are encountered. The most important of these concern:

- The regional location of production changes, and distribution between different farm types.
- The extent to which changes in production will be reflected in changes in cropped area and changes in yield, often associated with intensification.
- The likely impacts on land use, through, for example, substitution of one crop for another, clearance of non-agricultural habitats (of different types) and potential abandonment of agricultural land.
- The effects of liberalisation on different production techniques and systems, given that these may vary by location.
- The precise direction and magnitude of new trade flows.

Putting these considerations on one side, it is clear that the environmental impacts of trade liberalisation vary by commodity. These variations depend on:

- **The degree of support and protection in place and scope for further liberalisation.**
- **The extent to which products are internationally traded**.
- **The extent to which methods of production (and hence environmental impacts) vary by country.**
- **A variety of climatic, environmental and regulatory conditions in the producing country.**

In order to measure trade effects in the case studies, an anticipated rise or fall in the level of output in a country has been taken as the principal indicator, recognising that this is very imperfect, given other factors influencing modulation. It has been necessary to rely on models for such estimates but it would be desirable to validate the outputs by means of independent work, including detailed sectoral studies. Without this, it would be unwise to put too much confidence on the scale of trade effects relevant to other factors shaping patterns of production.

In some cases it is clear that the impacts of trade liberalisation are likely to be less significant than the effects of changing domestic patterns of production and consumption, especially for relatively less traded commodities experiencing strong worldwide demand growth (such as vegetables). The projected effects of trade liberalisation are more prominent in markets like sugar and cotton where demand growth is more moderate, trade relatively more significant, government intervention substantial and differences between production methods and costs pronounced.

Increased trade itself could be expected to have environmental impacts, irrespective of the commodity. Perhaps the most prominent is expanded international transport of foodstuffs, associated with energy consumption, greenhouse gas emissions, infrastructure development etc. Air freight is expanding rapidly and has the highest environmental impact of the different modes.

Table ES-1 provides a summary of the expected environmental impacts that give greatest cause for concern or offer potential benefits, and the key locations of these impacts.

Commodity	Impact	Location
Dairy	1. Intensification, where production increases, causing range of impacts, especially water pollution	Australia, New Zealand, Argentina, Brazil
	2. Expansion, particularly forage area, threatening semi-natural habitats and more extensive livestock systems	Australia, New Zealand, Argentina, Brazil
	3. Risk of abandonment of dairy systems in high nature value areas.	Parts of Central and Western Europe
	4. Reduced water pollution and fertiliser use in areas where dairy farming scaled back.	Parts of Central and Western Europe
Sugar	1. Expansion of production, placing increasing pressure on biodiversity, soil and water resources	Brazil, Thailand, India, Australia
	2. Reduced sugar beet production, eases pressure on soil and water resources but with some offsetting disadvantages e.g. less variety in arable crop rotations which affects some ground nesting birds.	Less competitive EU countries
	3. Likelihood of abandonment of some cane plantations in ACP countries, resulting in landscape change, significant rural development impacts but opportunities for habitat recreation	ACP countries, especially Barbados, Cote d'Ivoire, Jamaica, Madagascar, St. Kitts and Nevis.
Vegetables	1. Increased greenhouse gas emissions due to increased vegetable trade	Global
	2. Variety of potential impacts on soil, water, landscape, biodiversity, due to export related expansion including increased water abstraction and pesticide use in developing countries. Some offsetting reductions in pressure in Europe; depending on alternative land uses.	Middle East, Africa, Central and South America, China.
Poultry	1. Expansion of intensive poultry systems in low cost exporting countries, with varying environmental and animal welfare standards. Impacts on water, air, animal welfare.	Brazil, Thailand and US
	2. Environmental benefits of reduced poultry production	EU
Cotton	1. Increasing pesticide use in areas where production expands, with impacts on biodiversity and soil fertility.	Australia, Brazil, Uzbekistan, Turkey, Pakistan, Mexico, India, West and Central Africa
	2. Increased irrigation, with pressure on water resources and risk of salinisation.	Turkey, Pakistan, Uzbekistan, Australia, Mexico
	3. Land reclamation and the resulting problems of habitat destruction and fragmentation.	West and Central Africa and Brazil.
	4. Reduced environmental problems as production declines; any replacement crops likely to be less resource intense.	Greece, Spain, US

Table ES-1: Summary of Principal Impacts and their Location

As noted above, it is equally necessary to consider impacts in geographical locations taking account of a range of commodities as well as on a commodity-by-commodity basis. For example, Brazil is expanding production and exports of a variety of commodities (including sugar, cotton, dairy, poultry and vegetables) and trade liberalisation is expected to further increase the country's share of these markets. Some of the key potential environmental impacts – such as the risk of clearance of natural habitats – and potential policy responses - are not merely specific to individual commodities but relate to wider issues of the inter-relationship between agriculture and the environment in particular localities. The level of environmental risk and opportunity depends considerably on the political choices and institutional capacity of the country in question.

1.4 The Role of Flanking Measures

The range of potential environmental impacts identified as a result of trade liberalisation and our limited capacity to forecast exactly how and where they arise creates challenges for any policy response strategy. A variety of measures and ability to respond flexibly are both valuable. In selecting an appropriate group of flanking measures we have been conscious of a number of factors, including:

- **The need to distinguish between trade flanking measures and wider policy responses**.
- **The ability of the UK government and EU to address the environmental impact in question**.
- **The scope for action to address a variety of commodities or impacts**.

Table ES-2 provides a summary of some of the most appropriate flanking measures to deal with the key environmental impacts identified for the five commodities.

Commodity	**Impact**	***Flanking Measure***
Dairy	1. Localised water pollution impacts, most significant in countries where production is predicted to increase.	*Best dealt with by national legislation – limited UK role, except in encouraging UK compliance with the Nitrates Directive..*
	2. Risk of abandonment in Europe	*Agri-environment schemes and national envelopes. No new measures needed.*
	3. Global, non-sector-specific issues (e.g. greenhouse gases, risk of habitat clearance)	*Best addressed by existing international agreements (Kyoto, CBD).*
	4. Variety of global and local environmental and animal welfare issues	***Consumer awareness, certification and labelling schemes. Scope for new UK or EU initiatives.***
Sugar	1. Worldwide impacts on biodiversity, soil, water resources	***Consumer awareness, certification and labelling schemes. Scope for new UK or EU initiatives.***
	2. Localised impacts in Brazil, Thailand, Australia	*National regulations – limited UK role. Potential role for international agreements if globally important habitats affected. UK/EU overseas development programmes could seek to mitigate negative impacts and reinforce positive impacts.*
	3. Likelihood of reduced area of sugar beet, with some environmental costs as well as benefits in arable areas.	*EU agri-environment programme has role in managing impacts. No new measures needed.*
	4. Risk of abandonment of developing country sugar cane plantations	***UK/EU overseas development programmes could seek to mitigate negative impacts and reinforce positive impacts***
Vegetables	1. Greenhouse gas emissions caused by food miles	*Taxation of aircraft fuel, which is subject to ongoing discussion in the EU (or inclusion of*

		kerosene in the EU emissions trading system) ***Consumer awareness programmes linked to existing labelling of country of origin***
	2. Variety of potential impacts on soil, water, landscape, biodiversity, due to export related expansion.	*Regulations within producing countries. Limited scope for UK influence.* ***Market based measures, including consumer awareness programme, labelling and certification.***
Poultry	1. Air and water pollution, animal welfare concerns from intensive systems	*National regulations, with little scope for UK influence.* ***Attempts to introduce product standards harmonising animal welfare and environmental standards for imports and domestic production (problems of WTO compatibility)*** ***Market measures, including consumer awareness, product labelling, certification***
Cotton	1. Impacts of pest management and irrigation in developing countries	***Technical assistance programmes, designed to promote integrated pest management, organic production etc. and improve the efficiency of irrigation.***
	2. Wide ranging environmental impacts caused by cotton production	***Voluntary code of practice.*** ***Labelling and certification schemes, especially the development of an internationally recognised organic cotton standard.*** ***Consumer awareness building of key environmental problems and importance of above two measures.***
	3. Risk of land clearance for cotton production, e.g. in West and Central Africa	***Need for careful monitoring. Possible role for multilateral agreement.***
Bold indicates areas where new initiatives may be required, and where the UK and EU potentially have a role to play.		

Table ES-3: Summary of Key Potential Flanking Measures

Given sufficient political will, many of the expected environmental impacts of trade liberalisation can either be dealt with by existing measures (such as the EU agri-environment measures) or are most readily addressed by regulations or other measures at the national level in third countries. In these cases, the UK and, more broadly the EU, have relatively limited direct influence on choices made in these countries, particularly in the shorter term.. The table highlights a number of less direct and softer measures which are available such as development assistance, training, promoting good practice, capacity building etc. These measures can be taken forward at both the national and the EU level. There are also opportunities for pursuing this through international bodies, such as the FAO.

In principle, there is also scope for working at the global level, both to improve compliance with existing multilateral agreements, such as the Convention on Biodiversity and to negotiate new agreements. Measures to strengthen the multilateral framework, which might include agreeing environmental standards in certain areas, such as pesticide use on foodstuffs or minimum standards for farm animal welfare. Multilateral initiatives would be valuable but have not been discussed in any detail because of the long timescale involved in launching international agreements of this kind and the high level of opposition by many developing countries to more stringent environmental standards of this kind in the current climate. Nonetheless, they represent a key measure in a longer term suite of flanking policies.

More radically, a tighter linkage between trade policy and environmental sustainability can be envisaged. There is room for a debate on whether it would be possible to develop a sustainability index or a set of sustainability indicators which could be used to classify different products and production systems. This could be deployed through voluntary or mandatory labelling systems or through a direct linkage between tariffs and other trade policy instruments and a products' sustainability. This is not an immediately available flanking measure but could be seen as an issue to investigate further.

The principal shorter-term potential UK/EU policy responses are highlighted in bold in Table ES-3 and can be grouped as follows:

1. **Consumer awareness programmes**.
2. **Labelling and certification schemes**.
3. **UK/EU development assistance programmes**.
4. **Regulations related to process and production methods**.
5. **Multilateral environmental agreements**.
6. **Reducing negative externalities of transport**
7. **Incentives for appropriate agricultural production in the EU**

These measures are described more fully in the conclusions which also consider some key research needs to strengthen policy in this area.

2 INTRODUCTION AND CONTEXT

2.1 Purpose of this report

The Institute for European Environmental Policy (IEEP) and GHK Consulting Ltd (GHK) have been commissioned by Defra to examine the environmental impacts of trade liberalisation and to identify appropriate flanking measures to address these impacts. The study is intended to provide a relatively rapid survey of the potential environmental effects of trade liberalisation, based on existing published literature of the environmental impacts of different commodities and sectors, and the expected impacts of liberalisation on these commodities and sectors.

The study is organised in two stages:

- Stage 1 of the study focused on case studies of agricultural commodities – dairy, sugar, vegetables, cotton and poultry;
- Stage 2 of the study will examine the wider impacts of liberalisation in different sectors. The case studies for Stage 2 are yet to be decided.

The study is a desk-based exercise focused primarily on the literature and selected interviews with specialists and stakeholders. It has not been possible within the timescale and budget available to undertake any original research or fieldwork.

This report presents the findings of Stage 1 of the study.

2.2 Overview of trade liberalisation agenda

The process of trade liberalisation has been underway for several decades. At a global level, negotiations are now concentrated within the World Trade Organisation (WTO), with the majority of nations now members of this forum. Agreements within the WTO take place within a series of ‘rounds’. The current ‘Doha’ or ‘development’ round includes agriculture along with many other economic sectors. The round itself is in the process of moving towards conclusions and we are at an interim stage currently. The overall direction of liberalisation is fairly clear but the precise nature of further agreements and the timescale for their implementation is still uncertain.

Alongside the global picture is a series of bi-lateral and multi-lateral trade agreements, with the EU an active participant. Whilst these trade agreements vary greatly in focus and substance and do not necessarily include agriculture, the overall direction is towards greater liberalisation, even where ‘sensitive’ products are excluded.

In this report we are concerned particularly with agricultural trade and liberalisation. The main forms which liberalisation is expected to take are those at the core of the negotiations over the WTO Agreement on Agriculture. These are:

- Reductions in ‘Domestic Support’ i.e. levels of direct and indirect support to producers, with the main emphasis on reducing trade distorting subsidies. As downward pressure is exerted on support there is an increasing focus on the categories into which individual measures fall. Trade distorting measures are subject to greater discipline than those regarded as more neutral in their trade effects, particularly ‘green box’ measures. Liberalisation has been associated with a shift towards green box models of support in the EU and several other major trading countries.
- Increased market access, i.e. reductions in tariffs and other mechanisms designed to constrain imports. Tariffs in the EU are complex and structured in such a way as to discriminate against imports of certain products, particularly those where the EU is a major producer and does not have internal price levels comparable to those on the world market. Consequently the market access debate is focussed on a number of specific commodities as well as access as a whole.
- Reductions in export subsidies and other equivalent measures such as export credits. These subsidies are intended to bring the price of goods down to the level where they are competitive on the world market, thereby creating export opportunities, which would not otherwise exist. The EU is the major trading entity employing export subsidies for agricultural commodities and is the focus of attention in the WTO negotiations. These subsidies are used for a variety of commodities, but are particularly prominent in certain sectors, such as dairy and sugar.

In this study we do not propose to catalogue the precise state of play on liberalisation for all agricultural commodities. The focus is on five selected commodities, which are at different stages in the liberalisation process, some for example more affected by the recent CAP Mid Term Review than others. An account of the liberalisation agenda is given for each commodity.

2.3 Rationale for selecting case studies

It was agreed to examine agriculture primarily in relation to a range of commodities. Five were chosen in collaboration with Defra. The intention was to include a selection which illustrated both temperate and tropical products, including those of importance for both developing and developed countries, and capable of throwing light on different aspects of liberalisation. Commodities that are the subject of active negotiations at present were given some priority. The chosen commodities are:

- **Sugar:** selected because it is high on the trade agenda at present. A decision is required on the future of EU policy, potentially under the UK Presidency. There is a WTO case outstanding and sugar is a clear example of an internationally traded commodity with significant environmental impacts both in the tropics and temperate conditions.
- **Dairy Products:** chosen because they are important in international trade, widely produced and often heavily subsidised. Reductions in export subsidies have significant implications for the sector, and are high on the agenda at present. Dairy products are traded in various different forms, and the sector raises a variety of issues related to livestock farming which are quite different from those associated with crop production.
- **Cotton:** selected because it is high on the WTO agenda at present and is one of the priority crops from Defra’s perspective. It is produced in both tropical and more temperate regions and there are significant environmental implications of production choices. It is an important commodity for many developing countries.
- **Poultry:** an example of an intensively produced, industrialised, internationally mobile sector where trade is on a substantial scale. Although levels of protection are less than in many other sectors, liberalisation raises both environmental and farm animal welfare issues.
- **Vegetables:** chosen because they are increasingly traded with a wide variety of countries involved, raising substantive environmental issues, including long distance air freight. There is substantial scope for increased volumes of imports of temperate vegetables from developing countries as well as tropical vegetables.

2.4 Structure of this report

This report contains a series of introductory sections, outlining the approach adopted and discussing some of the key methodological issues addressed by the study, before moving on to present the individual commodity case studies.

Section 2 discusses some of the methodological issues inherent in the assessment of the effects of trade liberalisation on agricultural production and trade, introducing the various modelling approaches employed by different studies, and their characteristics and limitations. Section 3 addresses the assessment of environmental impacts, providing a brief overview of the literature available and the issues, gaps and limitations encountered. Section 4 provides a general introduction into the role of flanking measures in addressing the environmental impacts of trade, including the types of measures that can be adopted, and their advantages, disadvantages and potential applications.

Sections 5 to 9 present the individual commodity case studies. Each case study provides a brief introduction to the commodity concerned and the different methods used to produce it, before reviewing data on current patterns and trends in production and trade, considering the impact of government policy, and identifying the likely effects of trade liberalisation. By combining this with a review of the different environmental impacts of production and trade in different parts of the world, each case study is able to assess the likely environmental impacts of likely trade liberalisation scenarios. This is followed by a discussion of the flanking measures that can be adopted to address these key impacts. Key conclusions, including an assessment of further research needs, are then presented.

Section 10 presents the overall conclusions drawn by IEEP and GHK on completion of this stage of the work.

3 ASSESSING THE EFFECTS OF LIBERALISATION ON PRODUCTION AND TRADE

3.1 Overview of Methodological Approach

The current study is concerned with predicting the expected future environmental effects of current and expected future trade liberalisation scenarios. Though a review of literature examining the effects of previous trade liberalisation measures (e.g. North American Free Trade Agreement (NAFTA) and the Uruguay Round) on the environment can provide some insight into the possible impact of future reforms, exploring the effects of current and future scenarios requires a forward looking, predictive approach. This involves two stages, the first predicting the likely impacts of trade liberalisation scenarios on production and trade, and the second combining these predictions with knowledge of the environmental effects of changes in patterns of production and trade, in order to assess the potential environmental impacts of liberalisation.

A small number of studies combine the above two elements in order to predict the environmental impacts of trade liberalisation. For example, Saunders and Cagatay (2004) modelled the environmental impacts of dairy trade liberalisation by extending a trade model to incorporate some of the environmental effects of production, in terms of resource use and nitrate pollution, and their findings are summarised in the dairy case study, below. Though combined studies such as this are relatively scarce, substantial numbers of studies exist which either model the effects of trade liberalisation scenarios on patterns of production, consumption and trade, or review the various environmental impacts of different production systems and trade flows in different parts of the world.

Combining the findings of these two types of study, to predict the possible environmental impacts of trade liberalisation scenarios, is then a relatively straightforward exercise, at least in theory. In practice, it is hampered by gaps and limitations in environmental data; difficulties in assessing which impacts are priorities, especially where impacts are varied and widespread; and uncertainties in basing predictions on past evidence, especially where impacts may be specific to particular locations or production systems.

3.2 Key Methodological Issues In Trade Modelling

Though relatively straightforward in overall terms, the approach adopted does give rise to a number of significant methodological issues that affect the scope, reliability and policy relevance of the results obtained. These include:

- **Modelling issues –** Policy makers generally rely on models to estimate the potential effects of trade policy adjustment. The literature reflects this. However, from the perspective of this study there are considerable limitations in the models that dominate the literature. These include the definition of baseline scenarios (in a changing world) and the assumptions both within the models themselves and in the modelling process. Together these result in differences in the results arising from different models.

- **Data limitations** are frequently an issue in modelling studies, requiring the use of dummy or proxy variables, not least on the environment. Data gaps are often most significant in developing countries.
- **Uncertainties about trade liberalisation scenarios**. For example, the current Doha agenda is still being progressed and in most cases only the overall objectives and direction of reform are known, with the detail, extent and timetable still uncertain. As a result many modelling studies use theoretical scenarios involving total or partial liberalisation rather than actual proposals. These often result in scenarios assuming more radical change than is likely in the short to medium term.
- **Limitations in modelling outputs**, which may limit the conclusions that can be drawn about environmental effects. For example, many studies predict changes in output of different agricultural commodities at a national level, but do not distinguish between effects due to land area or yield, or predict where such changes are expected to take place, all of which are important for understanding environmental impacts.
- **Difficulty in interpreting results**, especially since models are often so complex as to be difficult to understand for non-technicians, and difficult for practitioners to explain adequately and concisely in the literature. In particular, the difficulty of understanding the sensitivity of the results achieved to the assumptions employed is a key issue.

These are significant issues, and are complicated further by political interest in the trade liberalisation agenda and for the scope for political considerations to influence modelling approaches. One of the conclusions of a 1999 Organisation for Economic Cooperation and Development (OECD) workshop on environmental assessment of trade liberalisation was that no assessment is a purely technical exercise, and there will always be an element of policy assumptions and value judgements. While this was considered legitimate, it was stressed that these assumptions and value judgements need to be made transparent (OECD, 2000). This remains equally true today.

3.3 Modelling Trade Liberalisation Scenarios

Different types of economic models can be used to assess trade liberalisation scenarios:

- **Partial Equilibrium Models** focus on the effects on a particular sector, such as agriculture or agri-food, in isolation, ignoring the inter-relationships between prices and outputs in different sectors, and assuming that these are sufficiently insignificant to be disregarded. This assumption may be reasonable in certain scenarios – e.g. assessing the effect of changes in tariffs for a particular commodity, where this is likely to be relatively insensitive to wider economic changes. Partial equilibrium models have limitations in terms of their inability to take account of economy wide effects and interactions between sectors, but have the advantage of their relative simplicity, low cost, manageable data requirements and ease of interpretation.

- **General Equilibrium Models** take account of the inter-relationships between different sectors of the economy, and the knock-on effect that changes in wages, prices and output in one sector are likely to have on those in other sectors. They are well suited to dealing with more complex trade reforms that involve a variety of changes and are likely to have repercussions in different parts of the economy. However, while they are attractive in principle for their ability to account for numerous factors and impacts, there are inevitably data and cost limitations, while their complexity and multi-sectoral nature tends to limit the sophistication of their approach to particular sectors or commodities.

Models also differ in their ability to deal with the dynamics of change. Comparative static models examine the outcome of a policy change by assuming that full equilibrium is reached, and are therefore most useful in examining longer-term impacts. Other models attempt to take account of the path towards this equilibrium, taking account of the speed and cost of adjustment and the process by which the factors of production are redeployed. Some dynamic models build in a process of ongoing learning, development and change, rather than assuming a fixed equilibrium is achieved (McCulloch et al, undated). Examples of widely used trade models include:

- GTAP (Global Trade Analysis Project) – a multi-region and multi-sector static general equilibrium model, developed by a global network of researchers and co-ordinated by the Centre for Global Trade Analysis. This is the most widely used model to forecast trade policy outcomes and utilises a sizeable database, but its application to environmental concerns is by no means easy.
- AGLINK – a partial equilibrium dynamic supply-demand model of world agriculture, developed by the OECD.
- ATPSM (Agricultural Trade Policy Simulation Model) – a comparative-static, multi-region, multi-commodity partial equilibrium world trade model for agricultural commodities, developed jointly by the United Nations Conference on Trade and Development (UNCTAD) and the FAO.

The OECD workshop on the environmental assessment of trade liberalisation agreed that the science of modelling is still evolving, such that one cannot definitively state that one approach is preferable to any of the others. Indeed, in some cases the approaches can be complementary, such that they can build upon each other, in particular with partial equilibrium models feeding into general equilibrium models. The workshop therefore welcomed the diversity of approaches to trade modelling (OECD, 2000).

Given the variety of approaches and assumptions employed, and recognising that it is often difficult to assess the relative merits of these, this study has sought to review as wide a range of modelling studies as possible for each commodity, in each case summarising key findings and identifying common themes.

4 ASSESSING THE EFFECTS OF LIBERALISATION ON THE ENVIRONMENT

4.1 General approach taken in the review

The review was undertaken as a desk-based research exercise. For each of the agricultural commodities examined, an analysis of environmental and trade-related literature was undertaken. Impacts in the EU and other OECD countries were examined, along with impacts in less developed countries. Where available, reviews of the effects of trade liberalisation to date were considered, and, where possible, used to estimate the potential effects of future changes in trade. Reviews were obtained from industry organisations, environmental non-governmental organisations and government agencies, as well as international organisations such as the OECD, the World Bank and FAO.

4.2 Brief analysis of key issues and limitations

4.2.1 Key issues

For some commodities, e.g. dairy, the environmental effects of different production systems have been studied to some degree and modelled with reference to various trade scenarios. For others there is very much less information.

One of the key issues in assessing environmental impacts of trade liberalisation is its impact on land use, both in terms of shifts between non-agricultural and agricultural land use, and use of the existing agricultural land. Substitution effects between crops are often difficult to determine, and can be highly location specific.

Although environmental impacts differ between commodities and production areas, the most important trade-related environmental issues appear to include:

- Expansion of agricultural land area at the expense of natural habitats through clearance, with complex consequences for biodiversity, landscape and downstream ecosystems;
- Substitution between different forms of agricultural land use (e.g. pastures and arable land), between crops (e.g. citrus and sugarcane), and changes in production systems (extensive and intensive), which may give rise to either positive or negative environmental impacts;
- Pressure on natural resources from commodity production and processing, especially on water and soil, with effects reaching downstream ecosystems (e.g. through increased water demand and higher risks of erosion);
- Shift of production between areas with lower and higher environmental and/or animal welfare standards;
- Losses of or increases in agricultural habitats that provide certain environmental benefits (e.g. biodiversity benefits of sugar beet as a nesting area for birds);
- Land abandonment, through, for example, contraction of dairy production in marginal areas of the EU;
- Problems of infrastructure disposal in areas where there is serious decline or cessation of certain production and/or processing activities.

4.2.2 Limitations

Information on some commodities was difficult to obtain, and the environmental impacts of trade liberalisation effects on developing countries were especially difficult to gauge. Most studies concentrate on acute socio-economic effects. In general, the limitations encountered in relation to analysis of environmental impacts of the commodities included the following:

- Lack of available references on the environmental effects of different production systems and commodities, e.g. accurate information about the impacts of the dairy industry in Russia;
- Uncertainties about the consequences of changes in production where changes are predicted in area or intensity, e.g. whether increases in production of sugarcane would involve conversion of natural habitat or change from existing irrigated crops or other agricultural land uses;
- Uncertainties about effects of decreases in production, where it could lead to either land abandonment or replacement by other types of agricultural production;
- Uncertainties about spatial distribution of trade liberalisation effects. Predictions are often made at a national level, while an adequate analysis of environmental impacts usually require greater spatial resolution;
- Uncertainties about the production methods that are going to be engaged where production levels increase;
- A tendency in the literature to give relatively little consideration to potential changes in production methods and technology over time.

It is recognised that secondary and tertiary impacts resulting from adjustment in production systems and land uses over time can be significant in environmental terms but these are difficult to capture other than in detailed case studies.

5 FLANKING MEASURES FOR TRADE LIBERALISATION

5.1 Overview of potential measures

Where implementing a policy will have significant environmental, social or economic effects, it may be necessary to establish 'flanking measures' to seek to improve the outcomes attributable to the policy. Flanking measures accompany central policy measures pursuing a core agenda and so help to achieve a more balanced outcome, correct perverse effects and reinforce positive impacts. In the context of trade liberalisation, flanking policies might aim to secure objectives which liberalisation could fail to do, prevent unwanted side effects, or encourage the delivery of desired environmental outcomes.

Liberalisation of trade is likely to have significant socio-economic and environmental effects in some countries and/or regions, and flanking measures may be desirable (and indeed are already being used in some places).

In the case of agricultural trade liberalisation, possible flanking measures can be categorised in several different ways. One approach is to consider different points where impacts arise, e.g.:

- Measures to buffer or balance the environmental impacts of trade liberalisation at the point of consumption (e.g. waste and pollution arising from increased consumption or a change in the pattern of consumption, such as through changes in fuel consumption).
- Measures to deal with the environmental consequences of trade liberalisation at the point of production (e.g. land use change, pollution and resource use).
- Measures to deal with the environmental consequences of the process of trade itself (e.g. food miles and other transport impacts).

Another approach is to differentiate between the potential actors. Several different parties could, in principle, launch flanking policies. These include:

- **The importing country**, which may be concerned about :
  - a) The nature of imports following liberalisation (e.g. meat produced with low animal welfare standards)
  - b) Effects in the country of origin, especially if a Least Developed Country (LDC) (e.g. burning tropical forests to grow crops)
  - c) Effects in the receiving country, which may be experienced by consumers (reduced choice, poor environmental quality etc.), producers (competition), the environment (e.g. less grazing) or others
  - d) Net effects of the production cycle on the environment, e.g. where trade leads to a new balance of production that increases overall greenhouse gas (GHG) emissions or water abstraction or pesticide use in the sector. More food miles would be another example

- **The exporting country**, which might have concerns mirroring those of the importing country. Exporters might have some different concerns e.g. if a new agreement (such as Everything But Arms (EBA)) makes them so attractive as a production base for a newly liberalised commodity, such as sugar, that this has adverse environmental and/or social consequences. Export constraint might be difficult for a government committed to a liberalisation agreement, so that more targeted environmental measures will be called for.

- **A third party**, such as an international organisation. Such bodies may have a role related to international trade, environmental standards (e.g. waste disposal, the regulation of genetically modified organisms (GMOs)), product labelling or commodity standards etc. Where countries sign up to regional trade agreements (such as the EU or NAFTA) the secretariat may operate flanking policies. Within the EU, the special arrangements for the French Overseas Departments, for Madeira and the Canaries could be classified as flanking policies.

Flanking measures can be applied through different types of policy intervention that might seek to deal with the environmental effects of trade liberalisation. These include:

- Trade bans and restrictions (e.g. bans on beef produced using certain hormonal treatments);
- Regulations relating to products (e.g. regulatory limits on chemical residues in meat/milk/fruit);
- Regulations related to production methods (e.g. regulations on animal welfare, pesticide application etc);
- Environmental regulations – e.g. limits on concentration of pollutants in waters, or requirements on designation of nature protection areas, where specific action or management plans have to be implemented;
- Import/export-related economic instruments such as tariffs;
- Domestic economic instruments such as fuel taxes, tradeable permits, water pricing, reform of agricultural or irrigation subsidies;
- Marketing and labelling initiatives – e.g. ecolabelling schemes, consumer information programmes;
- Incentive or compensation schemes – e.g. agri-environment and rural development measures - designed to mitigate the adverse effects of liberalisation in particular countries or to encourage the production of environmental goods that would be under-produced in a free trade scenario; and
- Technical assistance measures – e.g. advisory, training, education and business support programmes designed to help countries to reduce the environmental impacts of production and trade or respond to positive opportunities.

The above listed policy instruments might attempt to deal with different environmental issues and impacts, such as land use, animal welfare, pollution, waste, resource use, rural development, etc.

We can also identify different ways in which these measures might be applied. These are:

- Multilaterally – through environmental agreements, programmes or schemes that seek to ban, restrict, regulate or encourage trade in different goods and services;
- Bilaterally – through agreements between importing and exporting countries;
- Unilaterally by the importing country – e.g. regulations or restrictions on imports, product standards etc;
- Unilaterally by the exporting country – e.g. domestic planning policies, environmental regulations, production standards, measures to regulate exports.

Criteria for selection of flanking measures are likely to include:

- applicability to the environmental issue in question, and to the relevant national or international context;
- political acceptability;
- WTO compatibility;
- practicality;
- enforceability;
- cost-effectiveness; and
- coherence and consistency with other trade and environmental policies.

These criteria have each been considered in the analysis of potential flanking measures for each commodity.

Table 5-1 presents examples of different types of flanking measures, highlighting their advantages, disadvantages and potential for application.

Table 5-1: Review of potential flanking measures by type

	Examples	Advantages	Disadvantages	Potential Applications
Type of Measure:				
Trade bans and restrictions	Bans on imports of GMO crops	Effective, where feasible and acceptable	Low political acceptability in several countries and subject to challenge in WTO Likely to be limited to cases where environmental concerns are already reflected in consumer preferences. May not deal with production related impacts	Limited, and applicable only where environmental factors linked to product safety or quality.
Product regulations	Limits on chemical residues in food	Effective, where environmental impacts are reflected in product standards	Limited to cases where environmental concerns are reflected in product standards. May not deal with production related impacts May not be suitable for multilateral agreements	Limited, and applicable only where environmental factors linked to product safety or quality.
Regulations related to production methods	Animal welfare regulations Rules about pesticide applications in production processes	Environmental effectiveness (if feasible) Help to "level the playing field" with domestic production standards	Political acceptability and WTO compatibility of regulating products from overseas. Effectiveness may therefore be limited to domestic production.	Limited and subject to legal challenge.
Environmental regulations	EU Nitrates Directive	Targeted approach to undesirable environmental impacts	Political acceptability and WTO compatibility of regulating environmental externalities overseas. Effectiveness may therefore be limited to domestic production.	Widespread applicability where implemented by producing countries Scope for use by importing countries limited and subject to legal challenge.
Voluntary codes of practice	Industry codes, e.g. for Australian sugar production	Encourage industry engagement and ownership Relatively low cost or even gains through reduction of production costs	Voluntary nature and dependence on industry commitment may limit impact. May lack bite and fail to address real impacts Difficulty of achieving international uptake	Widely applicable, especially in cases where there is consumer concern about product in question, and where it helps to reduce costs/optimise use of inputs
Differential import tariffs	Tariffs on low welfare meat	Potentially effective and flexible, where feasible/acceptable	Likely low political acceptability and WTO compatibility	Limited and subject to legal challenge.
Economic instruments	Taxes on aircraft fuel Tradeable permits on greenhouse gases	Enforce polluter pays principle Can be applied equally to domestic production and imports Can encourage innovation and promote cost effective solutions	Difficulty of reaching international agreements (e.g. aircraft fuel) Competitiveness impacts of unilateral use of taxes May be blunt instruments where link between product and environment is complex or poorly defined	Applicable where there is a clear and direct link between product and impact, e.g. aircraft fuel, greenhouse gas emissions. Less applicable to generic commodities because of complexity of environmental effects.

Marketing and labelling initiatives	Organic labels Consumer information programmes	Voluntary and therefore less controversial and more politically acceptable Widely applicable Work with market mechanism	Can be perceived as discriminatory by some developing countries. Enforceability and traceability a challenge, especially where production chain is complex. Defining meaningful standards may be a challenge. Voluntary nature and dependence on consumer awareness and concern may limit impact. Proliferation of labels may confuse consumers.	Labelling initiatives widely applicable for most products where standards can be defined and enforced Consumer awareness programmes universally applicable
Incentive or compensation schemes	Agri-environment schemes Rural development schemes	Enable payment for environmental services that would otherwise be underprovided by market Environmental effectiveness Can be targeted by sector, geographically, on certain environmental objectives	In some cases may conflict with polluter pays principle Administrative complexity and financial costs of implementation, especially if applied internationally, or to large number of small producers Complexity of monitoring and enforcement issues Where environmental objectives are not very explicit it can be subject to challenge in WTO in future	Potentially widely applicable but subject to institutional/administrative and budgetary constraints.
Technical assistance measures	Training/awareness raising programmes for farmers	Effective where awareness, skills, techniques etc are factor limiting environmental quality in production process	Suitable where awareness, skills, techniques are limiting factor May only work where there is a potential “win-win” between achieving environmental and production objectives Uncertainty of outcomes High time/effort investment in learning required where significant innovations are involved Challenges of delivery in overseas countries	Widely applicable where there is potential for “win-win” solutions between environmental and economic objectives.
Multilateral environmental agreements	CITES, CBD	Much more acceptable under WTO than unilateral actions (though some issues to be resolved) Potential to deal with cross sectoral issues (e.g. forest destruction from multiple causes)	Challenge of reaching multilateral agreement Enforceability	Theoretically widely applicable but high reliance on political will of parties is a significant constraint.

CASE STUDIES

6 DAIRY

6.1 Brief overview of the dairy sector

This case study focuses on the production of milk from cows, which accounts for the largest share (around 85 per cent) of world milk production from farmed animals. The majority share of worldwide milk production is consumed domestically as fresh fluid milk, with international trade mostly made up of butter, cheese, and milk powder. The EU produces the largest share of the world's dairy products, followed by the USA, Brazil, Russia, India, Australia and New Zealand. Japan, Korea and Mexico also have some significant production.

Dairy production varies immensely between countries and regions. Germany is the largest producer of cow's milk in Europe, followed by France, the UK, the Netherlands and Italy. In all of these countries, dairy farming practices vary in intensity and extensiveness. High input/output systems account for around 85 per cent of milk production in the EU. These are generally large farm systems featuring high stocking rates and high use of supplementary feeds and fertilisers. Other farming systems can be classified as low input/output, alpine, or Mediterranean. It is clear that small, low-intensity European dairy farms have greater environmental benefits than large, intensive systems, but European dairy production is showing a trend towards intensification with larger herd sizes and fewer farms (CEAS 2002). Use of robotic milking sheds and other mechanised practices is also growing.

In developing countries such as Brazil and India, milk production is still characterised by smallholder production. This also takes varying forms, but is mostly carried out by family members with very little reliance on hired labour (Delgado et al, 2003). In many developing countries, dairying may be a supplementary activity to crop farming and highly integrated with the crop production sector. Crop residues are used to feed animals, and animal manure is used in the fields as organic fertiliser and as a fuel in rural areas.

New Zealand and Australia have traditionally had low intensity pastoral dairy systems, with little need for feed supplements or indoor housing. Stock is usually kept outside grazing on pasture all year, with milk production on a seasonal basis. In recent years, however, the dairy systems in both countries have shown a trend towards intensification, with increasing reliance on additional feeding (mainly of silage) and on pasture fertilisation (Parliamentary Commissioner for the Environment, 2004; Carnus, 2004).

In the United States, most milk is produced by cows raised in intensive production systems. These include tie stall barns, free stall barns, and open lots. The more intensively managed systems feed the cows on rations that are relatively high in concentrates and stored forages. Other cows are raised in pasture-based systems, and some producers use a combination of the two systems, which reduces costs, but still allows the feeding of concentrate to improve milk production levels (US EPA website). The intensity of these operations has greater infrastructure requirements than the largely pastoral-based systems in Oceania and Europe.

In both Korea and Japan, the dairy industry is intensive and relies on imported grain for stock feed. Production varies depending on the geographic location of the industry – for example, in Hokkaido, which is a leading dairy area in Japan, pastoral dairy farming is common, but in other areas farms are more reliant on purchasing fodder from abroad.

Dairying in Russia is in a state of adjustment at present, due to changing economic conditions. In the past, small farms produced over 40 per cent of milk in Russia, but this may not continue to be the case with new political and financial structures in place. Modernisation of dairy plants is taking place, with significant investment from overseas.

In many dairy production systems there is a close link to the beef industry with unwanted male calves sent directly for slaughter or raised as steers until they reach the desired size for meat production. Many of the environmental issues highlighted with reference to the dairy sector are also of relevance to beef production, and it is difficult to tease apart the specific issues for each industry.

6.2 Effects of trade liberalisation on the sector

6.2.1 Current patterns of Production, Consumption and Trade

World milk production was estimated to total 611 million tonnes in 2004 (FAO, 2004). Around 85 per cent of world production is of cows' milk, with the remainder accounted for by buffalo (12 per cent), sheep (2 per cent) and goats' milk (1 per cent), much of this produced in Asia (OECD, 2004; Dairy Australia, undated). The largest milk producers are the EU (20 per cent of world production), India (15 per cent) and the United States (13 per cent) (Table 6-1).

	mt	**per cent**		**Mt**	**per cent**
EU15	125.5	20.5	Ukraine	13.6	2.2
India	91.3	14.9	Poland	11.9	1.9
United States	77.5	12.7	Mexico	10.0	1.6
Russian Federation	31.9	5.2	Australia	10.0	1.6
Pakistan	29.1	4.8	Argentina	9.5	1.6
Brazil	24.4	4.0	Others	140.8	23.0
China	21.0	3.4			
New Zealand	15.0	2.5	**World**	**611.5**	**100.0**

Table 6-1: World Milk Production, 2004 Source: FAO (2004)

According to Dairy Australia figures, the EU accounts for 25 per cent of cow's milk production, followed by the USA (15 per cent) and the former Soviet Union (13 per cent).

Region	Percentage share	Region	Percentage share
EU15	25	Poland/E Europe	6
USA	15	Australia/N Zealand	5
Russia/Commonwealth of Independent States	13	Japan and China	3
Central/S America	11	Other	15
India	7	Total	100

Table 6-2: Share of World Cows Milk Production (2001) Source: Dairy Australia (undated)

Only about 5-7 per cent of global milk production is traded each year. The difficulty of transporting bulk raw liquid milk means that most of it is consumed close to the point of production, while most international trade involves processed dairy products, especially butter, cheese, milk powders, casein and condensed milk. About 48 per cent of whole milk powder (WMP), 27 per cent of skimmed milk powder (SMP), 10 per cent of butter and 7 per cent of cheese output is traded internationally each year (OECD, 2004).

While dairy production is distributed widely across the world, New Zealand, the EU and Australia together account for more than 80 per cent of exports (Table 6-3). Unlike most countries, New Zealand's dairy industry is highly export orientated, accounting for a mere 3 per cent of world production but 35 per cent of world exports. New Zealand's grazing based dairy systems have low production costs and export around 97 per cent of output (OECD, 2004). Other significant exporters include Canada, Argentina, Uruguay, Poland and the Czech Republic.

Country/Region	Percentage share of Exports
New Zealand	34.6
EU15	31.1
Australia	15.6
USA	4.0
Others	14.8
World	100.0

Table 6-3: Exporters' Share of International Markets (2001) Source: Dairy Australia (undated)

Asia accounts for one third of world dairy imports, by volume, with Latin America, North America and Africa also major importers.

	Percentage of Imports	Region	Percentage of Imports
Asia	33	CIS	6
Latin America	20	Eastern Europe	4
North America	14	Oceania	1
Africa	14	Baltic	1
Western Europe	7	Total	100

Table 6-4: Dairy Import Markets, by Volume. Source: FAO (2003)

Consumption of dairy products averages 79 kg per person per year across the world, but local consumption ranges from 46 kg/person in developing countries to 217 kg/person in developed countries (FAO, 2003).

6.2.2 Recent Trends in Production, Consumption and Trade

World milk production increased from the 1970s until the mid 1980s, then declined, mainly as a consequence of quota reductions in the EU, and increased only moderately in the 1990s. Cows' milk production has increased by less than 10 per cent in the last ten years, while production of buffalo milk has increased by 40 per cent (OECD, 2004). The moderate growth in output in recent years has resulted from increases in production in the EU, USA, India, South America and Oceania. In most developed countries, supply control measures have stabilised output, and there has been a reduction in the number of farms and dairy cows, accompanied by an increase in yields. The exception is in Oceania, where dairy cow numbers have been increasing since the early 1990s (Dairy Australia, undated).

The last 30 years have seen a small decline in global production of SMP, little change in butter output, and an increase in WMP and especially in cheese, which is accounting for an increasing share of dairy production. These changes have reflected trends in consumption, influenced by a variety of income, health, nutrition and lifestyle factors. OECD countries have experienced a rapid increase in demand for cheese but declining butter consumption, while non-OECD markets have seen an increase in butter consumption and rapid growth in demand for WMP, which is replacing SMP in the milk reconstitution market (OECD, 2004).

The decade between 1992 and 2002 saw major increases in trade in cheese (up more than 50 per cent) and WMP (up 30 per cent), with stagnant trade in butter and SMP. This reflects a shift from supply-driven trade in bulk commodities to demand-driven trade in higher value-added products. New Zealand and Australia have increased their share of the world dairy export market in the last decade, at the expense of the EU. In general, low value dairy products are exported to developing countries and high value products exchanged between developed countries (OECD, 2004).

World market prices for most dairy products are substantially below 1980 levels, having declined substantially in the 1980s, largely as a result of the subsidised export of surplus production by the EU. There was some recovery in prices in the late 1980s and early 1990s, following EU quota cuts, but prices have generally declined in the last decade, particularly for butter (OECD, 2004).

6.2.3 The Effects of Government Policy

Along with rice and sugar, milk is one of the most highly supported commodities in the world, receiving significantly higher levels of support than other livestock products. All OECD countries support their dairy industries to some extent, although in New Zealand support is now minimal. Support is highest in Japan, Korea, Iceland, Norway and Switzerland, where the OECD's Producer Support Estimates (PSE)[1] exceed 70 per cent of gross farm receipts. In the EU15, Hungary, Canada, Mexico and the US, the PSE ranges between 45-55 per cent. The lowest levels of support are in New Zealand, Poland and Australia (between 0 and 15 per cent). Most OECD countries reduced support to the dairy industry between 1986/88 and 2000/02, with

[1] The OECD's Producer Support Estimate is a measure of the annual monetary transfers from taxpayers and consumers to farmers, through market price support and direct payments.

the exceptions of Norway, Hungary, Turkey and Poland, with the greatest reductions occurring in New Zealand and Australia (OECD, 2004).

Many OECD countries have some form of market price support, backed by tariffs and export subsidies, with production quotas often used to control surpluses. Tariff levels are high in Canada, the EU, Japan, Norway, Poland and Switzerland, and low in Australia and New Zealand. The EU accounted for 81 per cent of world export subsidies between 1995 and 2000, and Switzerland a further 10 per cent (OECD, 2004).

EU policy has played a major role in distorting world dairy markets and depressing world prices in recent decades. The EU provides high levels of support to its dairy industry, and is a major exporter of dairy products and a major user of export subsidies.

Progress in reforming of the EU dairy regime has been relatively modest. The CAP mid term review announced extensions to the previously agreed Agenda 2000 package, but extended the milk quota regime to 2014-15. The SMP intervention price is being cut by 15 per cent over the period 2004-06, and the butter intervention price by 25 per cent over 2004-07, accompanied by reductions in annual ceilings for butter intervention buying. Farmers have been compensated by the introduction of direct payments, initially linked to quota but to be integrated with the Single Farm Payment from 2007. A national envelope allows Member States to make additional payments to dairy farmers based on agreed criteria. Milk quota will be increased by 1.5 per cent between 2006 and 2008.

6.2.4 Scope and Agenda for Further Liberalisation

The scope for further progress in liberalising dairy trade is substantial. Levels of support for dairy farming in most developed countries continue to be high, as evidenced by OECD producer support estimates. The WTO Uruguay Round made only limited progress in liberalising dairy trade, and market access for dairy products remains highly restricted. Current minimum access quantities are small, above quota tariffs are high, and the EU and US continue to maintain exports at relatively high levels. The current WTO negotiations are therefore seen as offering an opportunity to further progress efforts to reduce both trade barriers and the use of export subsidies (Shaw and Love, 2001).

The 2003 CAP reform made some progress towards liberalisation of dairy trade but there has been widespread criticism of the slow pace of change. For example, Action Aid (2003) considered that the dairy reforms would have little impact on developing countries, and that the EU would continue to rely heavily on export subsidies, with negative effects on world markets, quoting Commission forecasts that dairy export subsidies in 2013 would amount to 620 million euros (Action Aid, 2003).

The precise implications of the Doha agenda for liberalisation of dairy trade are difficult to predict. However, the agriculture negotiations have affirmed a commitment to make substantial progress on three fronts, substantially improving market access, reducing and phasing out export subsidies, and reducing trade distorting domestic support. Since dairy products remain among the most supported and protected commodities, it seems certain that the Doha agenda will seek significant liberalisation of dairy trade.

6.2.5 Expected Impact of Liberalisation on Patterns of Production, Consumption and Trade

Different studies have used a range of different modelling approaches to predict the impacts of trade liberalisation in the dairy sector. The different assumptions employed have meant that there are some variations in forecasts between studies. However, different studies are consistent in predicting the following effects of world trade liberalisation:

- A significant increase in the world price of dairy products;
- A significant shift in the balance of trade, with Argentina, Australia and New Zealand increasing production and capturing a greater share of world exports;
- Significant reductions in prices in areas where they are currently most supported (the EU, US, Canada and Japan);
- Minor changes in overall world production of milk;
- Limited effects on the majority of developing countries, most of which produce mainly for domestic markets;
- Varying predictions about impacts on overall production in the EU and North America, with some studies predicting little change and others forecasting significant falls in output. Some studies predict production growth in the EU, coupled with a shift in production to more efficient regions as the effects of quota removal outweigh those of declining prices.

The above impacts refer to the net effects of trade liberalisation, being based on studies that model the impacts of policy scenarios relative to baseline. These effects need to be viewed in the context of changing supply and demand conditions, which include steady growth in world supply and demand, especially in developing countries.

In forecasting production changes, most studies do not distinguish between the effects of changes in the land area devoted to dairy production, changes in stocking rates and changes in yields per cow. Available evidence suggests that production increases are likely to involve a combination of land use change and increases in yield, continuing trends observed in recent years in Australia and New Zealand. In those countries where production decreases, it is likely that some land will leave dairy production, while some studies suggest that dairy farms in some regions will reduce inputs in order to cut production costs.

Studies modelling the impacts of dairy trade liberalisation are summarised as follows.

An OECD (2004) study used the AgLink partial equilibrium dynamic supply-demand model to predict the effects of total liberalisation by different regions. The model predicted that multilateral dairy liberalisation would increase world prices for butter (+57 per cent), cheese (+35 per cent), WMP (+17 per cent) and SMP (+21.5 per cent). World production of milk would be broadly unchanged (-0.2 per cent), but there would be an increase in countries that do not currently support dairy prices and a reduction in those that do. Trade in WMP (exported by OECD countries) would decline by 3 per cent, while trade in cheese would increase by 25 per cent, as a result of lower prices in OECD countries, the main consumers.

The OECD study predicted that unilateral reform by the EU could reduce internal prices by 16.5 per cent compared to the baseline (which builds in current reform proposals), while a multilateral global reform scenario would reduce EU internal prices by 10 per cent. EU milk production would decline by between 7.3 per cent (multilateral reform) and 10.7 per cent (unilateral reform). The multilateral scenario would cut production in Canada (-0.8 per cent), the US (-4.6 per cent) and Japan (-20 per cent). It would increase producer prices by about 25 per cent in Australia, New Zealand and Argentina (which do not support prices) and raise production by 14 per cent in Australia, 10 per cent in New Zealand, 14 per cent in Argentina, 10 per cent in Brazil and 3 per cent in the rest of the world. Consumption would decline in these countries, as a result of higher prices.

Cox and Zhu (2004) used the University of Wisconsin-Madison World Dairy Model, a spatial equilibrium model, to predict the effects of different dairy liberalisation scenarios. A full liberalisation scenario, involving removal of all trade distorting measures and domestic supports, was expected to increase world milk production by 1.1 per cent, despite an overall reduction of 8 per cent in average world milk prices. Prices in developing countries increase by 3 per cent and those in developed countries fall by 21 per cent. World trade increases by 43 per cent, with the effects of domestic deregulation (especially quota removal) reinforcing reductions in trade barriers. Milk production increases in the EU (+8 per cent, as a result of restructuring and quota removal) but declines in the rest of western Europe (-12 per cent), Japan (-23 per cent), the US (-7 per cent) and Canada (-4 per cent). Increases in production occur in New Zealand (+7 per cent), Australia (+5 per cent), and potentially competitive exporting developing countries (Argentina, Uruguay and Chile, China, Mongolia, India, S Africa and Eastern Europe, +3 per cent), while there is no change in net importing developing countries. Changes under scenarios involving either trade liberalisation or removal of domestic supports only led to slightly less pronounced effects on patterns of production and trade. The study noted the importance of domestic market growth – driven by population, GDP growth and changing patterns of consumption – in influencing the dairy sectors in developing countries.

FAPRI (2002), using a partial equilibrium dynamic model, estimated that full liberalisation would increase net trade in all dairy products (butter, cheese, SMP, WMP). Argentina, Australia and New Zealand would increase market share while EU market share would decline compared to the baseline. CAP reform would reduce EU domestic prices and cut production of milk, butter and SMP, while increasing consumption of dairy products. EU butter and SMP exports would fall significantly. The model forecast increases in world butter prices (+40 per cent), cheese prices (+22 per cent), SMP prices (+30 per cent) and WMP prices (+26 per cent).

Using a hedonic spatial equilibrium mode, Zhu et al (1998) predicted that full trade liberalisation would cut milk prices in Japan (-36 per cent), Canada (-32 per cent), and the EU (-26 per cent), while increasing them in Australia (+22 per cent) and New Zealand (+51 per cent). Prices would be almost unchanged in the US. The study predicted moderate increases in milk production in the EU and Canada, with the removal of quota offsetting price changes.

Lariviere and Meilke (1998) used a non-spatial, multi-region model of the world dairy sector to predict substantial increases in the world price of dairy products under free trade, including butter (+32 per cent), cheese (+44 per cent) and SMP (+15 per cent). They also predicted increases in world production and consumption of milk (+0.8 per cent), butter (+0.3 per cent) and SMP (+2.3 per cent), but a decline in cheese production (-0.6 per cent). In Canada, a milk price reduction of 36 per cent but an increase in supply of 6.9 per cent was predicted.

Shaw and Love (2001) used a derivative of the OECD's Aglink model to estimate the impacts of increasing market access and reducing export subsidies for dairy products. They predicted that an increased market access scenario would increase trade by USD1.8 billion, with 7-9 per cent increases in production occurring in Argentina, Australia and New Zealand, and decreases of 1.2 per cent in the EU and 1.4 per cent in the US. Fifty per cent cuts in export subsidies in the EU and US were forecast to reduce the value of milk output in the EU by 5 per cent, and to increase it by 8 per cent in Australia, 11 per cent in New Zealand and 18 per cent in Argentina, with no change in the value of US production.

Using a partial equilibrium dynamic model, Langley et al (2003) predicted that full liberalisation would increase milk prices in Australia (+26 per cent), New Zealand (+24 per cent) and Argentina (+22 per cent), while they would decrease in Canada (-35 per cent), the EU15 (-8 per cent), the US (-8 per cent) and Japan (-8 per cent). World prices were forecast to increase for butter (+58 per cent), cheese (+30 per cent), WMP (+18 per cent) and SMP (+9 per cent). The model predicted a decrease in volumes of trade of butter, SMP and WMP but an increase for cheese and other dairy products, while the higher price of all products would enhance the overall value of the dairy trade by US$2bn. In the medium term, a 3-4 per cent reduction in production of milk was predicted in heavily subsidised countries like the EU, with a 12 per cent increase in production in Canada.

Poonyth and Sharma (2003) used the Agricultural Trade Policy Simulation Model (ATPSM) to model the effects on different commodities of three scenarios involving various partial reductions in tariffs, domestic support and export subsidies. These predicted an increase in the world price of fresh milk (4.4 per cent to 10.3 per cent), concentrated milk (7.0 per cent to 18.1 per cent), butter (10.6 per cent to 24.3 per cent) and cheese (7.3 per cent to 16.0 per cent). The lowest increase (the so called EU proposal) involved a 36 per cent average cut in tariffs, no changes to tariff rate quotas (TRQs), duty and quota free access for LDCs, a 55 per cent cut in amber box support and a 45 per cent reduction in export subsidies. The highest impact occurred under the so-called US package involving elimination of export subsidies, a reduction of all tariffs to below 25 per cent, a 20 per cent expansion in TRQ volume, and a reduction in domestic support to below 5 per cent of the value of agricultural production. The effect on trade balances for butter would be a decline of between $277m and $616m for developed countries, an increase of $270m to $606m for developing countries and only very minor impacts on LDCs. For cheese, trade balances would decline by $420m-$814m in developed countries and increase by $441m-850m in developing countries.

Saunders and Cagatay (2004) used a partial equilibrium model of the international dairy trade to predict the impacts of liberalisation on the environment. The study modelled three scenarios, involving no liberalisation, full unilateral liberalisation by the EU, and full liberalisation by OECD countries. Under the EU liberalisation scenario, a 20 per cent price drop for raw milk is predicted in the EU and a significant increase in all other main producer countries, resulting in a 7 per cent decrease in EU output of raw milk, with modest increases in Australia (+4 per cent), Japan (+3 per cent) and the US (+5 per cent) and little change in New Zealand. Under the OECD liberalisation scenario, the model forecast price falls for raw milk in the EU (-10 per cent), Japan (-8 per cent) and the US (-2 per cent), and 11 per cent increases in Australia and New Zealand. Production falls in the EU (-3 per cent), Japan (-8 per cent) and the US (-2.5 per cent) and increases in Australia (+4 per cent) and New Zealand (-3 per cent). The OECD liberalisation scenario results in a significant worsening of the net trade balance for all dairy products in the EU, Japan, and the US, while there is a significant increase in net exports by both Australia and New Zealand.

The study went on to consider the environmental effects of liberalisation by modelling changes in resource use and groundwater nitrate levels. In general, liberalisation is expected to result in some intensification of production in Australia and New Zealand, accompanied by extensification in the EU and to a lesser extent the US. Under the EU liberalisation scenario, there is a significant decrease in input use in the EU, with concentrate and nitrogen use declining by 20 per cent and 28 per cent respectively. There is some intensification in Australia and the US, with nitrogen and concentrate use rising by 6-7 per cent and 3-4 per cent respectively. In New Zealand, there is only a marginal rise in nitrogen use and concentrate use is predicted to fall. Under the OECD liberalisation scenario, the fall in nitrogen and concentrate use in the EU is less marked (at 11 per cent and 18 per cent respectively). Similar increases in nitrogen and concentrate use occur in Australia as under the EU liberalisation scenario. In the US, there is a marginal change in nitrogen use and a fall in concentrate use, while in New Zealand, nitrogen use rises by 9 per cent while concentrate use declines slightly.

In overall terms, there is a slight decline in global nitrogen and concentrate use in the EU liberalisation scenario, while in the OECD liberalisation scenario, nitrogen use rises marginally while feed use declines. This reflects a shift away from feed based systems common in parts of the EU and US, and towards grass based systems typical of New Zealand. Under both EU and OECD liberalisation scenarios, nitrate concentrations in groundwater increase slightly in Australia and New Zealand, and decrease slightly in the EU. The USA experiences a rise under EU liberalisation, but only marginal changes under OECD liberalisation. However, none of these changes is particularly dramatic.

6.3 Environmental impacts

Milk production has varying impacts worldwide depending on the system being used, and the features of the local environment. Figure 6-1 summarises the links between milk production and the environment. What is clear in all countries where dairy production is a major part of agricultural practice is that it has impacts on all parts of the rural and wider landscape. Life-cycle assessments of the dairy sector have consistently found that production at the farm level has the most significant impact of all the production stages (Berlin, 2002). The most significant environmental impacts from dairy production on a global scale are generally agreed as water and air pollution, although other effects may be significant locally (OECD, 2004).

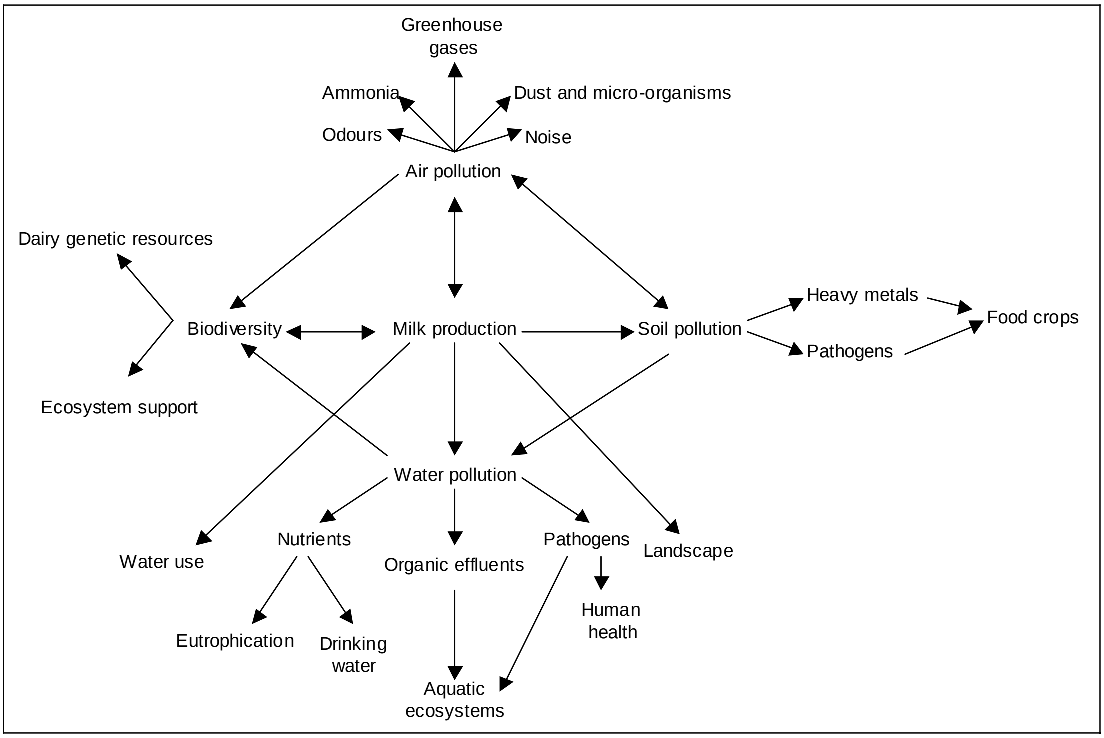

Figure 6-1: Links between milk production and the environment (based on diagram from OECD – Agriculture, Trade and the Environment)

Some recent changes in domestic support policies have been implemented or proposed, in part driven by the WTO Uruguay Round Agreement on Agriculture and/or the current round of WTO negotiations. These have included deregulation of the Australian dairy industry in 2000, introduction of new dairy legislation in the USA, and reduction of supports for dairy under the CAP reforms in the EU.

This level of trade liberalisation has already started to have effects in some countries where production levels have changed due to better profitability and market access. The effects that have been observed to date are discussed below in relation to various areas of impact. It should be noted that these effects are not solely due to trade liberalisation. However, trade patterns and increased/decreased profitability are certainly changing the production locations and scales in many countries, including the EU, USA, India, Australia and New Zealand, and are at least a contributing factor to the observed changes in production.

6.3.1 Land use/landscape

The trend in dairy farming worldwide is towards larger farms with higher herd sizes and higher pasture sizes. This has changed landscapes in Australia and New Zealand where large dairy herds have replaced traditional use of land for sheep farming. In the USA, reductions in dairy farming in the Northeast have led to increased forest cover in some areas (OECD, 2004). In the EU, both polyculture landscapes involving dairy and large tracts of open countryside that have been shaped by dairy farming systems are considered of importance (OECD, 2004).

In Europe, grassland maintained by dairy cattle may be valued for botanical interest or as habitats for breeding and migratory birds. On such High Nature Value (HNV) farmland, abandonment (e.g. as small dairy farms cease to be economically viable) may lead to significant losses of biodiversity, because the characteristic species depend on low inputs of fertilisers and grazing or mowing.

Dairy systems in Europe, especially those in mountain areas, may also be important for tourism as they maintain an open landscape, and protect human settlements from natural hazards such as avalanches and mudslides. Increased stocking rates, heavier animals and greater fertiliser use have led to problems in these areas, but generally abandonment is considered to be a greater problem (OECD, 2004).

6.3.2 Soil

Damage to soil quality from dairy production can occur from heavy metals present in manure, particularly copper and zinc which are added to concentrate feeds. Soils on which manure is applied can accumulate heavy metals, impairing soil function and contaminating crops, and leading to possible human health impacts.

Overgrazing of pasture by dairy cows can result in the removal of vegetation cover beyond the level needed for protecting soil – this exacerbates soil erosion and reduces soil fertility. In irrigated and high rainfall dairy districts of Australia, water logging and deteriorating soil structure are common problems.

6.3.3 Water quality and supply

Milk production involves both direct and indirect use of water. It is estimated that cows need to drink approximately 0.9 litres of water for every litre of milk they produce (OECD, 2004). Indirect use relates to the water used in forage production, whether pasture or forage crops.

6.3.3.1 Water use

In Australia and New Zealand, water use in dairy production has become a major issue as the result of increased production and the expansion of the sector in water-scarce areas. Irrigation is estimated to account for about 40 per cent of Australia's dairy production, with the total area under irrigation increasing by about 4.5 per cent per annum (OECD, 2004).

6.3.3.2 Water quality

Increased levels of dairy farming have also led to major issues with water quality, worldwide. Runoffs from dairy sheds (where manure is essentially hosed off the sheds and into drains leading directly to waterways without treatment), impacts of dairy cows with direct access to lakes, rivers and streams, and drainage of dairy cow urine directly into waterways from fields have all caused problems. The primary impact is via the pollution of groundwater with nitrates and pesticides and eutrophication of surface water. For example, the guide level of nitrate concentration is exceeded in the groundwater under 85 per cent of the EU's farmland (CEAS & EFNCP, 2000). Nutrients in surface water and groundwater can impair drinking water quality and increase purification costs, and in high enough concentrations lead to human health problems.

In New Zealand, the Ministry for the Environment and the leading dairy production company (Fonterra) have signed a voluntary code of conduct called the 'Dairying and Clean Stream Accord'. The Accord specifies targets to keep dairy cattle out of streams, lakes and wetlands, to treat farm effluent, and to manage the use of fertilisers and other nutrients. Despite the Accord, several water bodies in New Zealand have been subject to severe eutrophication, at least in part due to inputs from surrounding dairy farms. Rules relating to fencing of waterways have proved difficult and costly to enforce, however, some farmers have taken up the challenge of riparian restoration with vigour and the Ministry for the Environment has provided some funding to encourage this work.

In the EU, the Nitrates Directive (91/676/EEC) has been adopted, with the aim of reducing water pollution caused or induced by nitrates from agricultural sources and preventing further such pollution. The Directive promotes codes of good practice including some measures that are relevant to dairy farming, and many with wider application.

In the United Kingdom, dairy cattle were responsible for 700 water pollution incidents in 1998 where source was classified, representing almost one-third of all serious incidents of water pollution from agriculture. Similarly, one-third of water pollution complaints regarding livestock production in Japan in 1997 were caused by dairy farms (OECD 2004).

Another source of water pollution concerns pathogens in dairy manure (e.g. bacterial, parasites, and medicines) that can be transmitted in waterways directly from faecal discharges and leaking manure stores, and from field application of manure. These pathogens can damage fish and shellfish in aquatic ecosystems, and cause human health problems through impairing drinking water quality. Little is currently known about the fate, transport and overall potential human health and environmental effects that may occur from complex mixtures of pathogens released from livestock manure, although considerable research is now underway in this area. A study in the United States found that 9 per cent of farm-associated streams were cryptosporidium positive, with the frequency of manure spreading being the key influencing factor (Sischo et al, 2000).

6.3.4 Resource use/waste

Intensification of dairying leads to greater resource use. Modern dairy systems have high inputs, including high rates of fertiliser application and a need for larger areas of land to be devoted to growing forage crops. The growth of these crops leads to further loss of pastoral diversity, and raised pesticide and fertiliser inputs which lead in turn to problems with water, soil and air quality.

There has been a widespread trend in Europe towards ploughing permanent pasture in order to grow maize for dairy cattle, since maize produces more biomass over a given period of time. Maize is generally grown with much higher use of pesticides than grass and it exposes bare soil for a considerable part of the year, leading to higher rates of soil erosion.

Disposal of dairy wastes is considered in the sections on water and soil quality.

6.3.5 Biodiversity

Dairy farming has two links to biodiversity – genetics of the cattle breeds involved, and diversity of the ecosystems in which it operates. With regard to the first of these, the Holstein breed dominates dairy production, and intensive sire selection is leading to high inbreeding rates in this breed.

Globally there are 1,479 recorded farm cattle breeds, of which 255 have become extinct over the last 100 years. Pressures to intensify production may lead to more farmers adopting the Holstein breed in preference to other local/rare breeds, and this may be part of the reason for loss of breeds over the last 100 years.

Within agricultural systems, changes occur when the spatial patterns created by traditional production systems are replaced by the simpler patterns of intensive grazing with introduced species and silage cutting. In general, species richness decreases where grazing is intensified. Growing of some forage crops, such as maize, can be detrimental to bird populations due to the manner in which they are harvested.

In countries such as the USA, Australia, New Zealand and Brazil where cattle farming has involved a recent conversion of natural landscapes to dairy farmland, this usually has a devastating effect on native biodiversity, and creates habitats that remain suitable only for introduced species. Grazing of dairy cattle in remaining native forests can lead to damage such as collapse of forest structure and removal of habitat for forest birds (Environment Waikato, undated).

The role of dairy cattle with regard to maintaining healthy European biodiversity is probably slightly less important than the role of beef cattle and sheep, however, mountain dairy farming in countries like Austria, Italy, France and Switzerland can play a role in preserving alpine plant communities, and abandonment of such farms due to lack of market for dairy products can lead to biodiversity loss. Open grassland also plays an important role for farmland birds and migratory waterfowl, although this landscape can be provided by farming systems other than dairy.

6.3.6 Air quality

Apart from the greenhouse gas emissions (discussed below) the main source of air pollution from dairy production is ammonia. This is abundant in dairy manure. Levels of release of ammonia will depend on the concentration of dairy cows and the weather conditions in a particular season. Ammonia tends to be deposited in the area surrounding the dairy operation and can be harmful to ecosystems through acidification.

Dairy housing units also generate dust, micro-organisms and odours. Variations in ventilation and feeding practices lead to different emission rates for these. Rural area encroachment (due to urban spread) along with increasing intensification of dairying (leading to increasing use of indoor housing for cows) is leading to increasing emission rates, and increasing conflicts in relation to these emissions.

6.3.7 Climate change/greenhouse gas emissions

Since 1990, there has been a decline in overall greenhouse gas emissions arising from dairy production in many countries (e.g. Czech Republic, Germany, Canada) due to reductions in animal numbers. By contrast, emissions from dairy have risen in countries such as Australia and New Zealand where herd sizes have increased. Greenhouse gas emissions from dairy farming generally represent only 1-2 per cent of total net emissions in most countries. The exception is New Zealand, where contributions from milk production contribute more than 20 per cent of overall greenhouse gas emissions[2]. As a share of agricultural emissions, dairy is more significant (e.g. 48.5 per cent of agricultural emissions in the UK arose from dairy systems from 1998-2001) (OECD 2004).

The main greenhouse gases (GHG) from dairy production are methane and nitrous-oxide. Methane production from enteric fermentation is the most significant source of dairy GHG emissions in all OECD countries, accounting for between 50 per cent (USA) and 80 per cent (Australia) of the total (OECD, 2004).

In recent decades, total GHG emissions per cow have increased due to the increased feeding requirements of the larger cows that are now commonly used for dairying, leading to greater quantities of methane emitted from enteric fermentation and greater quantities of nitrogen excreted in manure (OECD 2004).

Nitrous oxide is also emitted during the dairy production process, from stored manure and from manure spread on soils. Carbon dioxide is emitted by the machinery used in dairy production – e.g. tractors, heating/ventilation systems in housing units and dairy milking machines. Carbon dioxide emissions are also produced when dairy products are shipped worldwide in global trade.

In contrast to many of the other environmental impacts discussed, extensive systems perform worse than intensive ones in terms of methane emissions. Ruminants fed on fibrous diets associated with extensive farming systems have a higher output of methane emissions from enteric fermentation than those in more intensively managed systems that use feed supplements (OECD 2004).

6.3.8 Plant and animal health

As a rule, intensive production means larger herd sizes. This means that the available time from the owner or worker for inspection and attention is less per cow. As the operation becomes more efficient the average life span of cows in the herd drops, because cows are more likely to be culled and replaced by higher producing animals.

Specific concerns have arisen in relation to the welfare of animals that are housed in tied and free stalls, and in relation to the selective breeding for high milk production that has been linked to increased rates of lameness in Holstein cattle. In some countries (e.g. USA), producers can use hormonal injections to stimulate increased milk production in their dairy herds (USEPA, undated). This practice has led to

[2] It should be noted that on a global scale, New Zealand does not have a high level of greenhouse gas emissions, and thus, reducing its dairy-related emissions would not make a significant contribution to global goals related to climate change.

concerns from animal welfare groups, who have also raised questions about the welfare of calves that are sold to veal producers as a by-product of dairy production.

6.3.9 Distributional impacts

Due to the requirements of fertile soils, space and flat land for intensive dairying, the trend worldwide is for dairy production to become concentrated in certain areas. In Europe, for example, about half of the EU’s milk production was from just 10 regions in the mid-1990s, of which the most important were the 8 regions of Austria, Lower Normandy, Brittany, the Netherlands, Lower Saxony, Denmark, Ireland and west England. In addition, worldwide trends in dairy production related to price for products has seen dairy production increase in a few countries while remaining stable in others. The countries that have seen the biggest increase in dairy cow numbers recently are Australia and New Zealand.

In New Zealand the dairy industry has been localised in certain areas where flat and fertile land provides a good base for pasture production. The majority of dairy farms are found in only a few provinces. This concentration of farms has put immense pressure on local waterways, leading to diminished water quality and also effects on flow rates due to irrigation demands from farmers.

In Brazil, dairy development has been marked by a shift from non-specialized farms where milk was almost a by-product, to specialized and vertically-integrated dairy production. The transition was spurred by price liberalisation in 1991, after decades of cooperative dairy marketing under tight government regulation. Since the mid-1990s, private processors have enforced the adoption of on-farm chilling and other technologies that have made continued participation by small producers infeasible. Small dairy farming has traditionally been located in the south of Brazil in states such as Santa Catarina; in 1996, only 28 per cent of farms in the south had more than 70 cows, up from 18 per cent in 1985. The growth area has been in the Centre-West, in settlement areas of states such as Goias, home to new and large farms. In 1996, 81 per cent of farms in the Centre-West had more than 70 cows, up from 69 per cent in 1985 (Delgado et al, 2003).

6.4 Analysis of impacts of current/forecast liberalisation proposals for dairy

Medium term forecasts indicate that world supply and demand for dairy products will continue to expand at a moderate rate. Output growth will increasingly be located in regions with rising demand for milk and milk products, continuing a trend evidenced in the 1990s. As a result, the proportion of world milk production originating in the developing countries is projected to increase. While some developing countries are projected to become more active in export markets, the developing countries as a whole will probably remain substantial net importers of dairy products.

The expected effects of trade liberalisation on patterns of production and trade can be identified with reference to the modelling studies summarised in the previous section. In general, these studies predict that the net effect of liberalisation will be to shift milk production away from high-cost (e.g. the EU, Western Europe, USA, Japan, Canada and Mexico) and towards low-cost producing countries (Australia, New Zealand and Argentina).

The environmental impacts of these changes will vary. Continued economic growth will mean that the global trend towards intensification of production will continue, and this will exacerbate some of the environmental effects discussed above (e.g. water use, water quality, air quality, resource use) in those countries where levels of production are predicted to increase. By contrast increased intensification may reduce the levels of greenhouse gas emissions being produced by the dairy industry. The expected shift in production may ease some of the environmental problems associated with intensive dairy farming in the Northern Hemisphere, but increase impacts in the exporting countries of the Southern Hemisphere.

In New Zealand, Australia, Argentina and Brazil, it is likely that an increased amount of land currently used for other agricultural purposes (e.g. sheep farming) will be converted for use in the dairy industry. Increasing the land devoted to dairy farming may also involve conversion of semi-natural habitats, including grassland, scrubland and forested habitats, with resulting impacts on biodiversity and landscape.

In general, the shift in production to the most competitive regions is likely to lead to increased specialisation and simplification of farming systems, leading to loss of mixed farming and countryside diversity. This may result in negative impacts on both biodiversity and landscape.

In the countries where production levels are likely to reduce, issues of land abandonment and infrastructure disposal may emerge. Many former dairy producers in the high-cost countries may switch to beef production if this is still viable. In this case, there will be only minor environmental impact. In relation to biodiversity, conservation of rare breeds may need to be addressed. In areas where beef and sheep production also struggles to compete in a free world market, the risk of land abandonment could have significant negative consequences for landscape and biodiversity, especially in marginal and high natural value farming systems.

In some developing countries, a switch from being largely importing industries to a situation where domestic production is satisfying domestic needs may lead to enforcement of stricter hygiene and other industrial requirements – this may lead to small producers ceasing operation as recorded in Argentina and Poland when large processing companies began operation.

Demand for milk products is predicted to increase in developing countries (in response to increased incomes and changes in diet), and there has already been a significant increase in production in these countries since 1990. Trade models seem to indicate that there will be consumer gains in developing countries if world trade in dairy products is liberalised. The dairy industry in many developing countries is currently made up of small extensive producers, and there is no immediate prediction that this will change in response to trade liberalisation.

Even after full implementation of currently proposed liberalisation scenarios, world dairy trade will continue to feature government intervention, tariffs, and limits on market access. This means that the full extent of the environmental impacts of liberalisation will not be observed in the short term, and are likely to take a decade or more to occur.

The mid-term review of the EU's CAP is not expected to have a substantial effect on global production patterns, as it will make only partial progress in liberalising the EU's trade in dairy products. However, if and when the CAP dairy regime is fully liberalised, it is likely that most marginal producers will cease to operate. These may be low-income small farmers in some areas, and in others, operators with high overheads. Switching by some of these producers into the beef industry, if viable, could in turn lead to downstream effects on small beef producers whose activities may have environmental benefits.

In summary, therefore, the principal environmental issues expected to arise from liberalisation are as follows:

- further intensification of dairy farming in Australia, New Zealand and South America, exerting a range of environmental impacts through air and water pollution, waste management and water abstraction;
- the cessation of marginal dairy farming activities in some parts of the Northern Hemisphere, leading to conversion to beef and sheep systems and/or a risk of overall abandonment, but also reduced nitrogen shedding and improvements in water quality; and
- potential biodiversity and landscape impacts resulting from expansion of dairy farming in Australia, New Zealand, Argentina and Brazil, at the expense of either semi-natural habitats and/or more extensive beef and sheep systems.

These changes are likely to take place mostly over the medium term (5-10 years), given that current reform proposals are not expected to have a major impact. While the impact of liberalisation could be significant, it is expected largely to continue current trends in world dairy markets rather than resulting in a sudden shift in production and trade patterns.

6.5 Analysis of potential flanking measures

As discussed above, the expected impacts of trade liberalisation in the dairy sector are varied, complex, and often difficult to predict. However, we consider the most likely key impacts overall to be those that are listed at the end of section 5.4 above. On a global environmental level, the key impact of the dairy industry is on water supplies through nitrification. Liberalisation is expected to have negative effects in this area in those countries where production will intensify or increase (e.g. Australia and New Zealand), and generally positive effects where production is predicted to decrease (e.g. USA, and parts of Europe).

Table 6-5 below summarises the main impacts of liberalised trade in dairy products in and outside Europe, and suggests flanking measures to deal with negative impacts where appropriate.

The priority for UK action would appear to be the development of market based measures, including a programme to raise awareness of domestic consumers of the different environmental impacts of dairy systems worldwide, and the development of appropriate certification and labelling schemes. There would be merits in the government working in partnership with major food processors and retailers on this issue.

6.6 Conclusions

In this sector, we have had to base judgements on environmental impacts on information which is highly incomplete. Liberalisation is one of a number of factors which will lead to a relocation of production within and between countries, potentially on a large scale. There will be accompanying changes in farm management. There is not sufficient information to be able to forecast exactly where production will move or how management will change and to some degree this must remain a matter of speculation, even if more detailed and reliable models were available.

Taking the global picture and bearing in mind the main sources of production now and in the future, the most important environmental issue related to changes in dairy production appears to be the risk of water pollution. This is an issue primarily of local concern and one that is likely to be most effectively dealt with through regulatory and other approaches at the national level, especially in countries outside Europe where production is expected to increase. Consequently, the scope for the EU or the UK to influence the problem directly through unilateral flanking measures is limited. Alongside this one can identify issues which seem likely to arise at a local or regional level, some of which may be of particular concern in certain areas (e.g. possible abandonment of high nature value farmland, particularly in parts of Central and Western Europe). While the latter is of concern in the EU, it can, in principle, be dealt with by existing policy measures such as agri-environment schemes and national envelopes. In practice this may require careful targeting as take up by dairy farms of agri-environment schemes is often limited.

6.7 Further Research Needs

We have been able to identify some of the key environmental pressures and benefits arising from dairy production but cannot specify exactly how these will arise at each of the main countries affected by liberalisation. It would be particularly helpful to have more research on certain questions e.g.:

- the expected effects of trade liberalisation on dairy production in non-OECD countries such as Russia and India;
- more information on the specific role of the dairy industry in contributing to environmental problems such as water and air pollution;
- more analysis of farm management changes following the cessation of dairy production in Europe and elsewhere; and
- more analysis of the implementation and effectiveness of existing measures to control the environmental impact of dairying in different countries.

Table 6-5: Summary of impacts of liberalised trade in dairy products, and potential flanking measures. Key impacts in bold.

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
Land use/landscape	May be local issues e.g. possible abandonment of farms in Poland and other countries.	Can already be addressed through National Envelopes and rural development measures under the CAP. No new measures needed.	No significant negative issues noted, but reliable information sparse.	Best addressed through local regulation - no new measures needed.
Soil	Some local issues related to overgrazing, and contamination of soil through feeds. Impacts may be mitigated by reduced production.	Contamination already addressed through current residue limits. Overgrazing issues can only be addressed at farm-by-farm level.	Issues as for Europe.	Best addressed through local regulation - no new measures needed.
Water quality and supply	**Guide level of nitrate concentration is already exceeded in 85 per cent of the EU's farmland. Levels of nitrogen shedding are predicted to fall if trade is liberalised and overall herd sizes are reduced, although there may be regional concentration of effects.** Impacts may be mitigated by expected reduced production.	**Nitrates Directive already in place, potentially reinforced by cross-compliance. The UK should encourage uptake of Codes of Conduct in its own territory and elsewhere in Europe. Effective implementation of the Water Framework Directive in the EU would address most issues in the dairy producing regions.**	**Contamination of water bodies is a significant issue in most producing countries.**	**This issue is already being addressed through voluntary codes and local body regulations in many countries, although information is incomplete. It does not seem appropriate for the UK to seek regulatory flanking measures to address this issue – but it would be appropriate to encourage good practice and sharing of information between producer states.** **Requiring evidence of environmental standards in production (labelling) could encourage domestic measures to be established in major exporting countries.**
Resource use/waste	Intensification is the global trend, leading to greater	Already addressed to some extent through CAP, cross-	Issues as for Europe.	Best addressed through local regulation - no new measures

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
	pressure on many natural resources, but trade effects may offset this.	compliance and rural development measures. No further specific measures needed.		needed.
Biodiversity	Intensification may lead to concerns about preservation of rare cattle breeds/races and maintenance of HNV farmland systems	Both can be addressed through well-targeted agri-environment measures to a large degree. No new measures needed.	Clearance of natural landscapes to make way for new dairy farms. Potential issue in South America – however, no indication in the literature that extensive clearing has been taking place specifically to make room for dairy. More information needed.	Best addressed locally through regulation and/or incentives - no specific measures needed, but the UK may wish to keep a watching brief on development of the dairy industry in South America and whether this is leading to degrading of biodiversity. Measures such as technical assistance, local capacity building and model projects etc may be relevant.
Air quality	Emissions from feeding units contribute to air pollution.	Local issues, dealt with by local authorities and governments. More enforcement needed.	As in Europe.	Best addressed locally through regulation - no new measures needed.
Climate change/greenhouse gases	GHG emissions are produced in the farming process.	Small percentage of overall emissions – no specific flanking measures needed.	GHG emissions from dairy are far more significant in some countries – e.g. Australia and New Zealand.	Issue is being addressed by governments. Support rather than need for new measures.
Plant and animal health	Intensification leading to less time available per animal and concerns about welfare.	Rules on animal welfare are already in place in the EU. No new measures required following liberalisation.	Welfare issues may be more significant in developing countries where standards and enforcement are not as advanced. More information needed.	• Requiring evidence of environmental standards in production (labelling) could encourage domestic measures to be established in major exporting countries.

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
Distributional impacts	Certain areas with conditions ideal for dairy farming will have a concentration of this form of farming.	No specific measures needed.	Issues as in Europe.	No specific measures needed.

7 SUGAR

7.1 Brief Overview of the Sugar Sector

For the purposes of this report, considerations about the sugar sector will be limited to sugarcane and sugar beet and the processing of sugar (sucrose) from these two crops. The importance of other sugar crops[3] is marginal, especially in terms of world trade. Approximately 70 per cent of total world sugar production is derived from sugarcane, with the remaining 30 per cent from sugar beet, and the crops are produced in around 130 countries.

Sugarcane

Sugarcane production is concentrated in tropical areas, and beet in regions with a temperate climate. In some regions, e.g. North Africa, Iran, Pakistan and Spain, both crops can be grown (Cheesman, 2005). Systems of cultivation vary significantly between locations, and there are large differences in production methods between smallholders and large-scale growers, especially in the case of sugarcane.

In Brazil, sugarcane is usually grown on large estates operated by sugar mills, while in India, Thailand and Mexico, most cane is produced by smallholders growing only one or two hectares. In Kenya and Swaziland, both large estate production and small farmers are important. Sugar beet is usually grown on private family farms, which can also vary significantly in size and climate conditions.

Sugarcane is a grass plant growing up to five metres high. It usually remains in the same field for 3 to 5 years through ‘ratooning’, i.e. re-growth of the crop from the old root stock after harvesting; this process can be continued for up to 7 years, but yields decline gradually over time. Sugarcane has high irrigation needs, requiring 1,500-3,000 litres of water per kilogram of crop (WWF, 2004b). Sugarcane requires at least 1,500 mm of rainfall or access to irrigation when growing, temperatures over 21 degrees Celsius, strong sunlight, and fertile well-drained soils.

Sugarcane contains about 10 to 15 per cent sucrose, and about 70 per cent water. The average yield per hectare is around 70 tonnes in Brazil and Australia, and around 60 tonnes in India and Thailand.

Sugarcane harvesting commences 10-22 months from the time of planting, and can be done by hand or mechanically. Manual harvest is an important source of rural employment in many developing countries. The cane is cut at ground level, green leaves are taken off and stalks are cut and bundled together for transportation to the sugar mill. Mechanised harvest can only be carried out on relatively flat ground, and the capital and running costs are relatively high. Once harvested, sugarcane has to be processed within 16 hours before it begins to spoil, which demands close coordination of growing, transportation and processing.

Sugarcane is initially processed to raw sugar in locations close to its production area. The next step, refining, often takes place at very distant locations, including the EU. A

[3] Sugar and syrups are also produced from the sap of certain species of maple trees, from sweet sorghum when cultivated explicitly for making syrup and from sugar palm.

by-product of sugarcane processing, bagasse (the fibre remaining after the sugarcane is crushed) is used as a fuel to generate energy for the processing.

Sugar beet

Sugar beet is a biennial root crop, which stores sucrose in its root during its first year of growth. The sugar content in the roots is typically about 17 per cent, well above sugarcane, but the crop has a much lower yield per hectare. Sugar beet is usually grown from seed as a spring crop, in a 3-5 year rotation with other crops to avoid accumulation of pests in the field. It is harvested in late autumn or early winter. Its soil and climate requirements are similar to those of winter wheat, barley and oil seed rape. In Mediterranean climates it can be sown in the autumn. Water requirements are relatively high. Around 20 per cent of the sugar beet in the world is irrigated (WWF, 2004a), e.g. in southern Europe (Greece, Italy, Spain).

Sugar beet roots are harvested in late autumn/early winter, usually with heavy mechanised harvesters. The green leaves cut from the tops of the plants can be left in the field, and in some mixed farming systems these are used as animal feed. The main environmental problem associated with harvesting of sugar beet relates to soil removed from the fields with the crop (called ‘tare’), and transportation of the crop to sugar factories. Both crops have to be cleaned on arrival at the mill, but beet requires thorough washing to remove soil, stones, leaves and other residues. This generates large quantities of wastewater and considerable amounts of waste soil. Sugar beet is processed directly to refined white sugar, usually close to its production area.

Processing of both crops is highly seasonal, with season lengths between 6 and 18 weeks for beet and 20 to 32 weeks for cane (WB Group, 1998). Processing poses high water demands and generates high quantities of effluent.

Both the sugarcane and sugar beet systems are characterised by a very high degree of integration between producers and the processing industry. Crops are grown on contract, which makes them potentially very suitable for developing sustainable production systems.

7.2 Effects of Trade Liberalisation on the sugar sector

7.2.1 Current patterns of Production, Consumption and Trade

According to latest USDA forecasts, world production of raw sugar will total 142 million tonnes in 2004/5. Brazil is the world’s largest producer, accounting for 20 per cent of world production, with the EU supplying 14 per cent, India 10 per cent and China 8 per cent (Table 7-1). By region, Asia and Oceania account for over a third of world production, with South America contributing 25 per cent, Western Europe 14 per cent and North America 10 per cent (Table 7-2).

The USDA forecasts that production will exceed consumption slightly in 2004/5, resulting in a net increase in stocks. South America is a major net exporter of sugar, generating a surplus of more than 19 million tonnes. Asia, Eastern Europe and the Middle East are major net importers. The world’s largest exporting countries are Brazil, Australia and Thailand.

	Beet/ cane	000te	Per cent		Beet/ cane	000te	per cent
Brazil	C	28,370	20.0	Phillipines	C	2,160	1.5
EU	B (+C)	19,684	13.9	Cuba	C	2,000	1.4
India	C	13,590	9.6	Russia	B	2,000	1.4
China	B+C	11,240	7.9	Turkey	B	1,990	1.4
US	B+C	7,718	5.4	Indonesia	C	1,950	1.4
Thailand	C	6,520	4.6	Guatemala	C	1,850	1.3
Mexico	C	5,690	4.0	Argentina	C	1,740	1.2
Australia	C	5,500	3.9	Egypt	B+C	1,410	1.0
Pakistan	C	3,662	2.6	Ukraine	B	1,400	1.0
Colombia	C	2,645	1.9	Other	B+C	18,197	12.8
S Africa	C	2,371	1.7	**World**	**B+C**	**141,687**	**100.0**

Table 7-1: Major Sugar Producers, 2004/5, Raw Value Source: USDA

The FAO estimates that cane production accounts for between 65 per cent and 70 per cent of total sugar output. The EU, US, China, Turkey, Russia and the Ukraine are the main beet producers. The FAO also estimates that developing countries accounted for 67 per cent of overall production in 1998-2000, while developed countries account for some 60 per cent of consumption, and are therefore major net importers.

Region	**Production (000 te)**	Consumption (000 te)	Balance (000 te)
Asia/Oceania	48,045	54,404	-6,359
South America	36,137	16,762	19,375
W Europe	19,918	18,293	1,625
North America	13,518	16,030	-2,512
Africa	7,999	10,682	-2,683
Total M East	4,985	10,221	-5,236
E Europe	4,439	11,067	-6,628
Central America	3,758	1,601	2,157
Caribbean	2,888	1,395	1,493
World	**141,687**	**140,455**	**1,232**

Table 7-2: Sugar Production and Consumption by Region, 2004/5, Raw Value Source: USDA

The USDA forecasts that total sugar exports will amount to 45 million tonnes in 2004/5, some 32 per cent of overall production. Sugar is therefore a relatively highly traded commodity compared to many other agricultural products. Sugar stocks currently stand at around 32 million tonnes, some 22 per cent of sugar output.

Sugar exports are highly significant sources of earnings for some countries. For example, sugar accounts for more than 5 per cent of the value of total exports of the African, Caribbean and Pacific (ACP) countries, and is particularly important for Belize (13 per cent), Fiji (22 per cent), Guyana (21 per cent), Malawi (11 per cent), Mauritius (16 per cent), St. Kitts (18 per cent) and Swaziland (14 per cent) (Ryberg, 2005). In Guyana, sugar accounts for 50 per cent of agricultural production and employs 26,000 people, while it is estimated to support the livelihoods of 20 per cent of the country's population (Huan Niemi, 2003).

7.2.2 Recent Trends in Production, Consumption and Trade

Sugar consumption is increasing steadily, reflecting rising incomes and shifts in food consumption patterns. As a consequence world production increased by 19 per cent from 113 million tonnes in 1991 to 134 million tonnes in 2001 (Table 7-3). Table 7-3 also shows a significant concentration of production among the top 10 producers, which increased their share from 67 per cent to 72 per cent over this period. This is especially due to a major expansion in production in Brazil and India over that decade. Production in India has since fallen dramatically from 22 million tonnes in 2002/3 to 13.6 million tonnes in 2004/5. In Brazil, sugarcane has replaced citrus and pasture areas in the leading producing region of Sao Paulo (USDA, 2003).

However, despite increases in production and consumption, the value of sugar exports declined from $9.8 billion in 1980 to $6.4 billion in 2001, as a result of both lower prices and volumes, as expansion of domestic production has eroded markets for exporters (FAO, 2003).

	1991		**2001**			**1991**		**2001**	
	mte	**per cent**	**Mte**	**per cent**		**mte**	**per cent**	**Mte**	**per cent**
Brazil	9.1	8	20.1	15	Mexico	3.4	3	5.1	4
India	13.0	12	20.0	15	Australia	3.4	3	4.6	3
EU15	18.0	16	18.0	13	Cuba	7.6	7	3.8	3
China	8.4	7	8.6	6	Pakistan	2.2	2	2.7	2
USA	6.7	6	7.4	6	*Top 10*	*76.0*	*67*	*96.2*	*72*
Thailand	4.2	4	6.0	4	**World**	**113.0**	**100**	**134.1**	**100**

Table 7-3: World Sugar Production 1991-2001 Source: EU International Analysis

7.2.3 Effects of Government policy

Sugar markets are heavily distorted by widespread government intervention, with EU and US policies having the greatest effect on world markets. Japan also subsidises its sugar production heavily, though output is on a smaller scale. Levels of subsidy in the EU, US and Japan have increased significantly in recent years as the world sugar price has fallen. Levels of protection and subsidy in the sugar market are high compared to most other agricultural commodities.

A total of 51 Tariff Rate Quotas (TRQs) were notified to the WTO in 1999, by a range of countries including Barbados, Colombia, Costa Rica, El Salvador, EU, Philippines, Guatemala, Hungary, Iceland, Malaysia, Mexico, Morocco, Nicaragua, Slovak Republic, South Africa, Thailand, Tunisia, the US and Venezuela (FAO, undated).

There are 11 export subsidy commitments by WTO member countries, with nine countries committed to reducing export subsidy levels. The largest commitments to reductions have been made by the EU, Mexico, Brazil and South Africa.

State trading enterprises are in operation in several countries, mainly to regulate exports (e.g. Australia) or to monitor internal and external prices and trade (e.g. China and India).

The US sugar programme provides market price support through a system of loan price guarantees to beet processors and cane millers. The program uses a system of TRQs to restrict sugar imports. WTO rules require the US to allow a minimum of 1.2 million tonnes of sugar imports to enter its market. Foreign sugar (including imports from Mexico under the NAFTA agreement) enters under two TRQs – one for raw cane and another for a small quantity of refined (including beet) sugar. The US offers preferential tariff treatment to a variety of countries under a range of trade agreements.

In the EU, sugar is one of the most heavily subsidised commodities. The EU sugar regime supports prices above world market levels, with prices guaranteed by an intervention purchase system. Production quotas are used to limit the quantity of production eligible for support, with export subsidies used to dispose of surpluses on world markets. The EU also allows preferential imports of sugar from the ACP countries. Under the 'Everything but Arms' agreement, the EU is liberalising trade with the least developed countries, which are to enjoy tariff free access to EU markets by 2009. The EU has come under further pressure to reform its sugar regime following a 2004 WTO ruling that found that it was in contravention of WTO export subsidy rules. The ruling referred to unsubsidised exports of sugar (so called 'non-quota' or 'C' sugar), which were ruled to be subject to cross-subsidies from quota sugar, and the subsidised re-export of ACP sugar.

The European Commission announced proposals for reform of the EU sugar regime in July 2004. These proposals include replacing the intervention price with a reference price, which will then be reduced by one-third, reducing the production quota, and introducing direct and decoupled income supports for sugar producers.

Japan also supports sugar prices at very high levels, restricting market access through high import levels and surcharges, and monopoly buying and selling by a government agency.

In Brazil, government support for ethanol production has been a major factor influencing the sugar market. Sugar and ethanol are substitutes, and there has been a surge in sugar production and exports following the phasing out of support for ethanol in the 1990s.

7.2.4 Scope and Agenda for Further Liberalisation

The Uruguay round made some progress in liberalising world trade in sugar, through reductions in export subsidies and tariffs, but sugar remains one of the most highly protected globally traded goods.

While the proposed EU reforms will go some way to reduce the trade distorting impacts of the EU sugar regime, they are seen by many as not going far enough, as prices will remain significantly above the world market price. Oxfam (2004) points out that even after the proposed reforms the EU regime will still have detrimental impacts on producers in developing countries. There is considerable scope for further liberalisation by the EU, US and other sugar producing countries.

The precise implications of the Doha agenda for liberalisation of trade in sugar are difficult to predict. However, the agriculture negotiations have affirmed a commitment to make substantial progress on three fronts, substantially improving market access, reducing and phasing out export subsidies, and reducing trade distorting domestic support. Since sugar remains one of the most protected commodities, it seems certain that the Doha agenda will seek significant liberalisation of sugar trade.

7.2.5 Expected impact on patterns of production, consumption and trade

Further liberalisation of the world sugar market is expected to have the following effects:

- An increase in the world price of sugar, with various studies predicting increases of up to 63 per cent (under full liberalisation).
- Reduced production in the EU, US and Japan.
- Expansion of production in the most efficient sugar producing countries, with the largest increases in Brazil, followed by Thailand, Australia and India.
- A major shift in production away from sugar beet and towards sugarcane production, and away from the developed world and towards the developing world.
- Mixed effects on ACP countries, which will be adversely affected by cuts in EU prices but will benefit from higher world prices. Studies suggest that some ACP countries where costs are high could lose most or all of their sugar production, with significant negative effects for rural economies, at least in the short term.

The above impacts refer to the net effects of trade liberalisation, being based on studies that model the impacts of policy scenarios relative to baseline. These effects need to be viewed in the context of changing supply and demand conditions, which include steady growth in world supply and demand

Though most studies do not forecast how much of the predicted changes in production result from changes in land area devoted to sugar and how much to changes in yield, there is some evidence that significant shifts in land use could result. For example, USDA (2003) points out that Brazil currently uses only a small proportion of the land that is suitable for sugar production. Other studies suggest a complete cessation of sugar growing in relatively high cost countries such as Greece, Ireland and Italy.

The conclusions above are based on a variety of studies.

The Centre for International Economics (CIE) (2002) used the GSM model to predict the effects of reductions in EU, US and Japanese support for sugar. The study predicted the following prices by 2012:

- US$185/te if full protection continues;
- US$215/te if protection is reduced by 50 per cent (a 16 per cent increase); or
- US$310/te if protection is eliminated (a 63 per cent increase).

The study found a non-linear relationship - price effects increase at a faster rate as markets are liberalised further. This is a result of effects on rises in production costs brought about by diminishing returns to land in exporting countries. The results exclude the effects of liberalisation in other countries such as India, Russia, Indonesia and China, which would be additional to those forecast above.

Effects on production from full liberalisation would be as follows:

- All regions except Japan, the US and Western Europe would increase their production due to higher prices;
- There would be significant declines in production in Western Europe (-12 mt), the US (-3mt) and Japan (-0.5mt);
- Even regions benefiting from preferential trade arrangements with the EU and US would expand production, as prices would rise despite the removal of preferences; and
- The greatest increases in production would occur in Brazil (+5.5 mt), Thailand (+2.25mt), Australia (+2mt) and India (+2mt), with smaller increases in the Middle East, other parts of the Americas and Asia, China, Eastern Europe, North Africa and the former Soviet Union.

A contrasting picture of the effect of EU sugar liberalisation on ACP countries was painted by Paul Ryberg, Counsel to the Mauritius Sugar Syndicate, in an address to the International Sweeteners Colloquium in February 2005, who argued that reform to the EU sugar regime would cut prices in some ACP countries to below the costs of production. Ryberg predicted that studies indicate that only a third of the most efficient ACP countries would survive the effects of proposed EU reforms. These would include Swaziland, Zimbabwe, Malawi and Tanzania, while a 37 per cent price cut would lead to a contraction in production in Belize, Congo, Fiji, Guyana and Mauritius, and the loss of sugar growing altogether in Barbados, Cote d'Ivoire, Jamaica, Madagascar, St. Kitts and Nevis, and Trinidad and Tobago, with a combined loss of more than 300,000 jobs. The opportunities for diversification in these countries, many of which have already suffered from difficulties in competing in the banana market, are often limited. Ryberg reported the direct effects of unilateral EU reforms without considering the resultant impact on world sugar prices (or the effects of liberalisation by other producing regions). The ACP countries themselves are also concerned about the effects of the proposed reforms (ACP Sugar, 2004).

The CIE predictions (above) of the impacts of liberalisation on sugar prices are high compared to those of other studies. For example, Diao, Somwaru and Rowe (2001) predicted that full policy liberalisation would increase sugar prices by 16.4 per cent. The effects of global tariff removal would be to increase prices by 10.9 per cent, OECD domestic subsidy removal would enhance prices by 1.6 per cent, while global export subsidy removal would increase them by 3.3 per cent.

Frandsen et al (2001) modelled the impact of a 25 per cent reduction in the EU sugar price using the GTAP model, and predicted an 18-19 per cent decline in EU production, depending on whether or not compensation was offered for the price change. Most of this change was predicted to occur in Greece, Ireland, Italy, Finland and the Netherlands in relation to in land used to grow sugar, rather than variation in production methods. The model predicted an increase in production in all third countries, most notably in Central America and the Caribbean, Brazil and South Asia. Only minor impacts on ACP-countries were predicted, whereas the main sugar producing countries that do not currently enjoy preferential access (Brazil, Thailand, South Asian countries) were predicted to benefit most.

Poonyth and Sharma (2003) used the Agricultural Trade Policy Simulation Model (ATPSM) to model the effects on different commodities of three scenarios involving various partial reductions in tariffs, domestic support and export subsidies. These predicted an increase in the world sugar market price of between 3.3 per cent and 9.2 per cent. The lowest increase (the so called EU proposal) involved a 36 per cent average cut in tariffs, no changes to TRQs, duty and quota free access for Least Developed Countries (LDCs), a 55 per cent cut in amber box support and a 45 per cent reduction in export subsidies. The highest impact occurred under the so-called US package involving elimination of export subsidies, a reduction of all tariffs to below 25 per cent, a 20 per cent expansion in TRQ volume, and a reduction in domestic support to below 5 per cent of the value of agricultural production. The effect on trade balances for sugar would be a decline of between $294m and $703m for developed countries, an increase of $277m to $698m for developing countries and only very minor impacts on LDCs.

A paper by Wohlgenant (1999) used a multi-region, non-spatial equilibrium model of the world sugar market to predict various reform scenarios. The Uruguay round agreement was predicted to increase the world price by 7 per cent. Global trade liberalisation would increase the world price by 43 per cent, with production increasing in many Latin American and Caribbean countries.

Knapp and Talks (2004), in a paper on the expected impacts of current EU reform proposals, predicted that:

- EU production will decline from 20 million to between 16 and 17 million tonnes, with an end to production in higher cost regions of the EU (Greece, Ireland, Italy);
- ACP price cuts of one third will leave some ACP countries unable to compete;
- LDCs are unlikely to become major suppliers to the EU market;
- Least Cost Countries will be best placed to benefit from reduced EU exports of 3-5mt, especially Brazil which is well placed to increase exports by an equivalent amount;
- The effect on the world market price is unclear – reduced EU exports will have a positive effect but this will be at least partly offset by increased exports from low cost producers (which are currently increasing exports even though prices have been falling).

Kerkela and Huan-Niemi (2005) used the multi-region general equilibrium framework (GTAP) to model the effects of a unilateral liberalisation of the EU sugar regime. Four scenarios were modelled:

- Partial liberalisation under the EBA agreement – removing all tariffs from LDCs only – increases imports to the EU by $8.9 billion. The major beneficiaries are Sub Saharan Africa ($5.0bn) and Nepal ($2.9bn).
- Partial liberalisation which allows tariff free access for both LDCs and ACP countries increases imports by $12.0 billion, with the largest beneficiaries being Central American and Caribbean countries, Swaziland and Mauritius.
- Full liberalisation, under a scenario that makes the unlikely assumption that all producers can adapt to export to the EU at world market prices, increases imports by $12.7 billion, with greatest increases coming from Central American and Caribbean countries, Brazil, Mauritius and India. This is an unlikely outcome, given wide current variations in production costs.
- If supply responses take account of differences in production costs, full liberalisation is predicted to increase imports to the EU by $11.7 billion, with Brazil accounting for 95 per cent of this increase.

- EU production decreases by between 64 per cent and 83 per cent under the different scenarios.

7.3 Environmental impacts

The links between sugar production and the environment are schematically presented in Figure 7-1, Figure 7-2, and Figure 7-3 (below).

The main environmental impacts of both sugarcane and beet growing are associated with water consumption and pollution, and negative impacts on soil (erosion, removal, compaction, declines in fertility). In the case of sugarcane, there are also significant negative impacts from air pollution (from pre-harvest burning) and loss of habitats and landscape change.

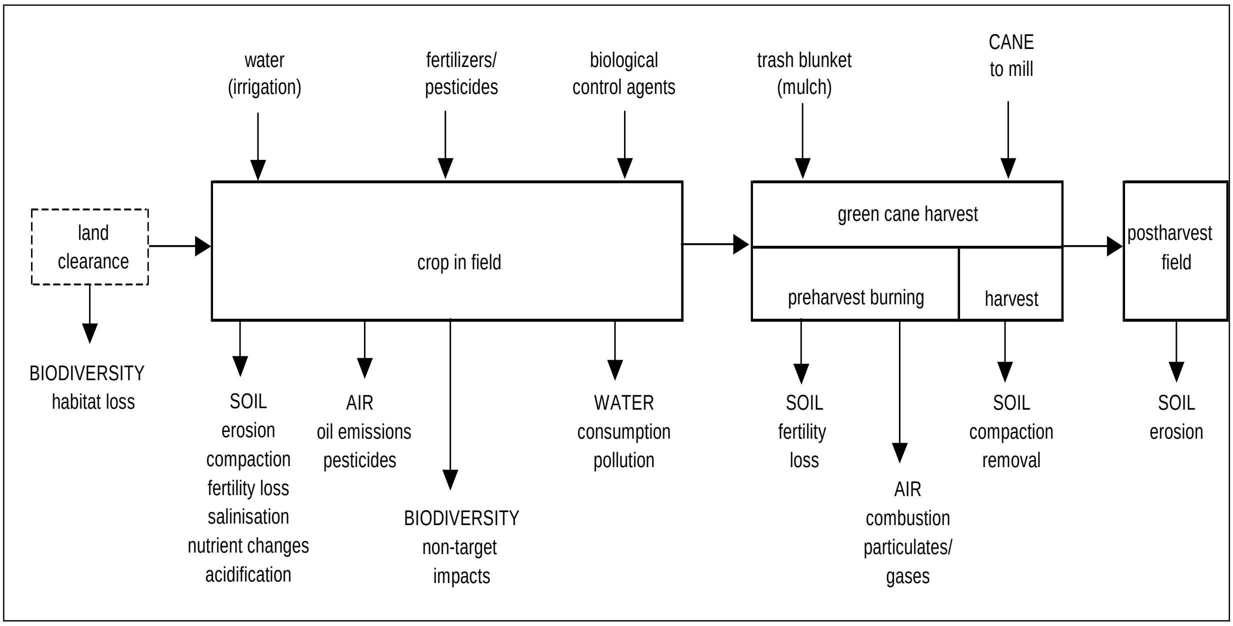

Figure 7-1 Sources of environmental impacts related to key processes and inputs in sugarcane growing, after Cheesman (2005)

In areas where high seasonal rainfalls are a regular occurrence, and where sugarcane is grown on slopes, soil erosion is one of the most significant environmental problems. Downstream water bodies suffer from silt deposits, and downstream water and wetland ecosystems may become enriched with nutrients in the runoff from cane fields.

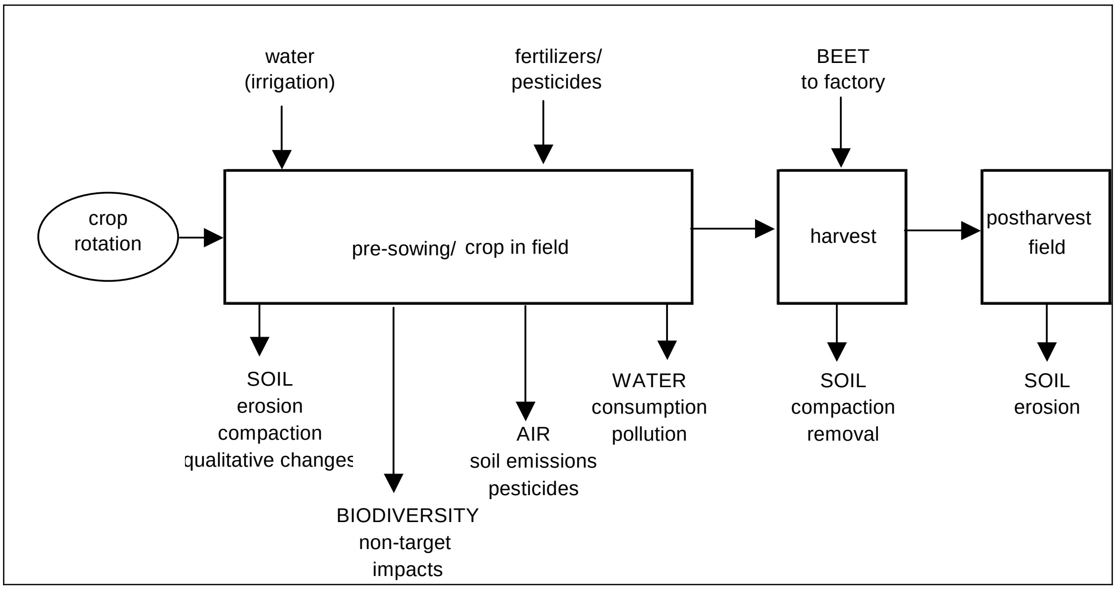

Figure 7-2: Sources of environmental impacts related to key processes and inputs in sugar beet growing, after Cheesman (2005)

Clearing of land for sugarcane crops has contributed historically to dramatic changes to landscapes, and loss of natural habitats in many tropical countries. Similar impacts extended over millennia rather than centuries or decades can be attributed to agriculture as an economic activity in general. Nevertheless in some areas where sugarcane production may expand, natural and semi-natural habitats are now scarce, and loss of biodiversity may be a more significant environmental impact, than water issues.

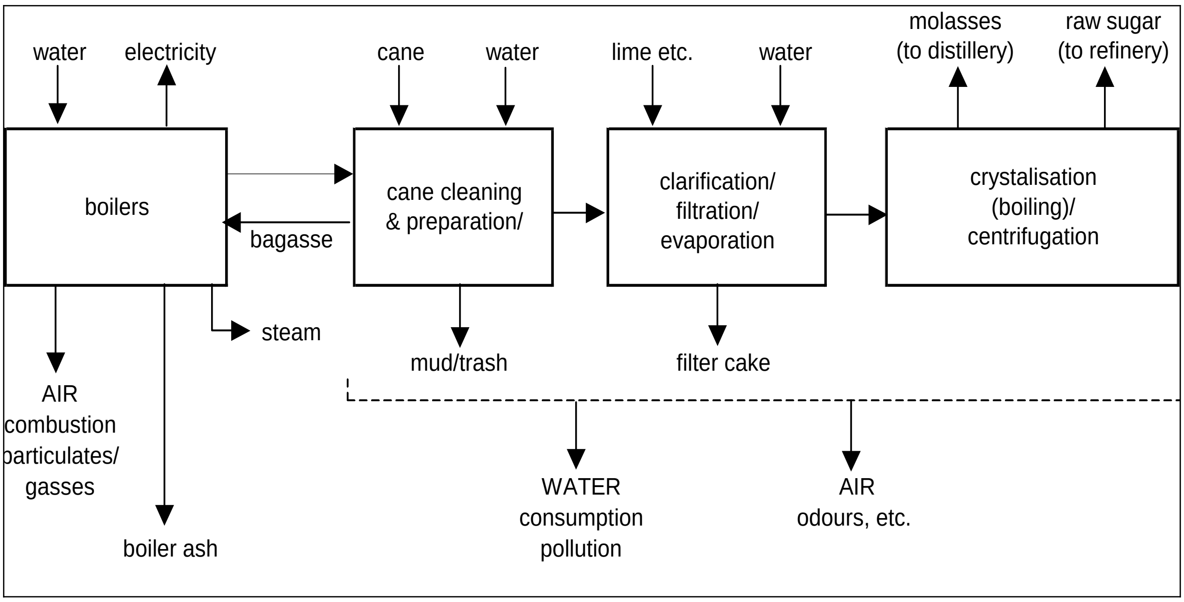

Figure 7-3: Sources of environmental impacts related to key processes and inputs in the processing of sugarcane and sugar beet, after Cheesman (2005)

Some of the potential environmental impacts discussed below may be not widespread but are very acute where they occur. This applies in particular to pollution of water bodies with effluent from sugar processing. In tropical conditions, decomposition of organic matter from sugar mill effluent may consume all available oxygen in water bodies, resulting in death of fish and other organisms. By contrast, disposal of effluent from sugar processing is very well regulated in Europe and incidents of this nature are very rare.

7.3.1 Land use/landscape

Sugar consumption has increased over 100 fold over the last 150 years and most of the expansion of the growing area took place at the expense of valuable habitats such as rain forest, tropical seasonal forest, thorn forest, semi-desert scrub and savannah. Between the 1960s and 1990s the largest expansion of sugar production was observed in India (3 to 15 Mt) and Brazil (5 to 10 Mt), with a decline in Barbados and Cuba. Recent land clearance has been reported in Indonesia, Thailand, and Australia (Cheesman, 2005).

In several countries, sugarcane is grown in large areas of monoculture, which has an impact on the character of the landscape. In 15 countries, 10 to 50 per cent of land area is used for sugarcane growing, and in seven countries more than 50 per cent (WWF, 2004a). For example, in Mauritius more than a third of the country area is under sugarcane.

7.3.2 Soil

The main effects of sugar production on soil are erosion (by water and wind), compaction and the side effects of intensive drainage and irrigation, such as salinisation. Acidification can also occur as a result of poor management of inorganic fertilizers such as urea or ammonium sulphate

Water erosion is one of the most serious environmental concerns in cane production, with soft soils and tropical rainfall patterns exacerbating the problem, especially on steep slopes. In Queensland, Australia, losses of up to 380 tonnes of soil per hectare have been recorded, compared to 4 tonnes per hectare lost in natural rain forests before reclamation for cane production (Sustain, 2000).

In sugar beet production, both water and wind erosion occur, due to the exposure of bare fields over the winter and low coverage with the crop at early stages of development in April-June. Soil erosion in sugar beet fields is high in comparison to alternative crops. For example, it is nearly twice as high as in cereal crops, with only maize grown for corn resulting in higher risks of soil erosion (CEC, 2003a). Losses of soil due to wind erosion reported in the USA reach values as high as 32 to 122 tonnes per hectare annually (WWF, 2004a).

Loss of soil by its removal with the harvested crop (‘tare’), is an issue of serious concern in sugar beet growing, with as much soil as 10 to 13 per cent of the crop weight leaving the fields (CEC, 2003a). In Turkey alone, 1.2 million tonnes of soil are removed annually from sugar beet fields with the crop (WWF, 2004a), and estimates for France are in the range of 5 million tones (CEC, 2003).

Although serious efforts are being undertaken to reduce tare in the EU, and in several countries the tare has been reduced significantly (with the lowest rate of 6.5 per cent achieved in the UK where most of this soil is subsequently recycled into gardening products) some environmental costs in terms of loss of soil from the fields and transportation cannot be avoided. Loss of soil by removal also occurs in mechanical harvest of sugarcane, but the rates are much lower (around 5 per cent of crop weight).

The effects of soil erosion and removal of soil with the harvested crop are seriously affecting the fertility of fields where soil losses occur, and also a range of habitats where suspended solids and nutrients from the eroded soil affect water bodies, and coastal zones. Soil particles, along with nutrients and agro-chemical residues, are polluting water bodies and damaging downstream ecosystems. Soil erosion from sugarcane growing is reported to have had an especially serious impact on wetland habitats.

Soil compaction is another issue related to sugar beet production, as fields require a lot of cultivation, and harvesting typically involves use of heavy machinery during periods when soils are relatively wet.

7.3.3 Water quality and supply

7.3.3.1 Water consumption and reduced water flows

High water consumption and reduced water flows are particularly associated with sugarcane growing, both in areas where the crops are irrigated and where they are rain fed. Irrigation of sugar beet often affects water resources. Changes in patterns of water availability may affect adjacent and downstream habitats, and the impacts can be significant.

Box 7.1: Examples of detrimental effects of sugarcane and beet growing on water resources

In the Godavari River basin in *India*, (Maharashtra state), sugarcane covers three per cent of the agricultural land, but uses around 60 per cent of water available for irrigation and contributed to some of the most extreme drops in water table levels reported over the past 20 years (from 15 to 65 metres) (WWF, 2004a).

In *Turkey*, in a conservation area of the Konya Closed basin, 50-80 per cent of available water supplies are used to irrigate 300 000 ha of sugar beet (WWF, 2004a).

Other harmful effects of irrigation schemes include water-logging and salinisation caused by rising water table, seawater intrusion to overexploited groundwater aquifers, and changes to the hydrology of the area resulting from the creation of dams and canals for water storage and distribution. Water demands from the sugar processing industry can be also very high, especially in sugar beet processing where large quantities of water are used to wash off the soil attached to the roots at harvest.

7.3.3.2 Water pollution

In addition to heavy demands on water resources, sediments and agrochemicals from sugarcane and beet growing pollute water bodies. Crop production results in water-borne organic matter and solids, which can affect groundwater, rivers, wetlands, and sensitive coastal areas. The runoff of nitrates and pesticides from cane and beet growing is not a problem specific to those two crops, but they certainly contribute to the overall problem.

In Queensland, Australia, 95 per cent of sugarcane is grown on a narrow coastal strip in proximity to the Great Barrier Reef. Sediments and nutrient loads from the fields and from processing are transported downstream, and the use of water by the cane has affected the pattern of fresh water flow into the coastal zone. The increased sediments and nutrients periodically lead to suffocation of offshore reefs and the near-shore environment.

7.3.4 Resource use/waste

7.3.4.1 Pesticides and herbicides

In the case of sugarcane, the use of pesticides is similar or lower than in alternative crops (e.g. cotton), but contributes significantly to the load of agrochemicals recorded in catchments where extensive areas of cane are grown.

In the EU, the use of pesticides in sugar beet crops is higher than for most alternative crops (e.g. cereals, oil seed rape or maize), but lower than for potatoes. However, while the use of pesticides in sugar beet has declined in the main producing EU countries (Germany, France, UK) during the 1990s, it increased in others, especially those growing irrigated crops. In Spain, pesticide use increased by 218 per cent between 1992 and 1999 when it was four times as high as in cereals, while in Greece it increased by 157 per cent and was ten times as high as in cereals and nearly twice as high as in potatoes (CEC, 2003a). Some reports refer to the high dependence of sugar beet on herbicides, especially in the early stages of crop development (Baldock et al., 2002).

7.3.4.2 Processing by-products

Bagasse, the main by-product of crushing sugarcane is used as fuel for heating boilers, making the process more energy-efficient. Molasses, another by-product, can be used as stock feed for cattle or as a raw material for the production of alcohol. Vinasse, liquid waste resulting from the alcohol fermentation, can be used as a fertiliser. In optimal efficiency conditions the process of processing sugarcane can be a closed process in terms of energy use.

7.3.4.3 Solid waste

Lime sludge left after purifying sugarcane and sugar beet juice is an important solid waste generated by sugar mills, and can be used as fertilizer. Press mud (impurities from sugarcane juice vacuum or press filtered) and ashes can also be used as fertilizer if applied in moderate amounts. Where air pollution control equipment is installed, solid waste is generated from the installations.

7.3.4.4 Effluents

The effluents produced by processing sugar and molasses (vinasse) are high in suspended solids and ammonium and have high Biological Oxygen Demand (BOD). BOD typically ranges from 1,700 to 6,600 milligrams per litre in untreated effluent from cane processing, and 4,000-7,000 from sugar beet processing; with chemical oxygen demands (COD) of 2,300-8,000 and 10,000 respectively. Suspended solids can be as high as 5,000 milligrams per litre, and ammonium content is high.

Effluents may also contain pathogens from contaminated raw material or production processes. Pollution of watercourses with effluent from sugar processing can result in deterioration of drinking water sources, and suffocation of fresh water biodiversity, especially in tropical rivers. For example, effluent from three sugar factories next to the River Nyando in Kenya led to deterioration of drinking water sources on its way to Lake Victoria, as well as undesirable nutrient enrichment of Lake Victoria (IIED et al., 2004).

7.3.5 Biodiversity

In many tropical and sub-tropical countries, large areas of rain forest, tropical seasonal forest, thorn forest, semi-desert scrub and savannah have been cleared to create sugarcane plantations, representing probably the greatest habitat and biodiversity loss attributable to a single crop. Most of this clearance happened some decades ago, but in some areas, e.g. South America, South-East Asia and Australia the area of sugarcane has continued to expand in response to increasing sugar demand, and recent land clearance has been reported in Sumatra, Thailand, and Australia (Cheesman, 2005).

Box 6.2: Examples of detrimental effects of sugarcane growing on biodiversity

Land clearance for sugarcane growing in *Australia* caused losses of large areas of riverine rainforest, riparian habitats, and some mangroves (Cheesman, 2005). Clearance of land for sugarcane cultivation was blamed for a 60 per cent reduction in wetland habitat area over the period 1951-1992 in the Johnston River catchment.

In the *USA*, large areas of the Everglades (a sensitive wetland area dependent on low nutrient levels) were reclaimed to grow sugarcane, which now is grown on 200,000 hectares. This resulted in a loss of about 50,000 hectares of valuable wetland habitat (WWF, 2004a).

In *Australia, Fiji, and many other cane-growing countries*, the cane toad (*Bufo marinus*) was introduced to control pests in sugarcane fields. The toad is now an invasive species with negative effects on native biodiversity almost everywhere it has been introduced (ISSG, undated).

Land clearance results in a direct loss of habitats and species, but impacts on adjacent, and often quite distant, ecosystems are much more complex and far reaching. As discussed above, the outflow of sediments, nutrients and agro-chemicals into water bodies can have far-reaching impacts on water and water-dependent habitats such as mangrove forests, wetlands, and coastal areas. Sugarcane is usually grown as a monoculture, and hence is usually much poorer in biodiversity than more mixed crop production systems.

However, there have been some ‘gains’ for biodiversity in sugarcane areas. In Queensland, the Mareeba Tropical Savanna and Wetland Reserve was conceived in 1994 to utilise water which remained unused after passage through the channel system of the Mareeba Dimbulah Irrigation area. Originally earmarked for development for sugarcane, the reserve was found to have significant environmental constraints, due to its complex soils and geological composition and the risk of downstream salinisation. Reports to the Department of Transport and Regional Development reveal phenomenal increases in wetland wildlife, with the wetlands after only two years already established as one of the most important brolga (*Grus rubicundus*) roosts in Far North Queensland (Mareeba Wetlands Foundation, undated).

European reports indicate that growing sugar beet may have some benefits for biodiversity, as compared with other forms of agriculture. Reports from the UK indicate that rotations including sugar beet as a spring crop are more beneficial to some farmland birds than cereal monocultures or rotations of winter crops only. Sugar beet fields may serve as nesting areas for certain ground nesting birds like stone curlew, skylarks and lapwings, and rest areas for migratory species such as pink-footed geese (Baldock et al., 2002; DEFRA, 2002). Beneficial effects of sugar beet growing on bird populations have also been reported in Slovenia (Turley et al., 2002).

7.3.6 Air quality

7.3.6.1 Pre-harvest burning of sugarcane

Pre-harvest burning of cane is widespread where sugarcane is harvested manually, as it makes harvesting easier. In some places it is done to clear snakes from the fields before harvest. Burning cane causes air pollution and increased erosion, but because manual harvesting of green cane is much harder and more labour consuming, and costs of mechanized green harvest are very high, pre-harvest burning is only banned in some of the major producing countries. Pre-harvest burning causes moderate losses in the sugar content of cane.

7.3.6.2 Air emissions from processing

The main air emissions from sugar processing and refining are particulate matter, nitrogen oxide and sulphur oxide, resulting from combustion of bagasse in cane processing, and/or use of fuel oil or coal in sugar beet processing. Approximately 5.5 kilograms of fly ashes are produced per tonne of cane processed; the ashes escape to the atmosphere and can cause irritation in eyes, nose, throat and lungs, and can also damage crops (WB Group, 1998; IIED et al., 2004).

Odours from sugar beet processing can range from musty smells to hazardous gases and can be a considerable nuisance to processing plant staff and neighbouring communities. The main odorous substances are NH3, H2S and methane (CH4). Processing odours are also a problem in sugarcane, and are usually related to sugar mill effluent and drying operations where deterioration of organic matter occurs (Cheesman, 2005).

7.3.7 Climate change/greenhouse gas emissions

Issues of GHG emissions from sugarcane production and processing are rather complex. Energy use in cane harvesting has significantly increased with more and more widespread mechanical harvesting and large volumes of sugarcane being transported to sugar mills and adding to emissions.

Sugarcane has an exceptional ability to use CO2 from the atmosphere, and the use of bagasse as a fuel in processing adds to the efficiency of the process. In Brazil, a considerable proportion of raw sugar and molasses are processed into alcohol and used as a renewable fuel for cars.

Solar energy efficiency in sugar beet production is much lower than in sugarcane, and this is coupled with concerns about the emissions produced in transport. Processing of sugar beet is, however, much more energy-efficient than sugarcane processing, with energy use per unit of product half that for sugarcane (Cheesman, 2005).

Thorough consideration should be given to the energy use and related GHG emissions resulting from transportation of raw sugar for processing to often very distant locations, as well as extensive trade movements of millions of tonnes of refined sugar between regions. In this regard, the EU preferential trade agreements with ACP countries present a special case, as they encourage significant trade flows.

7.3.8 Distributional impacts

Examples of localized and more geographically distant effects of both growing and processing of sugarcane and beet were given in the sections on soil, water and biodiversity impacts. The weight of such impacts vary greatly between different producer countries, depending on the size of the sugar sector, the vulnerability of the habitats and ecosystems affected both locally and downstream, and the existence and enforcement of environmental standards guarding against such impacts.

7.4 Analysis of impacts of current/forecast liberalisation proposals for sugar

The review of modelling studies suggests that world trade liberalisation will result in decreased sugar beet production in the EU, US and Japan, and a significant increase in sugarcane production in low-cost production countries, namely Brazil, Thailand, Australia and India. The impacts on cane production in ACP countries are more difficult to predict, but several studies indicate that there is a significant risk that sugarcane growing will cease in some countries, especially those with highest production costs, i.e. Barbados, Cote d'Ivoire, Jamaica, Madagascar, St. Kitts and Nevis. A significant risk of serious reduction in the area of sugarcane is also predicted in Belize, Congo, Fiji, Guyana and Mauritius (Ryberg, 2005)

Detailed assessment of the environmental impacts of such changes cannot be achieved within the scope of this study, as the modelling exercises predicting changes in production patterns say little about the means of expansion (e.g. clearance of natural habitats versus crop substitution or intensification on existing agricultural land) or the exact locations where the production increases and decreases may occur. Understanding how production will change is key to determining its impacts; very limited literature on the subject is available.

In the EU, studies are consistent in predicting significant declines in sugar beet area and production in Ireland, Greece, Italy and Finland, though evidence is more conflicting in Spain and the Netherlands. Decline in sugar beet production in these high-production cost EU Member States is more likely to have positive than negative environmental impacts, especially in the southern Member States where production heavily relies on irrigation. All sugar beet grown in Greece is irrigated, compared to

77 per cent in Spain and 36 per cent in Italy (CEC, 2003a). Substitution of cereals for sugar beet in these countries would have positive effects on water resources. A very broad assumption can be made that a decline in production of irrigated sugar beet, especially where high applications of pesticides are reported (e.g. Greece and Spain), may be environmentally beneficial.

The benefits are more questionable if sugar beet is substituted by corn maize, for which water demand is similar, higher quantities of mineral fertilisers are used and soil erosion risk is higher, or by vegetables which are likely to demand similar quantities of pesticides and fertilisers. Any crop substitution should have positive impacts in terms of preventing the negative effects of soil removal and the transportation of high volumes of crop, problems that are specific to sugar beet. Some negative impacts through nutrient leaching are likely if sugar beet is substituted by other crops, as less nitrogen fertilisers are applied in sugar beet, and its long root system allows for a relatively good utilisation of nutrients from the soil. Negative effects on biodiversity might be observed in areas where sugar beet is grown as the only spring crop in the rotation, in areas where birds use sugar beet fields as nesting or resting grounds, and where no measures are applied to provide alternative suitable habitats for such birds.

A large expansion of sugarcane production in Brazil, Thailand, Australia and India is predicted as a result of trade liberalisation. According to a USDA study (USDA, 2003), Brazil still has large areas of land suitable for conversion into arable land. The areas suitable for conversion are either permanent pastures or natural savannah called ‘cerrado’. Most of the recent increase in the soya bean production area (7 million hectares over a 7 year period) has already taken place by clearing cerrado. The total area of arable land in Brazil is 41.8 million hectares, with pastures occupying 177 million hectares and seen as a major potential source of new arable land, next to clearance of cerrado. Investment costs of establishing one hectare of sugarcane on cleared land are considerably lower than those for citrus or pastures. Sugarcane also offers better profit margins than other crops so is increasingly likely to be favoured in decisions about the use of newly cleared or existing agricultural land.

The environmental impacts of expansion in the area of sugarcane production depend not just on how the new arable land will be obtained, but also on the impact on water resources in the areas used for production, and downstream processing. Sugarcane has already replaced some pastures and citrus growing in the State of Sao Paulo. According to the USDA, sugarcane occupied 5.79 million hectares of agricultural land in 2004 (3.4 million in the State of Sao Paulo), with an estimated output of 28.37 million tonnes of raw sugar. Most of the models reviewed estimate increases in sugar production resulting from trade liberalisation to be approximately 5 million tonnes (raw value). This would require expansion in the area under sugarcane of about one million hectares (total EU-15 area of sugar beet in 2003/4 was 1.725 million hectares). Because sugarcane has to be processed within 24 hours of harvest the increase is most likely to occur where processing capacity is already well developed, and good transportation links exist.

The environmental consequences of such an expansion in sugarcane growing area will not be unprecedented as the area of sugarcane in Brazil increased from 4.356 to 5.790 million hectares between 1994 and 2004, and from 2.173 to 3.389 million hectares in the State of Sao Paulo alone (USDA, 2004 – GAIN report for Brazil). Current market trends suggest that Brazil will continue to expand cane plantings regardless of trade liberalisation, in order to meet growing demand for ethanol fuel as well as sugar for domestic consumption and export. Although the expansion of sugarcane growing over the last decade took place despite the EU and US sugar market policies, this is likely to intensify if the world sugar market is liberalised.

Similar considerations apply to other countries where the sugarcane production area is likely to expand as a result of trade liberalisation. In India, the area under sugarcane increased rapidly between 1985/6 and 1996/6 from 2.86 to 4.15 million hectares, reaching a peak of 4.43 million hectares in 2001/2 season and has gradually declined since then. In the last production season the area of sugarcane sharply declined in four out of six main production regions (Maharashtra, Karnataka, Tamil Nadu and Gujarat) as a result of droughts (USDA, 2004 – GAIN report for India). Uttar Paradesh and Maharashtra are the main sugar production regions in India, accounting for more than half of all production in India. Given that sugarcane production already exerts a serious strain on the water resources of the State of Maharashtra, any further expansion of sugarcane growing may exacerbate the impact on its water resources; similar problems are likely to occur in other production areas. Estimates of production increases of up to two million tonnes of raw sugar in response to improved export markets resulting from liberalisation would require a significant growth in the production area; at present India fails to even meet its market needs, with 3.9 million hectares under sugarcane, and a raw sugar output of approximately 15 million tonnes. If production was to increase by a further 2 million tonnes destined for export, this would require an increase in production area of around 500 thousand hectares, or a combination of an increase in the area grown with improvements in productivity.

Clearances of land for new sugarcane growing areas have been reported in Thailand and Australia, even under current market conditions (Cheesman, 2005), and the availability of new export markets is likely to intensify the process. Some of this expansion may occur at the expense of other agricultural crops, as the comparative profitability of sugarcane may be higher, and the marketing and processing infrastructure already exists. The area under sugarcane in the North-Eastern region of Thailand has already increased by 22 per cent between the 2003/4 and 2004/5 production seasons (USDA, 2004 – GAIN report for Thailand).

In some cases there may be few economic alternatives to growing sugarcane, and where production declines as a result of trade liberalisation, there is therefore a significant risk of land abandonment. This could have significant adverse impacts on rural development, threatening the livelihoods of significant sections of the rural population. Given that sugarcane is usually grown in monoculture, and there seems to be no evidence of special environmental benefits related to sugarcane growing, it is very unlikely that reduction in area under sugarcane will have any negative environmental impacts. In some countries abandonment of sugarcane production may result in the return of some land to forest. Different types of environmental impacts may emerge in relation to infrastructure disposal where sugar processing discontinues.

Some short term impacts are likely as a result of proposed EU sugar reforms and the Everything But Arms initiative, with further impacts resulting from future liberalisation measures.

7.5 Analysis of Potential Flanking Measures

Sugar trade liberalisation will bring significant shifts in production patterns of both sugarcane and sugar beet, with significant land areas moving into sugarcane plantation, as well as significant areas going out of sugar beet and sugarcane production. These changes need to be viewed in the context of recent and predicted baseline trends in the sugar market. They will reinforce the expansion in production currently taking place in Brazil, Thailand and Australia, even in the absence of liberalisation, while bringing about a new shift in the market and moving production away from the EU, US and Japan. The shift away from sugar beet in the EU is predicted to have largely positive effects, but the expected dramatic drops in production in some smaller states such as Mauritius may have severe socio-economic impacts. Increased production in Brazil, India and Australia will increase the pressure on water, soil and biodiversity resources in those countries.

Table 7-4 below summarises the main impacts of liberalised trade in sugar in and outside Europe, and suggests flanking measures to deal with negative impacts where appropriate.

The main priorities for the UK Government would appear to be:

- consumer information programmes, to inform UK consumers about the different impacts of sugar production systems in different countries, including the use of labelling and certification schemes;
- ensuring that international development programmes recognise the environmental impacts of trade liberalisation and that associated rural development programmes seek to mitigate negative impacts and maximise environmental opportunities (e.g. through habitat re-creation); and
- the potential use of Multilateral Environmental Agreements to address the environmental impacts caused by expansion of sugar, as well as other crops.

Please refer to Annex 1 for a description of voluntary environmental codes for sugarcane growing that are currently being used in Australia and South Africa.

Table 7-4: Summary of impacts of liberalised trade in sugar, and potential flanking measures. Key impacts in bold.

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
Land use/landscape	Predicted reduction in sugar beet growing may lead to some landscape-level changes.	None needed, replacement with other crops is likely.	Countries (e.g. Mauritius) where large proportion of land is under sugar cane may observe dramatic changes in landscape.	No hard measures needed, but it may be appropriate for the UK to encourage countries losing their cane industry to use land for restoration of native vegetation through aid programmes etc.
Soil	As sugar beet growing is predicted to decrease with liberalisation, there will probably be a positive effect on European soils. However, if the beet crop is replaced with maize then levels of wind erosion could increase.	None needed, though it may be useful to assess which crops are providing the main replacements for sugar beet.	**Water erosion where cane is grown on slopes in Australia and in other tropical locations can have severe impacts on local conditions. Production in Australia, Thailand, Brazil and India is predicted to increase with liberalisation. This issue intersects with water pollution when suspended soils and nutrients are washed into downstream ecosystems causing nutrification, suffocation of offshore reefs, etc.**	**It seems that despite local management efforts (e.g. in Australia) this problem is not yet being adequately addressed locally. The UK should encourage the introduction of labelling to differentiate those producers who are addressing this issue (e.g. those growing sugar cane on flat land only) and provide consumer information on the effects of sugarcane growing. It may be possible to work with supermarkets and processors to develop such schemes. In addition, through overseas aid programmes, the UK could encourage uptake of best practice to avoid ecosystem damage.**

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
Water quality and supply	Water use for irrigation of sugar beet is currently high in Spain and Turkey. Production is predicted to decline in these areas with liberalisation, so there will be positive effects on water supply.	None needed.	**Irrigation needs for sugar cane are high in Australia and India where production is predicted to increase. Some countries such as Australia appear to be addressing the water use issue through pricing of water for irrigation, and innovative schemes such as wetland creation to combat salinisation. In other countries, this is not the case.** **Water pollution issues are discussed under Soil (above), and effluents in Resource use/waste (below).**	**As with the water pollution issues, the most appropriate way for the UK to address these negative results of trade liberalisation is through education of UK consumers, and encouraging development of water use planning and pricing mechanisms via aid schemes and international cooperation.**
Resource use/waste	Pesticide use is not higher than for other crops; effluent disposal is well-regulated already. As a decline in production is predicted, these issues are likely to become less serious.	None needed.	**Disposal of effluents is the main waste issue internationally, and is likely to be exacerbated by increases in production in developing countries such as Brazil and India.**	**Suggested flanking measures similar to those for water use and soil erosion.**
Biodiversity	Loss of sugar beet fields may have some negative effects on those bird species that use the crop for nesting and migratory stops.	Current agrienvironment schemes could be used to encourage replacement of sugar beet with other crops suitable for birds. No new measures	**Continued clearance of natural vegetation to grow sugarcane will have negative effects on biodiversity where this occurs. There may be**	**Through participation in Multilateral Environmental Agreements, the UK could encourage other countries to avoid clearing of land for cane**

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
		needed.	**severe socio-economic effects in some countries if the sugarcane industry collapses, and these may lead to flow-on effects on biodiversity – e.g. more pressure on forests for hunting and wood collection.**	**production. Other flanking measures to address biodiversity issues include the awareness and aid programmes mentioned above. Specific aid to encourage new biodiversity-friendly industries where cane growing has ceased may be appropriate.**
Air quality	There are some air quality concerns in sugar processing. As a decline in production is predicted, these issues are likely to become less serious.	None needed.	Pre-harvest burning and processing cause issues with air quality. These issues are likely to be exacerbated by increases in production in developing countries such as Brazil and India.	This issue can best be addressed through regulatory measures by local governments and industry organisations. As with the other issues, the most appropriate way for the UK to address these negative results of trade liberalisation is through education of UK consumers, and encouraging development of realistic environmental standards in the countries concerned.

7.6 Conclusions

In this sector, we have had to base judgements on environmental impacts on information which is largely incomplete. Liberalisation is one of a number of factors which is already leading to a relocation of production within and between countries – increased production in Brazil, India and Australia has already been recorded. There is not sufficient information to be able to forecast exactly where production will move or how management will change and to some degree this must remain a matter of speculation, even if more detailed and reliable models were available.

Taking the global picture and bearing in mind the main sources of production now and in the future, the most important environmental issues appear to be related to water and soil management, and continuing land clearance for sugarcane plantations in those countries where production is predicted to increase. There appear to be no significant environmental issues related to the predicted reduction in sugar beet growing in Europe. All of the issues arise at a local or regional level, and may be of particular concern for communities in sugarcane growing areas. The concentration of sugarcane growing in developing countries means that the environment in those countries may be particularly vulnerable due to lack of good environmental regulation.

The UK’s main role in offsetting the negative environmental effects of changes in sugar production due to liberalised trade would seem limited to providing information to consumers and providing assistance to the growing countries to improve their environmental performance where possible.

7.7 Future research needs:

We can identify some of the key environmental pressures and benefits arising from sugar production but cannot specify exactly how these will arise at each of the main countries affected by liberalisation. It would be particularly helpful to have more research on certain questions e.g.:

- the consequences of increased production in different regions;
- means of expansion of sugar growing area (e.g. clearance of natural habitats versus crop substitution or intensification on existing agricultural land) or the exact locations where the production increases and decreases may occur. Understanding how production will change is key to determining its impacts; very limited literature on the subject is available; and
- detailed analysis of the significance of water pollution incidents related to sugar processing effluent and run-off from sugar plantations in comparison with other agricultural practices.

8 VEGETABLES

8.1 Brief Overview of the Vegetables sector

The vegetable sector includes both open-air field crops and those grown in a controlled environment under cover (glass or plastic ‘greenhouses’ or tunnels). Field crops are mostly the ‘temperate’ vegetables (such as brassicas and root vegetables). Greenhouses more commonly house the ‘Mediterranean’ vegetables (such as tomatoes, courgettes, aubergines and peppers). Field crops are highly seasonal, whereas greenhouse crops can be forced off-season by controlling the internal climate. For the purposes of this report the vegetable sector includes tomatoes and melons (technically fruit) since they are widely included in statistics describing the vegetable sector.

In the EU, the leading vegetable producing Member States are currently Italy, Spain and France (producing 15, 12 and 8 million tonnes per year respectively). Some new Member States are also major producers (Poland produces 5 million tonnes per year) and have the potential to increase production through mechanisation and intensification. The UK is a relatively small producer. Outside the EU, Turkey, Syria, China, Mexico, Canada and Argentina produce significant vegetable exports. Although not currently the biggest exporter, China is the biggest producer.

Throughout the area dedicated to vegetable production in the EU (around 4 per cent of the Utilised Agricultural Area (UAA)), production tends to be concentrated regionally. The major producing regions of the EU are Andalucia (with a share of fruit and vegetable production in total agricultural production of 28.3 per cent), Murcia (36.1 per cent), Provence Alpes Côte d’Azur (42.0 per cent), Emilia-Romagna (24.2 per cent), Campania (42.4 per cent), Puglia (42.4 per cent) and Sicilia (47.8 per cent). On the Mediterranean coastline, irrigated vegetable production in greenhouses has increased greatly over the past 20 years and is now the dominant land use and major source of regional revenue.

Tomatoes take up the largest proportion of vegetable production in the EU (16 million tonnes are produced per year of which 47 per cent are in Italy, 27 per cent in Spain, 13 per cent in Greece and 7 per cent in Portugal). Mexico is the leading exporter of tomatoes (0.9 million tonnes per year).

Vegetables are traded widely as a result of: the relatively high labour input required for their production and varying labour costs, giving some producer countries a significant competitive advantage, along with varying climatic conditions and the demand for off-season vegetables by consumers. In a growing market for vegetables many developing countries have expanded production of high value vegetables such as green beans and asparagus.

Fresh vegetables are traded in almost equal amounts as processed produce. Processing activities such as peeling, freezing, drying, canning, pickling, pureeing and juicing extend the shelf life. Processing is not always carried out in the place of origin due to pressures to minimise overheads such as energy and labour costs, and trade barriers. Some developing countries such as Chile and Thailand have specialised in exports of processed vegetables.

Vegetables are produced throughout the world both commercially on a large scale and in small, household plots for subsistence. Generally the large-scale producers use intensive methods and are highly specialised and mechanised. There is an increasing demand for organic vegetables, largely being met by innovative, medium scale producers.

Generally, the majority of vegetables produced for the domestic market within the EU are grown in relatively intensive systems. The use of some inputs is characteristically high in particular systems (e.g. fungicides on salad crops, fertilisers on tomatoes) but in other areas there has been a marked growth in the use of integrated farming systems applying techniques such as biological pest control and water recovery systems (e.g. in glasshouse tomato production). Greenhouse vegetable production following integrated pest management (IPM) techniques is quite advanced in France and is estimated to be practised on about 800 hectares, or half the total greenhouse crop (of which 50 per cent is tomato production).

The total number of EU holdings specialised in vegetable production decreased from 298,730 in 1990 to 212,300 in 2000 while the average UAA per holding increased from 3.8 to 5.5 hectares. The number of commercial holdings specialised in vegetable production has been relatively stable at around 67,000 with an increase of the average UAA per holding from 11.3 to 14.4 hectares.

Outside the EU vegetables for export are grown mostly in commercial, intensive systems with the same high inputs, although there are some exceptions.

8.2 Effects of trade liberalisation on the sector

8.2.1 Current patterns of Production, Consumption and Trade

According to the FAO, some 855 million tonnes of vegetables and melons were produced in the world in 2004. These figures exclude roots and tubers such as potatoes, yams, sweet potatoes and cassava. The largest production was of tomatoes (116mt), watermelons (94mt), cabbages (68mt) and dry onions (54mt). The FAO statistics indicate that a total of 51 million hectares were used to grow vegetables in 2004, at an average yield of 16.7 tonnes per hectare (see Table 8-1 below).

Type	**1994**	**2004**	**per cent change**
Tomatoes	83.4	116.0	39.1 per cent
Watermelons	37.8	93.5	147.6 per cent
Cabbages	43.1	68.4	58.6 per cent
Onions, Dry	34.9	53.6	53.4 per cent
Cucumbers and Gherkins	22.4	40.2	79.8 per cent
Aubergines	15.7	29.9	90.7 per cent
Green Chillies & Peppers	12.8	23.7	84.5 per cent
Carrots	15.7	23.6	49.9 per cent
Lettuce	14.1	21.4	51.6 per cent
Other	253.8	384.9	51.6 per cent
Total area (m ha)	34.3	51.3	49.8 per cent
Average yield (te/ha)	15.6	16.7	7.0 per cent
Total production (mt)	**533.7**	**855.1**	**60.2 per cent**

Table 8-1: World Production of Vegetables and Melons (million tonnes) Source: FAOSTAT

Table 8-2 presents data on areas, yields and production by region. Asia accounts for some 73 per cent of world production of vegetables and melons, with Europe the next main producer at 11 per cent of the world total. The table indicates significant variations in average yields, which range from 10 tonnes per hectare in Africa to 22.6 tonnes per hectare in North and Central America.

Country	Area	Yield	Production
Africa	5.0	10.0	49.7
Asia	37.2	16.9	627.3
Europe	5.1	19.0	96.6
North & Central America	2.6	22.6	57.9
Oceania	0.2	18.8	3.4
South America	1.3	15.1	20.1
Total	**51.3**	**16.7**	**855.1**

Table 8-2: Areas, Yields and Production of Vegetables and Melons by Region, 2004 (mt) Source: FAOSTAT.

China is the largest producer of vegetables in the world, with an output of 423 million tonnes in 2004, just less than 50 per cent of overall world production.

The largest producers of tomatoes in 2004 were China (30.1mt), the USA (12.4mt), Turkey (8.0mt), India (7.6mt), Egypt (6.8mt), Italy (6.5mt) and Spain (3.9mt).

Most vegetables are consumed within the country in which they are produced, and only a small proportion of production is traded internationally (Table 8-3). This is because of the perishable nature of most vegetables and the relatively high costs of transporting them to their point of consumption. For dry onions, which can be stored for relatively long periods, a larger proportion of output is traded than is the case for fresh vegetables such as cabbages and aubergines.

Type	000te	$m	Exports as per cent of world production, by volume
Tomatoes	4366	4242	3.8
Onions, Dry	4701	1085	8.8
Cucumbers and Gherkins	1616	1235	4.0
Cabbages	1112	522	2.6
Aubergines	288	228	1.0

Table 8-3: Volume and Value of World Exports, 2003, Selected Vegetables. Source: FAOSTAT.

Many trade statistics consider fruit and vegetables together. The USA was the world's leading exporter of fruit and vegetable products between 2000 and 2002, with 17.1 per cent of the world market, followed by the EU15 (11.7 per cent), China (8.6 per cent) and Mexico (7.3 per cent). Largest importers were the EU (25.0 per cent of world imports), the US (19.8 per cent) and Japan (11.1 per cent). These figures highlight that some regions are both major exporters and major importers. The EU and Japan had the largest trade deficits during this period, and China, Mexico and Turkey the largest surpluses (CEC, 2004).

The largest exporters of tomatoes in 2003 were Spain and Mexico (947,000 and 903,000 tonnes respectively) while the largest importers were the USA, Germany, France and the UK (FAO data).

8.2.2 Recent Trends in Production, Consumption and Trade

World production of vegetables and melons increased by 60 per cent in the decade to 2004, with substantial growth in production of all of the main vegetable types (see Table 8-1). This growth occurred largely as a result of a 50 per cent increase in the area devoted to vegetable production, but there was also a 7 per cent increase in yield over this period (Table 8-1). The most rapid growth in production occurred in Asia, where output increased by 82 per cent. This compares to modest growth in Europe and Oceania (Table 8-4).

Region	**1994**	**2004**	**per cent change**
Africa	36.9	49.7	34.8 per cent
Asia	344.4	627.3	82.2 per cent
Europe	85.4	96.6	13.1 per cent
North & Central America	47.4	57.9	22.2 per cent
Oceania	3.2	3.4	6.6 per cent
South America	16.5	20.1	21.9 per cent
World	**533.7**	**855.1**	**60.2 per cent**

Table 8-4: Trends in Production of Vegetables and Melons by Region: Source: FAOSTAT

Much of this growth occurred in China, which increased its output from 188 million tonnes in 1994 to 423 million tonnes in 2004, an increase of 125 per cent. This was largely due to an increase in the area of land devoted to vegetable production, which more than doubled to 22 million hectares (FAO data).

World trade in vegetables also increased significantly in the last decade (Table 8-5). China emerged as a major exporter over this period. For example, Chinese tomato exports increased eightfold from 9,300 tonnes in 1993 to 58,800 tonnes in 2003, while exports of dry onions increased twelve-fold from 37,000 tonnes to 456,000 tonnes in the same period (FAOSTAT data).

The FAO (2003) estimated that exports of fruit and vegetables by developing countries increased by 55 per cent between 1992 and 2001, increasing from 31 per cent to 37 per cent of world exports, although participation by Least Developed Countries remains very low, at 0.8 per cent of world exports.

Type	**1993**	**2003**	**per cent change**
Onions, Dry	2354.1	4700.7	100 per cent
Tomatoes	2957.4	4365.8	48 per cent
Cucumbers and Gherkins	1092.3	1616.0	48 per cent
Cabbages	814.9	1112.1	36 per cent
Aubergines	137.5	287.8	109 per cent

Table 8-5: World exports of selected vegetables (000 tonnes). Source FAOSTAT,

8.2.3 The Effects of Government Policy

Government intervention in the fruit and vegetables sector tends to be lower than for most agricultural commodities. Generally, industrialised countries do not subsidise horticulture directly. However, there are indirect supports through processing subsidies, provision of phytosanitary services and support to advertising and export promotion programmes in the US and EU. The main trade intervention occurs through regulation of market access (FAO, 2003).

The EU, US and Japan each operate a complex system of seasonal duties, quotas and entry prices to regulate fruit and vegetable imports, especially for temperate crops, in order to protect domestic producers. Tariffs on fresh vegetables average 68 per cent, higher than those for fresh fruits, and for agricultural and horticultural products overall, and are particularly high in the non-EU countries of western Europe. Of the 1376 tariff-rate quotas that existed in 2000, 25 per cent related to fruit and vegetables, with Norway and the EU accounting for two thirds of these. However, fresh fruit and vegetables accounted for only 2.5 per cent of global export subsidies in 2000, with the EU ($28m) and Switzerland ($11m) together accounting for more than half of these. The EU also dominates the provision of "amber box" (trade distorting) domestic support for fruit and vegetables, with much of this relating to tomato production (Rae, 2004).

Between 1995 and 2000, nearly 270 sanitary and phytosanitary (SPS) measures were introduced against imports of fresh fruit and vegetables worldwide, with controls being particularly stringent in the US, Australia and Japan. A lack of harmonised standards can be a problem, for example in relation to maximum pesticide residue limits (MRLs), for which some countries apply the Codex Alimentarius while others apply their own, often stricter limits (FAO, 2003).

The EU fruit and vegetables regime applies to all fruit and vegetables grown in the EU with the exception of potatoes, wine grapes, bananas, sweetcorn, peas and beans for fodder and olives. The regime provides financial assistance to producer organisations to set up operational funds, encouraging them to become a major means to market fruit and vegetables. Nearly 1400 producer organisations exist in the EU, responsible for marketing about 40 per cent of EU fruit and vegetable production. Their main aims are to ensure that production is planned and adjusted to demand, to encourage concentration of supply, to improve crop management and stabilise producer prices, and to improve the quality and sustainability of production practices. Producer Organisations are able to withdraw products from the market in order to stabilise prices. In addition, the EU grants specific aid for particular crops grown for processing, including tomatoes. Aid is paid to growers via producer organisations, and is limited to an annual threshold, which for tomatoes is 8.25 million tonnes (CEC, 2003).

Imports into the EU are checked for compliance with EU marketing standards. Imports of fresh produce, including courgettes, tomatoes, globe artichokes and cucumbers, are subject to a minimum entry price, used as the basis for calculating tariffs. Export refunds are paid for both fresh and processed tomatoes and a variety of fruits (CEC, 2003).

The EU fruit and vegetable regime has been widely criticised for distorting world markets and promoting unfair competition. For example, according to Christian Aid (2002), the livelihoods of tomato growers in Ghana are threatened by subsidised exports from the EU. EU subsidies, export refunds and tariffs are also blamed for negative impacts on tomato growing and processing in South Africa (ACTSA, 2002).

8.2.4 Scope and Agenda for Further Liberalisation

The GATT Uruguay Round made only limited progress in liberalisation of trade in vegetables, and there is substantial scope for further reforms, particularly in reducing tariffs. There is also scope to reduce export subsidies and trade distorting domestic supports, which are much more limited in extent but highly trade distorting for some commodities (such as tomatoes in the EU). In the EU, the 2003 mid term review of the CAP did not reform the fruit and vegetable regime, although various amendments and simplifications took place between 2002 and 2004.

The precise implications of the Doha agenda for liberalisation of trade in vegetables are difficult to predict, but are likely to be significant. The agriculture negotiations have affirmed a commitment to make progress on three fronts, substantially improving market access, reducing and phasing out export subsidies, and reducing trade distorting domestic support.

Trade liberalisation at the regional level also has the potential to affect patterns of production and trade of vegetables. For example, the Euro-Mediterranean Partnership agreement, between the EU and 12 Mediterranean countries, aims to establish a free trade area in the Mediterranean region by 2010. Countries such as Egypt and Morocco have a comparative advantage in the production of fresh vegetables, and are significant exporters to the EU. Preferential access to EU markets has already been granted to Mediterranean Partnership Countries for a variety of fresh and processed vegetables, and further liberalisation is likely to see further growth in vegetable production in the North Africa/Middle East region (Dell'Aquila and Kuiper, 2003).

8.2.5 Expected Impact on Patterns of Production, Consumption and Trade

Studies of the likely effects of liberalisation of trade in vegetables are relatively few in number, compared to studies of the more heavily supported commodities such as sugar, dairy products and cereals. Analysis is complicated by the many types and diverse nature of vegetables, in contrast to these more standardised commodities. Studies often therefore aggregate different types of vegetables and attempt to model the effects on the sector as a whole. Some of the evidence available is from multi-commodity studies, which do not assess the effects on vegetable products in any detail.

The available evidence suggests that trade liberalisation in the vegetables sector will have the following effects:

- An increase in average world prices of vegetables;
- Fairly modest increases in overall production;
- A more noticeable shift in trade patterns, with developing countries increasing their share of world export markets;

- A modest shift in production away from Western Europe, the US and Japan and towards Central and South America, the Middle East and Africa, and China.

These relatively subtle changes need to be viewed in the context of the major expansion of vegetable production that has taken place in the last decade, fuelled more by increased domestic demand than by international trade. An overall conclusion is therefore that trade liberalisation might be expected to have relatively insignificant impacts compared to trends in domestic production and consumption. Even in the EU, for example, the effects of liberalisation in depressing output are likely to be outweighed by continuing demand growth (which has driven a 13 per cent increase in output in the last decade).

Rae (2004) modelled the impacts of liberalisation of international trade in fruit and vegetables using the GTAP applied general equilibrium model. Two partial liberalisation scenarios were considered, involving reductions in tariffs of between 24 per cent and 60 per cent, export subsidies of between 45 per cent and 100 per cent, and trade distorting support of between 0 and 60 per cent, with greater reductions taking place in developed countries. Both scenarios were found to have relatively little impact on horticultural output, with minor increases of between 0 and 2.6 per cent in Canada, China, Australia, Central and South America, the Middle East and Africa, and decreases of between 0 and 6 per cent in other regions. The largest decline in output was forecast in the EFTA region, at between 3.8 per cent and 6.0 per cent. However, changes in trade balances were more noticeable in each case, with significant increases in China ($211m to $294m) and Central/South America ($459m to $624m), and decreases in the USA (-$240m to -$288m), EU (-$462m to -$520m) and Japan (-$132m to -$140m). In many cases, significant increases in trade flows in both directions were forecast, reflecting seasonality and diversity of production.

Vanzetti and Graham (2002) used the Agricultural Trade Policy Simulation Model (ATPSM), a deterministic, comparative-static, partial equilibrium trade model to assess the affects of trade liberalisation on a variety of commodities. The study modelled four liberalisation scenarios, including a Uruguay Round continuation scenario (with a 36 per cent cut in outquota tariffs, 21 per cent reduction in export subsidies, and 20 per cent reduction in domestic support in developed countries, two thirds of these cuts in developing countries and no reductions in least developed countries). The three other scenarios involved variations on this theme. Under each scenario, a 2.6 per cent increase in the world price of tomatoes was predicted. Export revenues for vegetables increase by $35m in developed countries, $421m in developing countries and $33m in LDCs. A total increase in world welfare of $225 million is attributed to reform of the vegetables sector, of which $209 million occurs in developed countries, $15m in developing countries and $1m in LDCs.

USDA (2001) quoted results from a study by Diao et al (2001), which predicted an 8.2 per cent increase in the world price of vegetables and fruits as a result of full trade liberalisation. The impacts of global tariff removal and global export subsidy removal alone would be to increase world prices by 4.9 per cent and 3.0 per cent respectively, while OECD domestic subsidy removal would reduce the world price by 0.1 per cent. The effects of trade liberalisation on the price of vegetables and fruit were considerably less than for most other commodities (e.g. livestock and products, cereals and sugar).

8.3 Environmental impacts

Across the EU as a whole, the vegetable sector has seen significant intensification of production systems in recent years, with greatly increased use of energy, artificial inputs and irrigation, as well as significant expansion of production under plastic. Southern Member States, particularly Spain, have seen a rapid expansion of intensive fruit and vegetable production, particularly in coastal areas, to supply buoyant consumer demand in northern Member States. This has led to significant environmental concerns related to unsustainable water abstraction, water pollution by nutrients, pesticides and soil sediments, and soil salinisation and subsequent land abandonment due to unsustainable irrigation practices (see Dwyer et al, 2000).

Outside the EU vegetable production is very varied. Specialisation has gone hand in hand with the development of intensive commercial production in some developing countries (e.g. green beans in Kenya, asparagus in Peru). Pesticide use and water abstraction are priority environmental issues.

The environmental cost of transport of vegetables is also an environmental concern due to the associated emissions of greenhouse gases. Recent research by Professor Jules Pretty has found that, of the overall environmental costs of food bought in the UK, domestic road transport (road haulage in the UK) is the biggest environmental cost (46 per cent of the total), with agriculture and private transport (from the shop to home) as the other major contributors (30 per cent and 25 per cent respectively) while international transport and waste disposal contribute only a tiny proportion (0.02 per cent) (see Figure 8-1). Vegetables are likely to broadly follow this pattern of environmental costs. Agriculture, waste disposal and international transport will be discussed below, but since liberalisation of trade is not expected significantly to affect domestic road or shopping transport these will not be addressed in this paper.

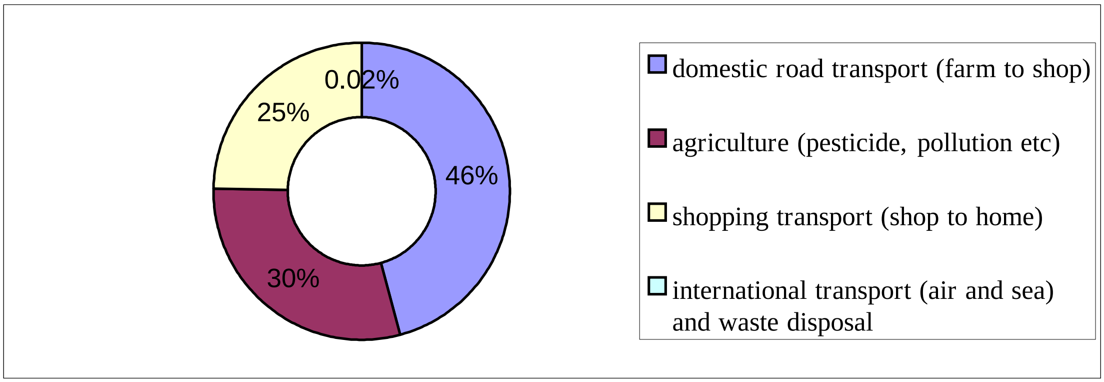

Figure 8-1: The environmental costs of food bought in the UK. Source: Pretty et al 2005.

8.3.1 Land use/landscape

The area of land used for vegetable production is growing due to worldwide demand. In the EU, the area rose by 50,000 ha between 1999-2000, although the number of farms decreased (i.e. holding size increased). The fastest growing vegetable producer outside the EU is in China, where the area of production rose from 15.3 million hectares in 1999 to 30 million hectares in 2004.

In some cases the increase in area has severely affected the landscape. This has been the case particularly where greenhouses or plastic polytunnels have been erected, covering the natural landscape altogether. In Spain concern has arisen in the previously picturesque Mediterranean coast areas that have drawn tourists for decades since a ‘sea’ of plastic now extends to the horizon in many areas just behind the coastal strip.

If vegetable production shifted away from the EU and North America, it is possible that it could begin in areas that were previously used for other types of agriculture. Regions expected to increase vegetable production (the Middle East, Central and South America, Asia and Africa) have a more appropriate climate for most vegetable production, so would be less likely to use glass or plastic cover. There are instances, however, when plastic is used in warmer climates. In Kenya, for instance, poly-tunnels round Lake Naivasha are increasingly being used for vegetable production with negative effects on landscape values (Lawrence 2004).

8.3.2 Soil

Soil erosion takes place when root vegetables are extracted with machinery and the soil leaves the field on the surface of the vegetables. Soil compaction also occurs when heavy machinery is used for preparation of seed-beds or harvesting, especially during wet conditions. Since vegetables require picking at certain times, are susceptible to decay and demand for quality is high, producers often use machinery in sub-optimal conditions realising that they must trade off the negative impacts soil compaction with losing crop quality. Machinery is increasingly used throughout the world where investments in vegetable production are rising, so these environmental impacts are likely wherever vegetable production takes place.

Organic matter is lost from soils used for intensive vegetable production. There is a tendency to use liquid fertiliser instead of compost and in areas that have invested in glass or green-houses and become very specialised it is more difficult to use an appropriate rotation to allow organic matter to be replaced.

Soil salinisation has taken place in some arid areas where water abstraction has been intense, and risks occurring in other areas. Salinisation results in completely unproductive soils, and affects 25 per cent of the total irrigated cropland in the Mediterranean countries (EEA 2004).

Use of the controversial chemical methyl bromide for disinfecting soil is widespread throughout the EU and elsewhere although its use is being phased out.

8.3.3 Water quality and supply

Water abstraction for irrigation of vegetables is a priority environmental issue throughout the world. Sprinklers are widely used for field crops while drip irrigation is used mainly for covered crops. Since vegetable production in the EU is concentrated in coastal areas with water shortages, ground and surface water abstraction is a particular problem, leading to salinisation of the water table by incursion of sea water. In the particular case of Spain, salinisation is widely spread along areas of the coast, mainly in the South East.

Water abstraction also leads to down-stream water shortages, lowering of water tables and loss of wetland areas. Growing tomatoes requires particularly high water inputs, and in Italy and Spain this has become a problem. Of the temperate vegetables potatoes are amongst the most irrigated crops, and their production has contributed to water resource depletion in northern Europe.

Box 8.1 Lettuce production in Spain
Spain is the biggest producer of lettuce in the EU, exporting 0.4 million tonnes (nearly one third of total production, of which 15 per cent is exported to the UK) (Sustain 1999). In the Mediterranean area the temperature and hours of sun are optimum for lettuce growth, but rainfall is low (300mm per year) and highly unpredictable, so irrigation is necessary. Market demand is for iceberg lettuces, not traditionally grown in Spain due to their high water requirements. As a result of irrigation in the region, groundwater reserves have been severely depleted and in some areas salinisation has occurred.

In parts of the world where vegetable production may increase if trade were liberalised, water abstraction would correspondingly increase. Systems and standards of water management vary between countries and some would be more able to manage greater demand than others e.g. through water pricing, more efficient irrigation, appropriate location of production. However, making judgements about national performance in this area requires considerable analysis. In all areas water abstraction for vegetable production would be likely to lower water tables which would negatively impact on wetlands and watercourses and could have serious knock-on effects on water supplies for human populations and other economic activities.

Country	Total renewable water resources (cubic km)	Water withdrawal for agriculture (cubic km)	Water withdrawal as percentage of renewable water resources
Argentina	814	21.52	3 per cent
Chile	922	7.97	1 per cent
China	2829.569	426.85	15 per cent
Dominican Republic	20.995	2.24	11 per cent
Ecuador	432	13.96	3 per cent
Egypt	58.3	53.85	92 per cent
India	1896.66	558.39	29 per cent
Indonesia	2838	75.6	3 per cent
Iran	137.51	66.23	48 per cent
Iraq	75.42	39.38	52 per cent
Jordan	0.88	0.76	86 per cent
Kenya	30.2	1.01	3 per cent
Lebanon	4.407	0.92	21 per cent
Mexico	457.222	60.34	13 per cent
Morocco	29	11.48	40 per cent
Pakistan	222.67	162.65	73 per cent
Peru	1913	16.42	1 per cent
Saudi Arabia	2.4	15.42	643 per cent
Somalia	13.5	3.28	24 per cent
South Africa	50	11.12	22 per cent
Sri Lanka	50	12	24 per cent
Sudan	64.5	36.07	56 per cent

Swaziland	4.51	0.76	17 per cent
Syria	26.26	18.93	72 per cent
Tanzania	91	1.85	2 per cent
Thailand	409.944	82.75	20 per cent
Tunisia	4.56	2.23	49 per cent
Turkey	229.3	27.86	12 per cent
Uganda	66	0.12	0 per cent
Vietnam	891.21	48.62	5 per cent
Yemen	4.1	6.32	154 per cent
Zambia	105.2	1.32	1 per cent
Zimbabwe	20	2.24	11 per cent

Table 8-6 Irrigation for agriculture as a percentage of renewable water resources in 2000 for countries that could increase vegetable production after trade liberalisation. Source: Aquastat 2005.

Processing and preparing vegetables for the market (i.e. cleaning) requires large water inputs, so the areas in which processing is concentrated have high demands on their water resources. Some examples of the water use for processing are provided in Table 8-7 below.

Product category	**Water use in cubic metres per metric ton of product**
Canned vegetables	3.5-6.0
Frozen vegetables	5.0-8.5
Baby food	6.0-9.0

Table 8-7: Water usage in the vegetable processing industry. Source: World Bank 1998.

Outputs of processing include effluents with high organic loads, cleansing and blanching agents, salt and suspended solids such as fibres and soil particles. They may also contain pesticide residues. These outputs contribute to pollution of ground water and water courses. It is likely that processing would be concentrated outside the EU if trade were liberalised, further impacting water abstraction effects.

High nitrate use in vegetable production contributes to eutrophication of watercourses and wetlands. Research in Spain has shown that around 1 tonne of nitrogen is applied per hectare, of which 35 per cent leached into surface and groundwater (Sustain 1999). The nitrate content of groundwater has gradually increased in many areas where intensive farming is practised, the concentrations of nitrate ions systematically exceeding 100 mg/l in such areas, the value being as high as 300 mg/l in some zones. While efficiency of nutrient use is improving in many areas, vegetables remain a high input crop.

8.3.4 Resource use/waste, including pesticides

Vegetable production is demanding on resources since the quality and specific standards demanded by the market require a high input regime and result in wastage.

One of the major inputs for vegetable production is pesticides, which are used extensively and have resulted in water pollution, algal blooms, reduced food for wild birds and consumer health concerns. A wide range of pesticides are used for vegetable production on a regular basis. In developing countries producers do not generally have training in how or when to apply pesticides. Pesticides classified as extremely hazardous by the World Health Organisation (WHO), such as monocrotophos, are commonly used and a number of studies have found it common practice to spray and harvest tomatoes within 20 hours (PAN-UK 2005). However, all vegetables traded in the EU must meet pesticide maximum residue limits (MRLs), and retailers also have their own standards on pesticide residues.

Wastage occurs since vegetables are highly perishable and many are sub-standard quality for the European market. Wastage also occurs since EU producer organisations can remove vegetables from the market to control supply and therefore prices, and can either give the produce to charities or destroy it. They are, however, committed, to disposing of such surplus in ‘a way that takes account of the possible environmental effects’ (CEC 2003).

Packaging is an environmental priority issue in vegetable production, both in terms of resources used to make it and in terms of its disposal. Increasingly vegetables are packaged in bags and trays for the European market to transport them without reducing quality, although in some cases packaging is made from surplus produce. Wherever vegetables are produced, packaging is used, yet, within the EU, relatively strict regulations regarding waste minimise negative environmental effects, provided they are enforced. It could be argued that increases in imports to the EU resulting from trade liberalisation may not increase packaging, since similar volumes of packaging are required in intra-EU trade. By ending market regulation measures involving the removal of surplus vegetables from the market by EU producer organisations, trade liberalisation is likely to reduce wastage.

In areas where vegetables are grown under cover, disposal of plastic polytunnels has become a problem as they must be replaced annually. In southern Spain, the plastic is often burnt or left in heaps to blow around (Lawrence 2004). Trade liberalisation will only reduce this problem where it leads to increases in vegetables not produced under plastic or in areas with more effective procedures for waste management.

Processing of vegetables (such as cleaning, trimming, peeling, cooking, canning or freezing) produces high levels of waste water, biodegradable and non-biodegradable waste. In addition, processing operations are often seasonal, so peaks of waste are high. It is likely that processing would be concentrated outside the EU if trade was liberalised, often in areas with lower regulatory standards than the EU, so environmental impacts could be expected to increase.

8.3.5 Biodiversity

Vegetable production does not generally provide good wildlife habitats due to its short seasons, and high use of fertilisers and pesticides. On the other hand smallholdings that practice ‘bocage’ agriculture (i.e. small plots with mosaic habitats) can provide habitats for wildlife. This type of production is rare and is mainly carried out by semi-subsistence farmers.

Although measures exist in the EU to improve the relationship between agriculture and biodiversity (e.g. agri-environment measures) there are still many examples where vegetable production has threatened biodiversity. The over-abstraction of water for irrigation and the overuse of agro-chemicals are particular threats to biodiversity. There are cases of particularly valuable habitats such as rivers and wetlands becoming threatened by vegetable production (e.g. the Ebro and Guadalquivir Rivers in Spain, both Natura 2000 sites).

Outside the EU an increase in vegetable production would most likely replace current agricultural crops rather than be expanded into natural areas, although patterns will vary between regions and reliable evidence on this topic is scarce.

The expansion of organic vegetable production is expected to reduce negative environmental impacts (apart from perhaps for water abstraction), but has a particularly important role to play in terms of biodiversity, which depends on healthy water, soil and air. Within the EU, measures to support organic farmers exist, but outside the EU organic production has also increased rapidly, and this growth is expected to continue, due to demand from consumers largely in the EU and United States of America.

Box 8.2 Organic vegetable production in Zambia

In 1999 an organic producers' association OPPAZ was established, and since then production has increased. Exports of organic produce such as beans, sweet potatoes, potatoes, mushrooms and okra have been increasing rapidly, mainly to the UK. By 2002 exports of certified organic vegetables (reaching the UK's Soil Association organic standard) had reached 650 tonnes (Nkonde 2003).

8.3.6 Air quality

There are no significant air quality issues associated with vegetable production other than pesticide spray drift and nitrogen dioxide which have been mentioned elsewhere, although solid waste from processing can be odorous, particularly when onions are processed and ready-meals are prepared.

8.3.7 Climate change/greenhouse gas emissions

The transport of vegetables to provide year-round supplies is a major contributor to greenhouse gas emissions and climate change and one of the major environmental issues associated with the sector. Air freight is the biggest emitter of greenhouse gases, but road, rail and sea freight also contribute. Due to high seasonal demand and the need for perishable vegetables to arrive in top condition, air freight is widely used for transport.

A trend has emerged for more vegetables to be imported to the UK. The UK producers' share of the UK vegetable market decreased by two per cent in the five years from1991 to 1996 (from 81 per cent to 79 per cent) (Sustain 1999b). Figures on the environmental impacts of vegetable importation are not available so this is difficult to assess.

Although food transport is polluting, negative impacts on climate change may be lower when sourcing fresh unseasonal vegetables (or produce which cannot readily be grown in our climate) from abroad rather than providing the appropriate growing climate in greenhouses in Europe with its associated energy expenditure (Carlsson 1997).

8.3.8 Plant and animal health

Serious concerns exist about monocultures and plant health in commercially grown greenhouse crops. The warm, damp climate is ideal for fungi and bacteria resulting in outbreaks and correspondingly frequent use of fungicides and pesticides.

Hygiene issues exist with pre-prepared and pre-washed vegetables. Research has shown that listeria occurs in 6.5 per cent of bagged salads, and e. coli in 13 per cent (PHLS 2000).

8.3.9 Distributional impacts

Even in the absence of liberalisation, countries that are counter-seasonal to Europe (such as Argentina, Chile and South Africa) will always have high export levels to satisfy demand in the EU. Trade liberalisation could increase exports to the EU from these and other countries in Central and South America, the Middle East, Africa and China.

8.4 Analysis of impacts of current/forecast liberalisation proposals

It is not expected that trade liberalisation will have a large effect on vegetable production patterns. Socio-economic factors are likely to have more influence, as rising world populations and incomes and changing consumer tastes continue to drive demand.

Nevertheless, against this baseline of global increases in supply and demand, trade liberalisation is expected to encourage a shift in production away from the EU and towards the Middle East, Central and South America, China and Africa. The environmental impacts will differ depending on the local climate, legislation and management techniques. An absolute reduction in vegetable production in the EU is not expected. A decline in the EU’s market share would not be expected to have negative environmental impacts in itself, but increased imports of vegetables (particularly by air) raise concerns with regard to increased emissions of greenhouse gases.

8.5 Analysis of potential flanking measures

Table 8-8 summarises the key environmental impacts that are expected to result from liberalisation of world trade in vegetables, and highlights potential flanking measures. The impacts of vegetable production are many and varied, and often localised in nature, and a series of targeted policy responses are likely to be required. Many of these measures will be the responsibility of national or regional governments, with little scope for the UK to intervene.

The highest priorities for potential flanking measures, from the UK’s perspective, are likely to be:

- market based measures, involving labelling, standards and raising consumer awareness;
- measures concerned with technical assistance, capacity building etc; and
- measures to tackle the food miles issue, especially taxation of aircraft fuel.

International standards and certification schemes have an important role to play in the sector. The market for labelled produce is growing due to increasing consumer and government awareness of the health and sustainability benefits of certified produce.

EUREP-GAP already certifies much of the vegetable sector, particularly in the EU. Even outside the EU some vegetable producers are realising the benefits of production according to EUREP-GAP standards. In Peru, for instance, asparagus is grown according to EUREP-GAP guidelines.

There is an opportunity to promote further standards amongst producers, including for water use, and to encourage more producers to seek certification. Voluntary codes of practice could be promoted internationally, or amongst countries in regional trade agreements. The market in the EU for certified produce could also be bolstered by increasing awareness amongst consumers and improving labelling information.

Raising consumer awareness of the environmental impacts of “food miles”, coupled with existing rules on labelling country of origin, could go some way to addressing the impacts of liberalisation on greenhouse gas emissions.

It should be noted that supermarkets and large buyers such as Unilever have an influential position in the sector and many have already realised that sustainability should be a priority and are promoting integrated pest management, drip irrigation and even certain biodiversity measures in vegetable crops. Unilever, for instance, has focused on promoting pilot projects in Australia, Brazil and the UK demonstrating methods of sustainable production of peas, tomatoes and spinach (Unilever 2001). Capital grant schemes are also provided by Unilever to promote installation of drip irrigation systems. Partnerships between government and the food retailing and processing sectors therefore have an important potential role to play in enhancing the sustainability standards required of imported.

Raising awareness and capacity building could also have an important role to play. Current high levels of pesticide use and water abstraction could be addressed through the dispersion of knowledge of more sustainable management practices such as drip irrigation, IPM and organic production. Capacity building through technical assistance at the local level has proven to be an effective method of implementing more sustainable practices.

Water abstraction is an area in which ‘soft’ flanking measures should focus, since it has been mostly overlooked by certification schemes and standards at present. Sustainable water management in third countries cannot be required other than through indirect measures such as certification schemes or through the negotiation of international agreements, however it can be encouraged through awareness raising and capacity building.

Box 8.3 Local credit for drip irrigation installation
Drip irrigation is around 70 per cent more efficient than traditional irrigation, but high investment is required by farmers to install the pumps and hoses. To encourage the adoption of drip irrigation in Brazil a scheme has been devised to pay for installation, to be repaid by the farmers over three years out of their increased yields (Unilever 2001).

The UK and other EU countries could work through development assistance, education programmes and other measures to focus on sustainability in this part of the food sector.

The UK should continue to pursue initiatives designed to incorporate external costs more fully in long distance transport, particularly for air freight. One priority is to address aircraft fuel e.g. by reaching an international agreement on the taxation of aircraft fuel, which would be the single most effective measure in internalising the externalities of food miles (and indeed all air freight). Within the EU, there are also possibilities of including kerosene with the Emissions Trading Scheme.

8.6 Conclusions

The effects of trade liberalisation on vegetable production are not expected to be major, relative to current and predicted trends, but further liberalisation, both globally and through regional agreements, could increase production of some vegetables in certain areas.

The major environmental issues associated with vegetable production are water abstraction, pesticide use and the impacts of vegetable transport. Relocation of production would have mixed effects. There would be a risk of more water stress, increased air miles and less regulated pesticide use, but this could occur alongside reduced use of greenhouses and polytunnels. Water stress depends on the amount of irrigation needed and methods of irrigation, which are highly variable throughout the world. Pesticide use depends on the climate, advice, information and capital investments for application and disposal so would also be highly variable.

If the location of vegetable production did change, the environmental impacts would differ depending on where production took place. Water resources, methods of irrigation, pesticide use and greenhouse use differ between countries and regions, as do the nature of habitats, landscapes and the local environment. The overall effects of a shift in production are complex and could be both negative and positive. Promotion of sustainable vegetable production in areas where production might increase could be achieved by encouraging farmers to meet voluntary certification schemes to reach a niche market, increasing the market for certified vegetables in the EU through awareness campaigns, promoting minimum production standards at international and regional trade agreement level and increasing awareness of and capacity for drip irrigation, IPM and organic production. Partnerships between government and key importers, notably supermarkets and food processors, would appear to be a promising way forward. Efforts to decrease emissions stemming from transportation of vegetables could be tackled through an air fuel tax.

8.7 Further Research Needs

The research has identified the following key gaps in the available literature:

- Figures for food miles/emissions from transport of vegetables (food miles/emissions are usually grouped together for all foodstuffs).
- Pesticide consumption and management and impacts in the production of different vegetables in different regions.

- Evidence of the likely effects of trade liberalisation on patterns of production and trade is very limited, both in overall terms and in relation to different types of vegetables.
- Further research would be helpful in relation to the development of specific flanking measures, and particularly the role of product standards, labelling and certification schemes as a means of encouraging higher environmental standards among imports.

Promotion of sustainable vegetable production in areas where production might increase could be achieved by encouraging farmers to meet voluntary certification schemes to reach a niche market, increasing the market for certified vegetables in the EU through awareness campaigns, promoting minimum production standards at international and regional trade agreement level and increasing awareness of and capacity for drip irrigation, IPM and organic production. Partnerships between government and key importers, notably supermarkets and food processors, would appear to be a promising way forward. Efforts to decrease emissions stemming from transportation of vegetables could be tackled through an air fuel tax.

Table 8-8: Summary of impacts of liberalised trade in vegetable products, and potential flanking measures. Key impacts in bold.

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
Land use/landscape	Expected effect of liberalisation is reduced vegetable production in Europe (compared to a rising baseline), hence reduction of adverse impacts.	Not needed.	Possibility of Increased area of greenhouses/polytunnels	No specific measures proposed.
Soil	Expected effect of liberalisation is reduced vegetable production in Europe (compared to a rising baseline), hence reduction of adverse impacts.	Not needed.	Erosion. Loss of organic matter. Salinisation.	Guidelines for good practice developed and training offered.
Water quality and supply	Expected effect of liberalisation is reduced vegetable production in Europe (compared to a rising baseline), hence reduction of adverse impacts.	Not needed.	**Lowering of water tables.** **Salinisation of aquifers.** **Diffuse pollution.**	**Largely to be addressed locally – it does not seem appropriate for the UK to seek regulatory flanking measures to address this issue.** **Sustainable water use could be added as organic standard and to other certification schemes.**
Resource use/waste	Expected effect of liberalisation is reduced vegetable production in Europe (compared to a rising baseline), hence reduction of adverse impacts.	Not needed.	High pesticide inputs. Production of seasonal processing waste.	Training on IPM. Voluntary codes of practice. Labelling schemes Technical assistance
Biodiversity	Expected effect of liberalisation is reduced vegetable production in Europe (compared to a rising baseline), hence reduction of	Not needed.	Loss of aquatic habitats from water abstraction. Negative impacts from increased pesticide use.	Limits on abstraction in sensitive areas to protect internationally important sites. Encouraging use of IPM.

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
	adverse impacts.			
Air quality	Expected effect of liberalisation is reduced vegetable production in Europe (compared to a rising baseline), hence reduction of adverse impacts.	Not needed.	Pesticide spray drift Gas emissions	Training on pesticide use. Support for Good Practice
Climate change/greenhouse gases	**Increased greenhouse gas emissions from imports.**	**Air fuel tax or related measures. Consumer awareness programme to raise understanding of impacts of food miles.** **Engagement with retailers e.g. regarding labels, buying policy**	**Increased greenhouse gas emissions from exports.**	**Air fuel tax or related measures. Consumer awareness programme to raise understanding of impacts of food miles.** **Engagement with retailers e.g. regarding labels, buying policy**
Distributional impacts	No change or less vegetable production.	Not needed.	More vegetable production.	Publicising the benefits of EUREP-GAP or organic standards.

9 POULTRY

9.1 Brief Overview of the Poultry Sector

This case study focuses on global poultry production, primarily chickens (broiler production for meat and laying hens for eggs) although the sector also includes the production of turkeys, geese, ducks and other species e.g. guinea fowl. Chicken is estimated at 70 per cent of the total world poultry meat output whereas turkey, duck, goose and other species such as guinea fowl and quail only account for 7.5 per cent, 4.2 per cent, 2.8 per cent and 0.5 per cent respectively (FAO 2001).

There is strong international trade in the poultry meat sector (both fresh and processed products) with the US, China, EU, Brazil and Mexico dominating the market. Global poultry meat production and consumption are expected to increase sharply over the next seven years, by more than 20 per cent (an average annual growth of about 2.5 per cent). Most of this growth is expected to take place in developing countries.

Poultry meat and eggs continue to be the most efficient and economical way to convert feed grains into animal protein. Most of the growth in production is attributed to intensification of production, vertical integration of the industry, relatively low feed prices and further processing. Poultry production and processing technologies have become readily accessible and implemented on a worldwide basis.

Prior to World War II, the majority of poultry in countries such as the United States of America and the members of the European Union was reared in backyard flocks on dirt-floored pens and in small sheds with natural or make-shift ventilation. These countries have now largely shifted to vertically integrated production systems starting with breeding flocks, moving through broiler production to processing and distribution. The same trends have been witnessed in much of the Asia-Pacific Region in recent years; in the mid 1990s, 80 per cent of poultry production in Thailand came from just 10 large, vertically integrated companies. Concentration and specialization of the poultry industry have led to the development of allied industries. These industries supply housing, feeding and other equipment, hatchery equipment, processing supplies and equipment, drugs and other health products, feed additives, and several other items. At one time, there were many distinct breeds of chicken, each having particular traits or characteristics. Through selective breeding only a few strains of birds dominate the market today. There are many primary breeding companies of poultry but only a handful are responsible for the majority of broiler chicken, laying hen and turkey production in the world.

Production in the US is indicative of the intensification of the poultry industry and the shift to a highly mechanized and concentrated industry. The birds used in the industry have been developed through intensive research and have pedigrees protected by patents and trade secrets. This has led to the broiler industry and the egg industry both experiencing enormous gains in output, shown by the fact that the feed conversion in 1920 averaged 13 kg of feed to one kg of broiler meat. By 1990, the conversion rate was 1.9 kg of feed to one kg of broiler meat. For the egg industry, the change has been no less spectacular: in 1930 hens averaged 93 eggs per year, but by 1983, the average was 246 eggs per year. Processing of poultry meat has also experienced dramatic change through the industry adopting new technology. In 1959, the United

States industry processed seven million birds, with the typical plant handling about 3 000 birds per hour. In 1997, 65 million birds were processed and the throughput of a typical plant was 32 500 birds per hour. By 2005, 125 million birds are forecast to be processed each year, with processors handling 62 500 birds per hour.

In sharp contrast to this industrialised production across the globe, in many developing countries poultry production is still largely based on scavenging indigenous chickens or backyard production; in most African countries, over 70 per cent of poultry products and 20 per cent of animal protein comes from this sector.

In more recent years, consumer concerns about animal welfare have led to some changes in production methods with the banning of battery cages in the EU from 2012 and the growth of free range and organic systems. However, these still account for a relatively small proportion of production globally.

9.2 Effects of Trade Liberalisation on the Sector

9.2.1 Current Patterns of Production, Consumption and Trade

World production of poultry meat is expected by the FAO to total almost 80 million tonnes in 2005 (Table 9-1). Almost one third of production occurs in Asia, and a further quarter in North America. Developing countries now account for 54 per cent of production of poultry meat, having overtaken developed countries in recent years.

	1997	**2005**	**2005**	**97 to 05**
	000te	*000te*	*per cent share*	*per cent growth*
Africa	2,744	3,535	4.4 per cent	28.8 per cent
North America	15,924	19,630	24.5 per cent	23.3 per cent
Central America and Caribbean	2,267	3,459	4.3 per cent	52.6 per cent
South America	7,484	13,253	16.6 per cent	77.1 per cent
Asia (excluding CIS)	19,249	25,654	32.1 per cent	33.3 per cent
Western Europe	8,634	9,011	11.3 per cent	4.4 per cent
Eastern Europe	1,620	2,402	3.0 per cent	48.3 per cent
Baltics	40	77	0.1 per cent	92.5 per cent
Oceania	694	898	1.1 per cent	29.4 per cent
CIS12	963	2,043	2.6 per cent	112.1 per cent
World	**59,619**	**79,962**	**100.0 per cent**	**34.1 per cent**
of which:				
Developed Countries	30,053	36,722	45.9 per cent	22.2 per cent
Developing Countries	29,566	43,240	54.1 per cent	46.2 per cent

Table 9-1: World Production of Poultry Meat. Source: FAO (www.fao.org)

Table 9-2 presents data on poultry meat exports by world region. Exports are expected to total 8.2 million tonnes in 2005, just over 10 per cent of total output. North America and South America together account for almost 70 per cent of the internationally traded market.

	1997	2005	2005	97 to 05
	000te	*000te*	*per cent share*	per cent growth
Africa	7.1	17.2	0.2 per cent	142.3 per cent
North America	2,679.2	2,840.0	34.7 per cent	6.0 per cent
Central America and Caribbean	12.1	9.4	0.1 per cent	-22.3 per cent
South America	454.4	2,842.6	34.7 per cent	525.6 per cent
Asia (excluding CIS)	1,247.4	936.6	11.4 per cent	-24.9 per cent
Western Europe	898.7	1,100.7	13.4 per cent	22.5 per cent
Eastern Europe	223.2	348.7	4.3 per cent	56.2 per cent
Baltics	186.7	53.0	0.6 per cent	-71.6 per cent
Oceania	17.7	22.1	0.3 per cent	24.9 per cent
CIS12	14.4	22.2	0.3 per cent	54.2 per cent
World	**5,740.9**	**8,192.5**	**100.0 per cent**	42.7 per cent
of which:				
Developed Countries	4,033.9	4,402.6	53.7 per cent	9.1 per cent
Developing Countries	1,707.0	3,789.9	46.3 per cent	122.0 per cent

Table 9-2: Poultry Meat Exports, by World Region. Source: FAO, www.fao.org

Asian countries are expected to account for 41 per cent of world imports in 2005, with the CIS12 (20 per cent) and Central America and the Caribbean (11 per cent) also major importers. In net terms, North America, South America and (to a lesser extent) Western Europe are major net exporters of poultry meat, while Asia, Central America, the former Soviet Union and Africa are significant net importers (Table 9-3). In overall terms, the developed countries are net exporters to the developing countries.

	1997	2005	2005	97 to 05
	000 te	*000te*	*per cent share*	*per cent growth*
Africa	236.3	742.8	9.1 per cent	214.3 per cent
North America	99.2	232.3	2.8 per cent	134.2 per cent
Central America and Caribbean	444.2	928.8	11.4 per cent	109.1 per cent
South America	98.0	182.6	2.2 per cent	86.3 per cent
Asia (excluding CIS)	2742.4	3339.7	41.0 per cent	21.8 per cent
Western Europe	324.8	557.7	6.8 per cent	71.7 per cent
Eastern Europe	171.1	424.0	5.2 per cent	147.8 per cent
Baltics	219.0	109.0	1.3 per cent	-50.2 per cent
Oceania	27.9	47.1	0.6 per cent	68.8 per cent
CIS12	1648.0	1590.0	19.5 per cent	-3.5 per cent
World	**6010.9**	**8154.0**	**10.2 per cent**	**35.7 per cent**
of which:				
Developed Countries	3176.6	3744.5	45.9 per cent	17.9 per cent
Developing Countries	2835.2	4412.1	54.1 per cent	55.6 per cent

Table 9-3: Poultry Imports, by World Region Source: FAO, www.fao.org

World production of hen eggs totalled 56 million tonnes in 2003, having increased from 47 million tonnes in 1997 (Table 9-4). Two thirds of production is now in developing countries. Less than 2 per cent of output is exported, with nearly 70 per cent of exports coming from developed countries. Imports are also dominated by developed countries; this is because a large proportion of world trade in hen eggs involves movement between developed countries, e.g. intra EU trade.

	1997	**2003**	**2003**	**97 to 03**
	000 tonnes	*000 tonnes*	*per cent share*	*per cent increase*
Production				
Developed Countries	17,630	18,728	33.3 per cent	6.2 per cent
Developing Countries	28,943	37,508	66.7 per cent	29.6 per cent
World	**46,574**	**56,236**	**100.0 per cent**	20.7 per cent
Exports				
Developed Countries	682	725	69.6 per cent	6.3 per cent
Developing Countries	191	316	30.4 per cent	65.8 per cent
World	**872**	**1041**	**100.0 per cent**	19.3 per cent
Imports				
Developed Countries	604	673	68.4 per cent	11.4 per cent
Developing Countries	264	311	31.6 per cent	17.4 per cent
World	**869**	**984**	**100.0 per cent**	13.2 per cent

Table 9-4: Production and Trade in Hens Eggs. Source: FAO www.fao.org/faostat

At a national level, the US is the world's largest producer of chicken meat, with output of 14.9 million tonnes in 2003. China and Brazil are the second and third largest producers (Table 9-5). China is by far the world's largest producer of hens eggs, with estimated output of 22 million tonnes in 2003, followed by the USA, Japan, India and Russia.

Rank	**Chicken meat**		**Hens Eggs**	
	Country	***Weight (Mt)***	***Country***	***Weight (Mt)***
1	USA	14,927,000	China	22,156,950
2	China	8,897,964	USA	5,168,500
3	Brazil	7,760,500	Japan	2,505,508
4	Mexico	2,150,000	India	2,155,000
5	India	1,601,890	Russia	2,040,000
6	UK	1,300,000	Mexico	1,881,770
7	Japan	1,236,872	Brazil	1,550,000
8	Thailand	1,231,618	France	988,200
9	France	1,180,000	Indonesia	881,300
10	Russia	1,028,559	Germany	814,00

Table 9-5: Top 10 producing countries by commodity in 2003 (FAO). Source: FAO (www.fao.org).

Brazil is the world's largest exporter of chicken meat, with exports valued at $1.7 billion in 2003, followed by the USA, the Netherlands, France and Thailand. The Netherlands is the largest exporter of hens eggs, with exports worth $265 million in the same year. The USA, Spain, Germany, Belgium and France are also major exporters (Table 9-6).

Rank	Chicken meat		Hens Eggs	
	Country	***Value '000 US$***	***Country***	***Value '000 US$***
1	Brazil	1,709,743	Netherlands	265,236
2	USA	1,517,377	USA	121,035
3	Netherlands	931,859	Spain	109,598
4	France	615,926	Germany	97,312
5	Thailand	597,634	Belgium	95,410
6	Belgium	466,267	France	87,116
7	Germany	362,764	China	42,921
8	China	288,913	Malaysia	42,825
9	Denmark	213,667	India	29,912
10	UK	201,788	Italy	29,403

Table 9-6: Top 10 exporting countries (by value) by commodity in 2003 (FAO). Source: FAO (www.fao.org)

The largest import markets for chicken are the UK ($924m), Japan ($741m), Russia ($631m), Saudi Arabia ($457m) and China ($412m). For hens eggs, the five largest import markets are all EU countries (Germany, the Netherlands, France, the UK and Belgium, Table 9-7). These figures demonstrate the importance of short distance movements in international trade, especially for hens eggs, where EU countries export to each other.

Rank	Chicken meat		Hens Eggs	
	Country	***Value '000 US$***	***Country***	***Value '000 US$***
1	UK	924,417	Germany	303,288
2	Japan	741,326	Netherlands	113,591
3	Russia	630,689	France	85,866
4	Germany	513,036	UK	68,720
5	Saudi Arabia	456,649	Belgium	47,749
6	China	412,121	Singapore	43,790
7	Netherlands	360,211	Switzerland	34,582
8	France	281,345	Canada	34,188
9	Belgium	168,413	Austria	29,308
10	Mexico	158,624	Mexico	26,678

Table 9-7: Top 10 importing countries (by value) by commodity in 2003 (FAO) Source: FAO (www.fao.org)

9.2.2 Recent Trends in Production, Consumption and Trade

World production of poultry meat has increased by 34 per cent between 1997 and 2005, with growth occurring in all regions of the world. The most rapid output growth has occurred in the former Soviet Union, followed by South America, Central America and the Caribbean, and Eastern Europe (Table 9-1). According to the FAO, growth in poultry meat production has accounted for more than 50 per cent of growth in meat output in the last decade.

Table 9-2 demonstrates that exports increased by 42 per cent between 1997 and 2005. A large proportion of this growth took place in South America, where there was a six fold increase in export volumes. Exports from Asian countries declined over this period, as growth in production was outstripped by growth in consumption. Exports from developing countries more than doubled, while those from developed countries increased by only 9 per cent.

Import trends between 1997 and 2005 are given in Table 9-3, and indicate that imports grew in most world regions over this period, with faster growth in developing than in developed countries.

Table 9-4 indicates that world trade in hen eggs increased by 20 per cent between 1997 and 2003, with developing countries increasing their share of production and trade over this period.

Between 2000 and 2015, world demand for eggs is expected to increase by 1.9 per cent p.a., with growth in developing countries at 2.6 per cent p.a. Global demand for poultry meat is expected to average 2.6 per cent p.a., with demand in developing countries increasing by 3.5 per cent p.a. These increases depend on the availability and price of feed (Gillin, 2003).

9.2.3 The Effects of Government Policy

Production of poultry meat and eggs is less subsidised than that of many other agricultural commodities. The OECD producer support estimates (PSE)[4] for poultry and eggs were equivalent to 17 per cent and 8 per cent respectively of the value of production in OECD countries between 2001 and 2003. Moreover, these PSE estimates have declined from 20 per cent and 17 per cent respectively in 1986/88. Of all agricultural commodities measured by the OECD, only wool had a lower PSE (5 per cent). For poultry, the PSE was highest in Switzerland (83 per cent), Iceland (85 per cent) and Norway (66 per cent). Support was relatively high in the EU (37 per cent), but low in the US (4 per cent), Japan (11 per cent) and Australia (3 per cent). Egg production was heavily subsidised in Switzerland (75 per cent PSE), Iceland (68 per cent) and Norway (44 per cent), but not in the EU (2 per cent) or US (4 per cent).

Because poultry is the least protected of the meat sectors, it is characterised by the fewest new market access opportunities under the Agreement on Agriculture. Canada and Mexico contribute the main share of TRQ access opportunities. The AoA has also limited export subsidies, with limits reduced from 802,000 tonnes in 1995 to 594,000 tonnes in 2000. However, the actual use of subsidies is lower than this, with only the EU and Hungary regularly using their allocations (FAO, 2002).

The EU market organisations for poultry and eggs aim to structure and safeguard the stability of market prices in the sector, to facilitate the marketing of products and to establish rules on trade with third countries in order to maintain farmers' incomes. The poultry regime covers a wide range of products including chicken and chicken products, ducks, geese, turkeys and guinea fowl. Trade for both meat and eggs is regulated through a series of import and export licenses, tariffs, import levies, tariff quotas, export refunds and marketing standards. The latter relate to grading by

[4] The OECD's Producer Support Estimate is a measure of the annual monetary transfers from taxpayers and consumers to farmers, through market price support and direct payments.

category, quality, weight and labelling. Exceptional market measures may be taken in the event of animal diseases.

9.2.4 Scope and Agenda for Further Liberalisation

Because poultry meat and egg production are less subsidised and protected than most other commodities, they tend to receive less attention in the debate about trade liberalisation. There is, however, likely to be further pressure to reduce domestic support, improve market access and phase out export subsidies.

Much of the trade liberalisation debate in the poultry sector relates to the regulation of trade, with the issues of standards and labelling prominent. Concerns are expressed by developed country producers about quality, environmental, animal health and food safety standards relating to foreign imports (e.g. British Poultry Council, 2003, 2004). Indeed, an EFRA Committee Inquiry into Poultry Farming in the United Kingdom expressed concern about the ability of the British industry to compete with imports produced to lower standards overseas, and argued that "it is appropriate for those who wish to sell in our marketplace to meet the standards expected of our own producers." The report called for the Government and its EU partners to develop a strategy to ensure that all poultry meat, eggs and products containing them conform to the EU's food safety, animal welfare and environmental standards.

9.2.5 Expected Impact of Liberalisation on Patterns of Production, Consumption and Trade

Trade liberalisation has already had significant impacts on poultry production, with the Agreement on Agriculture being followed by surges in poultry imports in several developing countries. In Indonesia, improved market access for poultry imports, accompanied by a large increase in the cost of imported feed grains, led to an 80 per cent contraction in the domestic chicken producing sector in the late 1990s. Sri Lanka's chicken and egg producers also came under threat from cheap imports, with many being forced out of business (Khor, 2002).

Studies modelling the effects of further trade liberalisation in the poultry sector are few in number. Given that poultry tends to be subject to less support and protection than most other agricultural commodities, few studies are dedicated to the sector, and most evidence is available in multi-commodity studies, which tend to provide little detail about expected impacts.

FAPRI (2002) used their model to assess the effects for a variety of commodities of a full trade liberalisation scenario and a trade only scenario, the latter considering the removal of border measures only. Under both scenarios, the US, Brazil and Thailand make significant gains in poultry export markets, with their exports increasing by 25 per cent, 24 per cent and 42 per cent respectively in the full liberalisation scenario. The removal of duties and subsidies result in a 47 per cent decline in net exports from the EU. The removal of prohibitive duties on imports turns Canada into a major net importer of poultry. Japan's broiler imports decline by 12 per cent under both scenarios, as the removal of its already low duties is offset by a rise in the world poultry price, as well as a switch in favour of beef and pork caused by larger duty cuts for those commodities. Imports to the Philippines increase significantly, in response to a removal of the 45 per cent duty.

The world price of broilers increases by 8 per cent by 2011, compared to the baseline. Production increases by 4 per cent in Brazil and 4 per cent in Thailand by 2011, and declines by 6 per cent in the EU, 4 per cent in China and 18 per cent in Canada, compared to the baseline. However, the absolute level of production rises substantially in all of these countries, as the effects of rising consumer demand outweigh the effects of trade liberalisation.

USDA (2001) used a combination of modelling approaches to examine the effects of trade liberalisation on markets for a range of agricultural commodities. They predicted that the elimination of EU export subsidies would result in a 12 per cent reduction in the EU poultry price, a 3 per cent increase in the world price, a 5 per cent decline in EU poultry production and a 30 per cent decline in exports. US production would increase by 0.4 per cent and exports by 1.1 per cent.

Vanzetti and Graham (2002) used ATPSM, a static, multi-commodity, multi-region partial equilibrium model to forecast the effects of trade liberalisation scenarios. Poultry meat prices were forecast to increase by 1.5 per cent under the Uruguay Round continuation scenario, involving a 36 per cent reduction in outquota tariffs, 21 per cent reduction in export subsidies and 20 per cent cut in domestic support in developed countries, with two thirds of these cuts in developing countries and no cuts in least developed countries. Liberalisation in developed countries only would lead to a 0.6 per cent increase in prices.

USDA (2003) considered a variety of different factors affecting growth in India's poultry sector, which is being affected by increasing consumer demand, vertical integration of production and marketing, and the price and availability of feed. Using a simple economic model, the authors predicted that income growth would increase production and consumption of poultry meat by 66 per cent and of eggs by 17 per cent between 2001 and 2010. Compared to this baseline scenario, a scenario introducing free trade in corn (zero tariff and no quota from 2002) would increase production and consumption of poultry by 11 per cent and eggs by 17 per cent. This is a result of a 36 per cent reduction in the wholesale price of corn and hence a 14 per cent increase in feed use, accompanied by a substantial increase in corn imports. The study concluded that, by reducing the cost of key inputs, trade liberalisation had an important role in fuelling the expansion of the industry, reinforcing the effect of economic growth and increased vertical integration.

Huang (undated) used the CCAP Agricultural Policy Projection and Simulation Model (CAPSiM), a partial equilibrium single country model, to forecast the effects of trade liberalisation by China on domestic agricultural markets. The model predicted that trade liberalisation will increase the prices of poultry and eggs in China by 10 per cent and 4 per cent respectively, by enabling an increase in China's exports. Production of poultry, which was forecast to increase by 4.7 per cent per year between 2000 and 2005 under the baseline scenario, increases by 7.4 per cent per year under the free trade scenario, as a result of higher product prices and lower prices for feed grains. Higher poultry prices reduce consumption growth from 4.6 per cent to 3.7 per cent per year. Net imports in 2005 are 1.5 million tonnes lower under the trade liberalisation scenario. Similar impacts occur in the egg sector, where annual production growth increases from 4.2 per cent to 6.3 per cent, consumption growth declines from 4.2 per cent to 3.9 per cent and net imports are reduced by 1.9 million tonnes in 2005.

Chang (2004), in a study of the Philippine poultry industry, concluded that the sector is relatively uncompetitive because of a combination of high input costs, low productivity and inefficient marketing. The sector is protected by tariffs, and trade liberalisation is therefore expected to lead to negative impacts on domestic production, including both commercial and small scale, back yard systems. Improvements in production and marketing efficiency were considered important for the industry's survival.

The expected effects of trade liberalisation can be summarised as follows:

- There will be a moderate increase in the world price of poultry, by up to 10 per cent under full liberalisation, compared to the baseline.
- There will be an increase in production among low cost producers, such as Brazil, Thailand and the US, at the expense of countries that currently subsidise and protect their poultry sectors, such as Canada and Western European countries. The shift in the share of world exports will be more significant.
- The effects of liberalisation are relatively insignificant compared to global trends in the expansion of production and consumption, so production may increase even in Canada and the EU, which lose market share to lower cost producers.
- In many countries, the effects of liberalisation of the cereals market could be more significant than those of the poultry market itself. In China and India, for example, cheaper grain will help to fuel expansion in production of poultry meat and eggs.

9.3 Environmental impacts

The main environmental issues associated with intensive poultry production are as follows:

- Soil contamination including pathogens and heavy metals arising from disposal of poultry manure
- Air pollution by gases such as ammonia and methane and dust and pathogens arising from production units and manure storage and disposal
- Odours arising from production units and manure storage and disposal. Also other nuisances such as flies.
- Water pollution by nitrates and phosphates arising mainly from the disposal of poultry manure
- Excessive water use particularly in relation to poultry processing plants and for egg washing

The main impacts of poultry production arise from the disposal of litter (a mixture of excreta, feathers, wasted feed and bedding materials) or liquid manure. While these products are excellent sources of nutrients, they can also be highly toxic if mishandled or applied incorrectly. Broiler houses and laying units produce large quantities of litter and/or manure. A 40 x 400 ft broiler house will produce about 105 tons of litter annually. Disposing of these waste materials is a major undertaking for the poultry industry. Most intensive poultry farmers do not own land beyond that occupied by broiler/laying houses and associated buildings and hence need other farmers to take manure. Application to agricultural land is the most common method of disposal of poultry litter and manure in developed countries (no information could be found for disposal methods in developing countries) although manure is now also being used in some countries as a fuel for power plants to generate electricity (see section on Resource Use). For many years, poultry litter was also added to animal feed compounds as a low cost source of protein. This practice has now been banned in many countries following outbreaks of bovine spongiform encephalopothy (BSE).

Given that poultry production occupies relatively small areas of land compared to the production of other agricultural commodities, direct impacts on biodiversity are less commonly associated with it. Biodiversity impacts arise mainly indirectly and in two ways: first, as a result of the impacts of production on soil, air and water resources e.g. pollution of water by nitrates leading to eutrophication with knock-on impacts on aquatic biodiversity; and, secondly, as a result of land being used to produce feed for intensive livestock systems including poultry. The location and design of poultry production units can also have negative impacts on the landscape but these are more likely to be relatively localised than other impacts.

Very little data on the environmental impacts of poultry production could be found in the literature. The most comprehensive information can be found in the US (the world's largest producer of chicken meat) and is drawn from the US Environment Protection Agency website. However much of this describes the general impacts of production with little information available for the scale, distribution and intensity of impacts. As a result, what follows is a general description of the environmental impacts associated with intensive poultry production.

9.3.1 Land Use and Landscape

There is relatively little evidence that poultry production has a major impact on land use[5] or landscapes given that production units and processing plants occupy relatively small areas of land compared to the production of other commodities. However, concerns have been expressed in the US (UPC 2005) about damage to wildlife habitats and landscape impacts arising from the erection of new poultry houses, processing plants and trailer parks to accommodate workers. Wider land use impacts in relation to poultry production may arise from the production of feedstuffs; wheat and soya are major components of poultry feed and the production of these crops will have associated environmental impacts. The expansion of free range systems may result in wider landscape and other environmental impacts.

9.3.2 Soil

Potential contaminants from litter and manure include excess nutrients, chemicals, heavy metals and pathogens. The main impact of these contaminants is primarily in relation to water resources (see Section 9.3.3 below) following run-off or leaching from soils. However, heavy metals such as copper, zinc and arsenic can be present in litter and manure and can affect soil fauna such as earthworms.

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[5] Impacts on land arising from the disposal of large quantities of poultry manure and other waste are discussed in the sections on soil and water.

9.3.3 Water quality and supply

9.3.3.1 Water quality

Excess nutrients (nitrogen and phosphorus), chemicals (including veterinary products and antibiotics), heavy metals and pathogens contained in manure are all potential contaminants of water. Such contaminants reach surface waters through run-off and tile drainage and ground water through leaching. Nitrogen and phosphorus accelerate algae production in surface waters resulting in a range of impacts including clogged pipelines, fish kills and reduced recreational opportunities.

Most available data on the impacts of poultry production on water resources can be found in the US. When animals are concentrated geographically, operators may have difficulty finding enough land off the producing farm to fully assimilate the nutrients in the manure. USDA estimates that recoverable manure nitrogen exceeds crop system needs in 266 of 3,141 counties in the U.S. (8 per cent) and that recoverable manure phosphorus exceeds crop system needs in 485 counties (15 per cent). These excess nutrients are a serious risk to ground and surface waters.

The US Environment Protection Agency’s 1998 National Water Quality Inventory indicates that agricultural operations, including animal feeding operations (AFOs), are a significant source of water pollution in the U.S. The States estimate that agriculture contributes in part to the impairment of at least 170,750 river miles, 2,417,801 lake acres, and 1,827 estuary square miles. Agriculture was reported to be the most common pollutant of rivers and streams in the US. While poultry production is not the only source of pollution it represents a significant problem due to the high nutrient value of litter and manure. In 1997, poultry were estimated to generate 60 per cent of all excess nitrogen on confined animal farms and 61 per cent of excess phosphorus. While dairy farms made up nearly half of all confined animal farms, they generated only 7 per cent of excess nitrogen and 5 per cent of excess phosphorus.

Pathogens from manure may also be a cause of water contamination and present risks to human health. The treatment of public water supplies reduces the risk of infection via drinking water. However, protecting source water is the best way to ensure safe drinking water. Cryptosporidium parvum, a protozoan that can produce gastrointestinal illness, is a concern, since it is resistant to conventional treatment. Healthy people typically recover relatively quickly from such illnesses. However, they can be fatal in people with weakened immune systems such as the elderly and small children. Runoff from fields where manure has been applied can be a source of pathogen contamination, particularly if a rainfall event occurs soon after application. The natural filtering and adsorption action of soils typically strands microorganisms in land-applied manure near the soil surface. This protects underlying groundwater, but increases the likelihood of runoff losses to surface waters. Depending on soil type and operating conditions, however, subsurface flows can be a mechanism for pathogen transport. Experiments on land-applied poultry manure have indicated that the population of fecal organisms decreases rapidly as the manure is heated, dried, or exposed to sunlight on the soil surface (EPA).

9.3.3.2 *Water supply*

The most significant use of water by the poultry industry is for egg washing and meat processing. The following information is sourced from the UNEP Working Group for Cleaner Production in the Food Industry: Fact Sheet 7 Food Manufacturing Series.

Like many other food processing activities, the necessity for hygiene and quality control in meat processing results in high water usage and consequently high wastewater generation. In poultry processing plants, as well as being used for carcass washing and cleaning, water is also used for hot water scalding of birds prior to defeathering, in water flumes for transporting feathers, heads, feet and viscera and for chilling birds. As a result poultry processing tends to be more water intensive on a per unit of production basis than red meat processing. Water consumption rates are in the range 15-90 kL/1,000 birds processed and vary considerably depending on the type of process used. For poultry processing, taking advantage of more water efficient processes and equipment can make significant gains. For example the use of pneumatic waste handling systems instead of water fluming systems and the use of modern scalding systems significantly reduce water consumption. There are also opportunities for reusing wastewaters, for example by using scald water overflow for the plucking flume and by recycling chiller water.

Volumes of wastewater from meat processing are generally 80-95 per cent of the total freshwater consumption. Fresh water consumption has a major impact on the volume and pollutant load of the resulting wastewater. Wastewaters generally have high organic loads and are also high in oils and grease, salt, nitrogen and phosphorous.

Meat processing operations, which are often located in rural areas, generally treat wastewater in biological lagoons and irrigate the treated wastewater to land. Reducing the salt and nutrient (nitrogen and phosphorous) content of the wastewater and establishing sustainable irrigation practices is therefore desirable. Plants located in metropolitan areas generally treat and discharge wastewater to municipal sewage systems.

The efficient recovery and segregation of blood is an important means of reducing the pollution loads in wastewaters, since blood is a highly polluting substance. An operation with an efficient blood recovery system will have a 40 per cent lower polluting load than one that allows blood to flow to the wastewater stream. Other opportunities for reducing the pollutant load of wastewaters are: the removal and recovery of solids from the wastewater stream by screening, the use of biodegradable detergents and sanitisers, the collection of paunch manure and intestinal contents without the use of water and the provision of receptacles to catch hair and meat trimmings. Additionally, biological treatment of wastewater will reduce organic load and to some extent nutrients.

9.3.4 Resource use/waste

Fuel for space heating is typically the single greatest operating expense for broiler and turkey producers. At the same time there are increasing pressures on poultry producers to embrace alternative management practices for surplus litter (due to environmental concerns associated with traditional land application of the litter). One option is to convert the litter into thermal energy and use the heat for space heating, thereby displacing some of the fossil fuel otherwise consumed at the site. Recognizing these potential economic benefits as well as the potential benefits associated with on-site management of the surplus litter (including reduced regulatory scrutiny and potential liability associated with traditional land application of the surplus litter), numerous efforts have been invested in the US in the past twenty years to develop on-farm litter-fired energy systems for heating poultry houses. Most efforts have used combustion or gasification technologies coupled with air-to-air or water-based heat exchangers for delivery of the heat into the poultry house. Most systems, at least during development stages, have been single house units, although some systems were designed from the onset to heat two or more houses per furnace unit.

But the challenges of developing a viable farm-scale litter-fired furnace system are significant. To date, no such systems have been developed that are commercially available, despite substantial past investments in research and development activities by both the public and private sectors in the US. However, because of increasing regulatory pressures and increasing energy prices, the potential benefits and attractiveness of on-farm litter-to-energy systems are greater than ever; accordingly, several efforts are currently underway in the US to develop and deploy such systems.

Large-scale, centralized litter-to-energy systems represent another approach for addressing environmental concerns associated with traditional management of surplus litter while also generating renewable energy from litter fuel. Key considerations associated with centralized litter-to-energy systems include:

- Energy products that can be made from litter include thermal and/or electrical energy and liquid fuels. Thermal energy is generally the most attractive option, although siting options are limited to locations where litter can be processed adjacent to a large thermal load. Electrical energy provides greater flexibility in that siting options are much less restricted and the electricity can be transported to end-users via existing power lines. Converting poultry litter into liquid fuels (e.g., ethanol, bio-oil) is attractive for numerous reasons, although recent assessments of litter-to-ethanol options concluded that the characteristics of litter make it much less attractive than other biomass feedstocks and that cellulose-to-ethanol conversion technologies are not yet ready for commercialisation.
- Technologies for converting litter into electricity are already proven and at commercial scale, which minimizes the technological risk for such systems. Four large-scale litter-to-electricity processing facilities are already in operation in the U.K., with additional sites under development in the U.S. The U.K. sites include three facilities in England owned and operated by Fibrowatt Ltd. (using spreader-stoker and travelling grate boiler designs) and one facility in Scotland owned and operated by Energy Power Resources Ltd. (using a fluidised bed boiler design). Fuel consumption at the four sites range from about 110,000 dry tons of litter per year to over 400,000 dry tons of litter per year, with operating experiences ranging from one to ten years.
- Unlike other litter-derived products (e.g., compost, pellets), long-term product purchase contracts for litter-derived electricity can be arranged (for ten-, fifteen-, or even twenty-year periods). Such long-term commitments can greatly reduce the financial risks associated with large-scale litter processing facility.

- All of the phosphorus and most of the other nutrients in the litter survive the conversion process as ash. The nutrient-rich ash co-product has significant market value as a fertilizer ingredient. The material has high bulk density and is readily transportable to distant agricultural markets out of a region of concentrated poultry production (thereby addressing surplus phosphorus concerns in such areas).

Aggregation of the litter feedstocks is one of the greatest challenges for large-scale litter-to-energy systems. Various ideas are being explored in the US including 'litter banks' and the use of federal taxes to fund litter-to-energy initiatives.

9.3.5 Air quality

9.3.5.1 Air emissions

The main gaseous emissions arise from poultry housing, manure storage facilities and land application of manure. Much of the nitrogen consumed in livestock diets is excreted in manure as urea (uric acid for poultry); this is readily broken down to ammonia. Estimates of whole farm ammonia emissions suggest that as much as 35 per cent of emissions may occur during land application of manure. Ammonia is damaging to the natural environment because it:

- contributes to acid rain which can damage forests, lakes and rivers; and
- adds nitrogen to nutrient-poor soils which can change the type of vegetation that grows there.

Strategies to reduce ammonia from animal housing focus primarily on preventing ammonia formation and volatilisation, or downwind transmission of ammonia after it is volatilised.

9.3.5.2 Odour

Odour emissions from animal production systems originate from three primary sources: manure storage facilities, animal housing, and land application of manure. Odour from animal feeding operations is not caused by a single compound, but is rather the result of a large number of contributing compounds including NH3, volatile organic compounds (VOCs), and H2S. A further complication is that odour involves a subjective human response. What is objectionable to some is not to everyone. The most common odour complaint by the public associated with poultry production is related to land application of manure. When manure is land applied, it is typically applied to an area up to 700 times the surface area of the original storage, creating a large but short-term downwind odour plume.

For odour to be detected, odour-producing compounds must have been produced, released and transported downwind. A complex mixture of gases produce the odour associated with a poultry operation. Some of the principal classes of odorous compounds are: amines, sulfides, volatile fatty acids, indoles, skatoles, phenols, mercaptans, alcohols, and carbonyls. Ammonia creates strong odours near manure storage areas and poultry buildings themselves, but is not a significant component of odour downwind from a poultry farm.

9.3.5.3 Dust, pathogens and flies

Dust, pathogens, and flies from animal operations are also sources of airborne emission concerns. Dust, a combination of manure solids, dander, feathers, hair, and feed, is very difficult to eliminate from animal production units. It is typically more of a problem in buildings that have solid floors and use bedding as opposed to slotted floors and liquid manure. Concentrations inside animal buildings and near outdoor feedlots have been measured in a few studies. In 1998, the UK poultry sector was estimated to produce 10,000 tonnes of aerial dust annually. Dust can create respiratory problems in both animals and humans and can also carry gases and odours. A large portion of odour associated with exhaust air from ventilated poultry houses is dust particles that have absorbed the odour from within the house.

Pathogens are another airborne emission concern. Although pathogens are present in buildings and manure storage units, they typically do not survive aerosolisation well, but some may be transported by dust particles.

Flies are an additional concern from certain types of poultry and livestock operations. The housefly completes a cycle from egg to adult in 6 to 7 days when temperatures are 80 to 90°F. Females can produce 600 to 800 eggs, larvae can survive burial at depths up to 4 feet, and adults can fly up to 20 miles. Large populations of flies can be produced relatively quickly if the correct environment is provided. Flies tend to proliferate in moist animal production areas with low animal traffic.

9.3.6 Climate change

Methane and nitrous oxide emissions are generally much lower from poultry production than from cattle and pig production. The main carbon dioxide emissions are likely to arise from burning fossil fuels to heat broiler units, from processing plants and from the transportation of poultry products around the globe. Little data could be found on the impacts of poultry production on climate change.

9.3.7 Animal health and welfare

Broiler chickens and laying hens are subject to a wide range of diseases and health problems especially when reared under intensive conditions. Parasites such as coccidiosis, metabolic diseases such as Sudden Death Syndrome and ascites, leg problems and cannibalism can all occur within chicken flocks.

Diseases in poultry can cause major economic losses and in the case of Avian Flu pose risks to human health. Avian influenza was first identified over 100 years ago during an outbreak in Italy. Since then, the disease has cropped up at irregular intervals in all world regions. In addition to the current outbreak in Asia, recent epidemics have occurred in Hong Kong in 1997-1998 and 2003, in the Netherlands in 2003, and in the Republic of Korea in 2003. Once domestic birds are infected, avian influenza outbreaks can be difficult to control and often cause major economic impacts for poultry farmers in affected countries, since mortality rates are high and infected fowl generally must be culled in order to prevent the spread of the disease. There is an ongoing outbreak of Avian Flu in Asia; FAO estimates that around 20-25 million birds had been culled in the region as of 28 January 2004. Avian influenza viruses do not normally infect species other than birds and pigs however humans have contracted the virus and died. The World Health Organisation is concerned that the current outbreak of Avian Flu in Asia could lead to a major global flu pandemic if not adequately dealt with.

Poultry are also carriers of bacteria such as salmonella and campylobacter which can lead to food poisoning in humans following the consumption of chicken meat and eggs.

Health problems and diseases in poultry flocks are treated in a number of ways including vaccination, the use of insecticides (to treat housing), antibiotics and other pharmaceuticals and culling. The regular use of antibiotics in intensive livestock systems is of some concern as some strains of bacteria have become resistant to these drugs making the use of these drugs to treat illnesses in humans ineffective.

The conditions under which intensively reared broiler chickens and laying hens are kept are of concern from an animal welfare perspective. Modern broilers reach slaughter weight in approximately 41 days; a growth rate twice as fast as 30 years ago. While muscle grows quickly, the supporting structures of legs, hearts and lungs fail to keep pace. Leg deformities, Sudden-Death-Syndrome and ascites can be the result. Many birds die before they reach slaughter age or are prematurely culled due to such problems. Broiler breeders (i.e. those that produce subsequent generations) are required to grow at slower rates than broilers and are often kept on permanently restricted diets. Such birds have been found to be chronically hungry and stressed. Overcrowding in broiler houses can lead to serious welfare problems. Birds kept at high densities suffer from a higher incidence of pathologies including leg disorders, breast blisters and contact dermatitis and higher death rates than birds stocked at lower densities.

The most controversial system for keeping laying hens is battery cages; these severely restrict the movement of birds and prevent natural behaviours such as dust-bathing and laying their eggs in secluded nests. The wire floor of cages frequently results in foot problems and lack of movement results in osteoporosis and brittle bones. Light is controlled to ensure maximum laying time. The battery hen remains caged until high levels of production drop off, usually after laying for one year and is then sent to slaughter. In some countries such as the US, hens may be subjected to forced moulting where they are deprived of food for up to two weeks in order to extend their productive lifespan by ‘shocking’ them into another cycle of egg laying. In 1999, the EU agreed to phase out battery cages and from 1st January 2012 such cages will be prohibited; only ‘enriched’ cages will be permitted (CIWF 2002). At present there is no EU legislation specifically protecting broilers on farms.

9.3.8 Distributional impacts

Poultry production is usually situated in or near cereal producing areas (sources of poultry feed), in close proximity to coastal areas giving access to ports which receive imports of feed ingredients (at least two thirds of the cost of a live bird is in the cost of feed), or urban areas. Hence, production appears to be highly regionalised in many countries. In the US, production is concentrated in western states such as California, Oregon and Washington, the southern central belt of Texas and Oklahoma and the eastern states of Georgia, South and North Carolina, Virginia and Pennsylvania. In Brazil, production is concentrated mainly in the south of the country and centre west.

Meanwhile, in Thailand, the majority of production can be found within a 60-250km radius of Bangkok. In China, large numbers of industrial livestock units can be found near Shanghai and Beijing and in India, close to Calcutta The locating of industrial farming enterprises close to urban centres appears to be a relatively common trend in many developing countries, raising concerns. In the absence of strict planning and environmental laws, such a trend presents a significant human health hazard. (D'Silva 2000). In the EU, the main producing countries are the Netherlands and parts of Denmark, France, Germany, Italy and the UK. Of the 10 new Member States, Poland, Hungary and Romania dominate production.

The distribution of poultry production as described above means that many of the environmental impacts of production are likely to occur at a local/regional level. The disposal of manure and its impact on water quality appears to be a major environmental issue for the sector as does air pollution (both gaseous emissions and odours).

9.4 Analysis of Impacts of Current/Forecast Liberalisation Proposals

Detailed analysis of the impacts of trade liberalisation in the poultry sector is hampered by the lack of studies on the environmental impacts of production (especially in terms of the type, scale and distribution of impacts) and of studies modelling the effects of liberalisation on markets and production. These are areas where further study would be beneficial. The following comments are therefore rather general in nature and reflect the lack of good evidence on which to base any analysis.

A continued global increase in consumption of poultry meat rather than trade liberalisation appears to be the more significant driver of change in the global poultry industry. However, production in low cost producing countries such as Brazil, Thailand and the US is likely to increase and their share of the world export market likely to grow significantly. Production may also increase in high cost countries such as Canada and the EU due to rising consumption but as liberalisation occurs, Canada is likely to become a net importer and the EU's share of world exports decline. By reducing the costs of inputs such as feed, liberalisation is likely to aid the expansion of poultry production.

The expansion of intensive poultry production in both developed and developing countries is likely to put further pressure on the environment with negative impacts arising directly from poultry production itself and indirectly from possible increases in the production of feedstuffs such as soya, maize and wheat. It is beyond the scope of this case study to explore the environmental impacts of any increase in the production of feedstuffs and comments are focused on the direct impacts of increased poultry production.

The shift from small scale, extensive, back yard poultry production to intensive, vertically integrated systems has been relatively rapid across much of the globe. Developing countries, in particular, have been quick, over the last 10-15 years, to adopt the production methods and systems first introduced in countries such as the US. The homogeneity of production systems means that the environmental problems associated with them are relatively consistent from country to country. The main environmental problems are:

- Impacts on water quality from the disposal of chicken litter and manure
- Impacts on air quality arising from production units themselves and the disposal of manure

Of considerable significance also are the issues of animal health and welfare. All of these have implications for human health in one way or another. While there is evidence that developed countries have or are taking steps to respond to these environmental, animal health and welfare issues, relatively little is know about the situation in developing countries. In the absence of any mitigating measures, the expansion of poultry production in both developed and developing countries is likely to increase pressures on the environment.

While the environmental impacts of production in many developing countries are often poorly understood or documented, the effect of trade liberalisation in shifting in production away from the EU and Canada and towards countries such as Brazil and Thailand gives some cause for concern, given that the former have generally higher environmental and animal welfare standards.

9.5 Analysis of Flanking Measures

On a global environment level, the key impacts of the poultry industry are in relation to water pollution and animal health and welfare issues. Expansion of production, in both developed and developing countries, will lead to greater pressures in relation to these two issues. The effects of trade liberalisation itself are expected to be relatively minor in comparison with wider economic trends, and a discussion of potential flanking measures needs to be seen in this light.

Water pollution is primarily a national issue requiring national controls and mitigating measures. Animal health and welfare issues have much wider implications. The potential for spread of poultry diseases such as Avian Flu and problems caused by salmonella arising in both EU and non-EU countries requires measures relating to disease prevention and control; these are largely already in place in the EU. Equally, concerns among UK and EU consumers regarding animal welfare standards and conditions suggest that a response is needed to non-EU poultry production where standards and conditions are likely to be lower. Exploring the potential to harmonise environmental and animal welfare standards for imports with those faced by domestic producers and introducing requirements for labelling and providing consumer information are possible approaches to this issue. Working closely with the food industry appears to be a pre-requisite to make this approach effective.

It should be noted however that developing trade policies attempting to distinguish between products based on their methods of production is a contentious issue within the WTO and may fall foul of rules relating to ‘process and production methods’ (PPMs). The ‘shrimp-turtle’ ruling of the WTO is a case in point. The WTO ruled (November 1998) against the US in its attempts to prevent imports of shrimp from India, Pakistan, Malaysia and Thailand caught without turtle excluder devices on the basis not of the environmental restrictions but on discrimination against these countries. The WTO concluded that the US had not worked sufficiently with these producing countries, as it had with the Caribbean, to introduce turtle excluder devices. Further investigation of the options into trade restrictions based on PPMs would be worth undertaking.

Specific recommendations are therefore to:

1. Assess the feasibility of introducing measures to harmonise environmental and animal welfare standards for imports with those faced by domestic producers, in a way that is compatible with WTO rules.
2. Consider developing a programme to raise consumer awareness of the environmental and animal welfare implications of different poultry systems, accompanied by a labelling scheme to provide consumers with information about the environmental and animal welfare standards of products.

Table 9-8 summarises the main impacts arising from trade liberalisation in the poultry sector in the EU and non-EU countries and possible flanking measures for each.

9.6 Conclusions

Liberalisation is one factor that is likely to lead to an increase in poultry production in both developed and developing countries; a more significant factor is the increasing global demand for poultry products. The environmental impacts of intensive poultry production are understood at a rather general level but little information is available on the exact nature of these impacts, their intensity and distribution. Models for predicting the impacts of trade liberalisation on the sector are much less readily found than for other commodities. Together, these information gaps make it difficult to assess the exact nature of the environmental impacts of trade liberalisation and hence the flanking measures that might be required to deal with them.

The most important environmental issues appear to be those relating to water pollution arising from the large quantities of poultry litter and manure that must be disposed of and the animal health and welfare issues prevalent in intensive broiler and egg laying units. In relation to water pollution, regulations are already in place in the UK and EU; in non-EU countries, the issue is mainly of national concern and it is difficult to see what scope, if any, there is for Defra to influence national situations. Animal health and welfare issues are of much wider concern and there are legitimate steps that can be taken in relation to disease prevention and control, product labelling and the provision of consumer information. In the case of the latter, working closely with the food industry will be necessary to achieve any meaningful results.

9.7 Further Research Needs

We have been able to identify some of the broad environmental pressures and benefits arising from poultry production but lack details on specific impacts (scale, intensity, distribution) and on the impacts of trade liberalisation. It would be particularly helpful to have more research on certain questions as follows:

- The environmental impacts of current poultry production, especially in developing countries where production has increased in recent years, in terms of their scale, intensity and distribution.
- A more detailed assessment of environmental and animal welfare standards in the poultry sector worldwide, with a particular focus on major exporters such as Brazil, Thailand and the US

- More specific models on the impacts of trade liberalisation in the poultry sector.
- Research into the feasibility and possible mechanisms of extending EU standards to cover imports.

Table 9-8: Summary of impacts of liberalised trade in poultry products, and potential flanking measures. Key impacts in bold.

Type of impact	In Europe	European flanking measures. *Note that most measures at the EU level are responses to domestic production rather than liberalisation, which is expected to have a negative net effect on output.*	Outside Europe	Flanking measures for effects outside Europe
Land use/landscape	May be local landscape impacts from location and design of poultry houses, but not exacerbated by liberalisation.	Can be addressed through national planning legislation and EU legislation such as IPPC regulation	Some evidence of similar issues in countries such as US, which could be exacerbated by increased production.	National issue, best addressed by planning legislation. No new measures needed.
Soil	Some concerns about soil contamination by heavy metals, but not exacerbated by liberalisation.	May be addressed through EU Soil Strategy and national legislation.	No evidence but likely to be similar issues where poultry litter and manure disposed to land.	National issue, best addressed by regulation. No new measures needed.
Water quality	**Nitrate and phosphate pollution already problematic in UK and EU. Expansion of poultry production e.g. in new Member States likely to increase pressures on water quality. As net effect of liberalisation is to reduce production, it should mitigate the problem, but concerns remain about expansion driven by domestic demand.**	**Nitrates Directive already in place. The UK should ensure compliance in Nitrate Vulnerable Zones and promote good farming practice standards elsewhere. The UK should use its position in international negotiations to encourage compliance with the Directive.**	**Contamination of surface and ground waters is likely to be a significant issue in most producing countries on a localised or regionalised basis. Increased production (e.g. in Brazil, Thailand and US) could exacerbate these problems.**	**National issue, best addressed by domestic regulation. No new measures needed but it would be appropriate to encourage good practice and sharing of information between producer states.** **Requiring evidence of environmental standards in production (labelling) could encourage domestic measures to be established.**

Type of impact	**In Europe**	**European flanking measures.** ***Note that most measures at the EU level are responses to domestic production rather than liberalisation, which is expected to have a negative net effect on output.***	**Outside Europe**	**Flanking measures for effects outside Europe**
Resource use/waste	Energy use by the poultry sector is significant, but not exacerbated by liberalisation.	Litter to energy schemes already operating in UK but development of on-farm energy schemes is lagging. Investment in developing new technologies may be appropriate.	Energy use by the poultry sector is significant and likely to be exacerbated by liberalisation.	Climate change implications of fossil fuel use suggest sharing developments in new technologies may be beneficial.
Air quality	Emissions from poultry units and manure disposal contribute to air pollution, but not exacerbated by liberalisation.	Local issues, dealt with by local authorities and governments. No measures needed.	Emissions from poultry units and manure disposal contribute to air pollution and are likely to be exacerbated by liberalisation	National issue, best addressed by regulation. No new measures required.
Climate change/greenhouse gases	GHG emissions are produced in the production process, but not exacerbated by liberalisation.	Small percentage of overall emissions – no specific flanking measures needed.	GHG emissions are produced in the production process and are likely to be exacerbated by liberalisation	Issue is being addressed by governments and climate change agreements. No need for new measures.
Animal health and welfare	**Significant concerns about animal health and welfare in EU. Specific concerns about spread of diseases e.g. Avian Flu, with a risk that these could be exacerbated by increased imports.**	**Rules on animal welfare are already in place in the EU and stringent disease prevention and control measures in place. No new measures required.**	**Animal health issues of particular concern due to risks to human health. Welfare issues may be more significant in developing countries where standards are not as advanced.**	**Given concerns of UK and EU consumers, greater emphasis required on measures such as:** • **Harmonizing standards for imports with domestic production** • **Labelling/Consumer information**

10 COTTON

10.1 Brief overview of the cotton sector

10.1.1 Conventional cotton production

Cotton is the largest commercial non-food crop produced in the world (Clay, 2004). Cotton growing areas cover nearly 33m ha, or approximately 2.5 per cent of the world's total available arable land (Banuri, 1998). The crop requires rather exact environmental conditions in order to achieve optimum growth. About 180 frost-free days are needed per crop, a substantial amount of water needs to be applied during the growing cycle, and there must be little or no rain as well as low levels of humidity when the cotton bolls are maturing (Clay, 2004). Cotton production can be characterised as both water and pesticide intensive. Cotton is irrigated on 53 per cent of all land where it is grown and 73 per cent of all cotton is produced on irrigated land (Clay, 2004). Thus 27 per cent of cotton is produced under conditions where the freshwater requirement is provided mainly by rain (Soth, 1999). Cotton is grown across a range of agricultural systems, from smallholder agriculture typical of developing countries to large-scale, highly mechanised industrial systems typical of countries such as the US, Australia, Sudan and Uzbekistan (Myers, 1999).

Cotton production occurs globally and is grown under a wide range of agro-ecological conditions (Elzakker, 1999). Climates vary from the monsoon tropics to those areas with a Mediterranean or desert climate where water can be provided by irrigation. According to statistics prepared by the International Cotton Advisory Committee (2002), cotton is grown in 66 countries worldwide (although Banuri (1998) states that cotton is grown in 82 countries and Clay (2004) that cotton is grown in more than 100). In terms of weight produced, four fifths of global production is concentrated in seven countries: Brazil, China, USA, India, Pakistan, Uzbekistan and Turkey. The average yield of lint (the fibres that grow within the bolls) varies considerably between these countries, and the global average for the 2003/04 growing season was predicted to be 714kg/ha (USDA, 2004). The most intensive producers are Australia, Brazil, China, Greece, Kyrgyzstan Mexico, Spain, Syria, and Turkey, with forecast yields of more than 1000 kgs/ha in the 2004/05 season. The most intensive producer is Israel, which, according to provisional figures, is expected to yield 1,851kgs/ha in 2004/05 (USDA, 2004). Yields have been steadily increasing worldwide since the 1930s whilst the total cotton growing area has not (Myers, 1999).

About two thirds of all production now occurs in less-developed countries, where China is the biggest producer (Clay, 2004). In Africa, cotton is typically a smallholder crop grown on rain-fed land, with minimal use of purchased inputs such as pesticides and fertilisers (Baffes, 2004). The average yield is therefore much lower in developing countries, typically half the global average, but it is difficult to make generalisations. For example while the expected yield in Uganda for 2004/05 is 109kgs/ha over a total cotton growing area of 400,000 ha, in Sudan the forecast yield is 544kgs/ha over a total cotton growing area of 210,000ha. Greece and Spain are the only producers in the European Union and together produce 501,000 metric tons a year (USDA, 2004). The main production areas are concentrated in Thessaly in

Greece and Andalucia in Spain (DG Agriculture, no date). Some of this data is reproduced in Table 10-1, demonstrating the global variations in production.

	Country	**Area under production (000 Ha)**	Yield (Kg/Ha)	Production (000 Metric Tons)
Top 7 producers	Brazil	1,150	1,193	1,372
	China	5,690	1,110	6,314
	India	9,000	397	3,571
	Pakistan	3,200	782	2,504
	Turkey	715	1,294	925
	USA	5,284	948	5,009
	Uzbekistan	1,415	777	1,100
Selected developing countries	*North/South America*			
	Argentina	390	419	163
	Mexico	105	1,296	136
	Paraguay	250	361	90
	Africa			
	Cameroon	220	495	109
	Chad	425	192	82
	Egypt	307	904	278
	Mali	540	444	239
	Sudan	210	544	114
	Uganda	400	109	44
	Zimbabwe	330	307	101
	Asia			
	Burma	300	196	59
	Kyrgyzstan	40	1,197	48
	Syria	215	1,519	327
Developed countries	Israel	14	1,851	26
	Australia	325	1,742	566
Europe	Greece	375	1,045	392
	Spain	90	1,210	109
	Other European	17	410	7
	World Total	*35,912*	*714*	*25,629*

Table 10-1: Comparison of area under production, yield and total production for selected cotton producing countries for the 2004/05 season. Source: USDA, 2004.

The variation in the figures for area under production and yield can be explained in terms of the growing conditions used for the cultivation of conventional cotton. These conditions include soils, technology, farmers' knowledge, farm size and finance, but two primary variables would seem to be the availability of water and the methods used to control pests. Those countries with the largest yields are those where irrigation is extensively used and pesticides are intensively applied. The prime environmental problems result from cotton growers' dependence on irrigation and pesticides. These practices can result in severe negative environmental impacts such as reduced soil fertility, salinisation, a loss of biodiversity, water pollution, adverse changes to the water balance and pesticide related problems, including resistance (Myers, 1999). Cotton is a demanding crop and few benefits to the environment appear to emerge from conventional growing. Alternative production methods, by contrast, offer some scope for environmentally sustainable production.

10.1.2 Alternative production methods

The current way in which most cotton is produced is widely regarded as unsustainable (Clay, 2004). However, given the variation in practices worldwide, for example varying reliance on irrigated water supplies, it is difficult to generalise. In order for cotton production to become more acceptable environmentally, a number of new production techniques have emerged. Advanced irrigation technology, organic farming, integrated pest management (IPM) and, possibly, the use of genetically modified cotton, are all ways to minimise cotton's use of water and to reduce its dependency on pesticides.

By 1995, organic production accounted for only 0.06 per cent of the total global output of cotton (Myers, 1999) with about 75 per cent of production occurring within the USA (Banuri, 1998). At the time it was assumed that demand was increasing. For example, the outdoor clothes manufacturer Patagonia has used organic cotton exclusively since 1994 (Ton, 1997). However, Baffes (2004) reports that the outlook for organic cotton is less promising than for organic food crops, mainly because consumer demand continues to remain weak.

IPM seeks to protect the environment through an ecosystem-based approach to pest management and aims to reduce the use of insecticides (Cotton IPM Newsletter, 2004). IPM involves the integrated use of a variety of pest control methods including pest resistant varieties, planting time, use of natural predators and other forms of biological control. Pesticides are only used on an as-needed basis and as a last resort (Myers, 1999). IPM has been implemented with some success in Asia and West Africa, but overall uptake remains low due to the costly demand of farmer training (Cotton IPM Newsletter, 2004).

Genetically modified cotton has involved the development of insect resistant varieties by modifying plant characteristics such as the speed of ripening and the introduction of insect repellent genes into plants. Cotton is the third most important transgenic crop in terms of surface area after soya and maize and covered 6.8m ha, or 20 per cent of the total area under cotton production in the 2002/03 season, with the majority of production concentrated in the USA and China (DG Agriculture, no date). Baffes (2004) reports that in 2002 genetically modified cotton accounted for almost 30 per cent of global cotton output, with the USA allocating more than 70 per cent of its cotton area to genetically modified cotton, Australia 40 per cent and China 20 per cent. The environmental benefits and problems are not fully understood yet (Banuri, 1998), and different reports detail both benefits and emerging problems. These are discussed in more detail in the environmental impacts section.

10.2 Effects of Trade Liberalisation on the Cotton Sector

10.2.1 Current patterns of Production, Consumption and Trade

USDA statistics estimate world cotton production to total 25.6 million metric tonnes. As stated above, seven countries account for more than 80 per cent of world production, with China, the US and India the largest producers, accounting for 25 per cent, 20 per cent and 14 per cent of world output respectively.

	1999/00	2004/05	per cent of world production, 2004/05	per cent change, 1999/00 to 2004/05
China	3,832	6,314	24.6 per cent	64.8 per cent
US	3,694	5,009	19.5 per cent	35.6 per cent
India	2,652	3,571	13.9 per cent	34.7 per cent
Pakistan	1,872	2,504	9.8 per cent	33.8 per cent
Brazil	700	1,372	5.4 per cent	96.0 per cent
Turkey	791	925	3.6 per cent	16.9 per cent
Uzbekistan	1,128	1,100	4.3 per cent	-2.5 per cent
Other	4,405	4,835	18.9 per cent	9.8 per cent
World	**19,074**	**25,630**	**100.0 per cent**	**34.4 per cent**

Table 10-2: World cotton production (000 metric tonnes). Source: USDA, 2004.

Seven countries also account for almost 80 per cent of world consumption (Table 10-3). Six of these are also the world's largest producers. China accounts for more than a third of world consumption, and is a major net importer of cotton. The other largest consumers are India and Pakistan, accounting for 14 per cent and 10 per cent of world consumption respectively, with consumption broadly in line with production in both countries. The US consumes significantly less cotton than it produces, and is therefore a substantial net exporter. Consumption was forecast by the USDA to be 2.5 million tonnes less than production in 2004/5, resulting in a substantial increase in stocks (to 10.3 million tonnes).

A relatively high proportion (30 per cent) of cotton production is traded internationally. Table 10-4 presents data on world cotton exports. These indicate that seven countries together account for 70 per cent of the world total. The US is the world's largest cotton exporter, accounting for 39 per cent of global exports, followed by Uzbekistan (10 per cent), Brazil (6 per cent) and Australia (5 per cent). Greece and the western African countries of Mali and Burkina Faso also figure among the world's largest exporters, each with around three per cent of the market.

	1999/00	2004/05	Share of world consumption	Change, 1999/00 to 2004/05
China	4,638	8,165	35.3 per cent	76.0 per cent
India	2,950	3,211	13.9 per cent	8.8 per cent
Pakistan	1,666	2,221	9.6 per cent	33.3 per cent
US	2,220	1,372	5.9 per cent	-38.2 per cent
Turkey	1,219	1,437	6.2 per cent	17.9 per cent

Brazil	922	893	3.9 per cent	-3.1 per cent
Indonesia	435	479	2.1 per cent	10.1 per cent
Other	5,771	5,337	23.1 per cent	-7.5 per cent
World	**19,821**	**23,115**	**100.0 per cent**	**16.6 per cent**

Table 10-3: World cotton consumption (000 metric tonnes). Source: USDA 2004.

	1999/00	**2004/05**	**Share of world exports**	**Change, 1999/00 to 2004/05**
US	1,470	2,874	39.3 per cent	95.5 per cent
Uzbekistan	893	729	10.0 per cent	-18.4 per cent
Brazil	3	457	6.3 per cent	15133.3 per cent
Australia	699	392	5.4 per cent	-43.9 per cent
Greece	235	218	3.0 per cent	-7.2 per cent
Mali	196	212	2.9 per cent	8.2 per cent
Burkina	113	201	2.7 per cent	77.9 per cent
Other	2,299	2,228	30.5 per cent	-3.1 per cent
World	**5,908**	**7,311**	**100.0 per cent**	**23.7 per cent**

Table 10-4: World cotton exports (000 metric tonnes). Source USDA 2004.

Cotton is an important cash crop for a number of developing countries. It contributed between 30 and 44 per cent of total merchandise exports in five West African countries – Benin, Burkina Faso, Chad, Mali and Togo - between 1998 and 1999. The corresponding figures for Uzbekistan, Tajikistan and Turkmenistan were 32 per cent, 15 per cent and 12 per cent respectively.

The EU is a net importer of cotton, producing 0.5 million tonnes per year and using 1.0 million tonnes. The EU exports small quantities of cotton, (0.2 million tonnes in 2002/03 (DG Agriculture, undated)). Though cotton is relatively unimportant in the overall agricultural economy of the EU, it is an important crop for cotton growing regions in the south of Europe, particularly in Greece, where it accounts for 9 per cent of agricultural output. This proportion is higher still in the three main producing regions of Thessaly, Macedonia-Thrace and Sterea Ellada (DG Agriculture, undated).

10.2.2 Recent Trends in Production, Consumption and Trade

Tables 10.2-10.4 also indicate trends in production, consumption and trade in different countries since 1999/2000. World production of cotton has increased by 34 per cent over this period, with the fastest growth occurring in Brazil (+96 per cent) and China (+65 per cent). Significant growth has occurred in each of the main producing countries, with the exception of Uzbekistan, where output has fallen slightly.

The use of cotton grew less rapidly than production over the 1999/2000 to 2004/2005 period, partly because the latter was predicted to be a bumper year in terms of output. China’s use of cotton increased by 76 per cent over this period. In contrast, there was a significant decline in consumption in the US (-38 per cent) and the “other” category (-7.5 per cent), reflecting declining cotton use in many developed nations.

World exports increased by 24 per cent over the same time period. However, there were contrasting trends between countries, with a substantial increase in exports in the US, Brazil and Burkina Faso, and declines in exports from Uzbekistan, Australia and Greece.

Real cotton prices have declined over the last two centuries, due to the effects of technological development on production costs coupled with stagnant per capita consumption and increased competition from synthetic products. There was a 55 per cent decline in real prices between 1960/64 and 1999/2003, with a doubling of average yields from 300kg to 600kg per hectare over this period (Baffes, 2004).

10.2.3 The Effects of Government Policy

The world cotton market has been subject to considerable market interventions, including subsidization in the US, EU and China and taxation in Africa and Central Asia. Support by the major players totalled $6 billion in 2002, more than a quarter of the value of world production, at a time when world prices reached very low levels. In this year, assistance to US producers totalled $3.6 billion, compared to $1.2 billion in China and $1 billion in the EU.

The US has a long history of supporting the cotton sector, and has a system of support that is both complex and expensive. The principal instruments of support are price-based (loan-rate) payments, decoupled payments, insurance and counter-cyclical payments. US cotton users and exporters also receive some support.

The EU's cotton regime is based on a system of guaranteed prices, with payments made to growers to compensate them for the difference between the market price and the support price. EU cotton growers are heavily subsidised, and it has been estimated that the amount of cotton that the EU produces could be imported at one third of the current cost of production (Goreux, 2004b). Greece and Spain together accounted for only 2.5 per cent of world production but 18 per cent of world cotton subsidies in 2001/02 (Goreux, 2004b). However, reforms to be introduced in 2006 will introduce a new system based on two payments – one fully decoupled from production, and a second based on the area of cotton in current production.

China currently supports its cotton sector through a system of price supports (with a reference price set above world market levels), import tariffs, subsidies for transportation and marketing, and public stockholding. Recent years have seen a reduction in support and deregulation of the market.

In Uzbekistan, the entire cotton sector was controlled by the state prior to 1991, and many aspects of marketing and trade still remain under state control. State companies remain responsible for all primary processing, exports, transportation and quality monitoring. Cotton producers are effectively taxed, receiving only one third of the world market price, but benefit from subsidised inputs and irrigation systems.

These interventions have a dramatic impact on world cotton markets. For example, the International Cotton Advisory Committee concluded that prices in 2000/01 would have been 30 per cent higher in the absence of intervention.

Price changes have been shown to have a major impact on rural poverty. For example, in Benin, Minot and Daniels (2004) found that a 40 per cent reduction in farmgate cotton prices – as occurred between December 2000 and May 2002, implied a 7 per cent reduction in per capita rural incomes in the short run and a 5-6 per cent decline in the long run, resulting in substantial increases in rural poverty.

Concerns about the trade distorting effects of cotton subsidies prompted Brazil to initiate a WTO consultation process in 2002, arguing that US subsidies were causing unfair competition. Brazil quoted results from the FAPRI econometric model, which estimated that US policies increase US cotton exports by 41 per cent and decrease the world price of cotton by 12.6 per cent, causing losses of $600 million to Brazil in 2001. The WTO issued an interim ruling in 2004 in favour of Brazil, but the US has since appealed against this decision, and the matter has yet to be resolved (Baffes, 2004).

In 2004, Benin, Burkina Faso, Chad and Mali submitted a joint proposal to the WTO calling for the removal of cotton subsidies by the US, EU and China, and requesting compensation from these countries until subsidies are fully removed. The four producers estimated that they lost $250 million in export revenues in 2001/2 due to cotton subsidies, with additional indirect impacts. The proposal has encouraged the WTO to prioritise reform of the cotton sector (Baffes, 2004).

10.2.4 Scope and Agenda for Further Liberalisation

While there has been some progress towards trade liberalisation in the cotton sector, cotton remains a heavily supported commodity and there is substantial scope for further reform. In the US, while the 1996 Farm Bill made progress through the introduction of decoupled payments, this progress was reversed by the introduction of emergency payments in 1998 and their legitimisation in the 2002 Farm Bill. Proposed reforms by the EU make significant progress towards liberalisation, but the retention of an area based payment means that support is not fully decoupled from production, while no timetable has been set for the elimination of subsidies. In China, the reform process is still at an early stage. In many developing countries, reform of state controlled trading systems has helped to increase efficiency and enhance growers' incomes, but there is scope for significant further progress (Baffes, 2004).

Actions brought by Brazil and the four African countries have placed cotton at the centre of the WTO's agenda. In response to these proposals, a sub-committee dealing specifically with the cotton issue has been established and has begun work. The July Package decision of 1 August 2004 stipulates that cotton will be addressed "ambitiously, expeditiously and specifically" within the agriculture negotiations. The sub-committee is tasked to work on "all trade-distorting policies affecting the sector", in the "three pillars of market access, domestic support, and export competition" as specified in the 2001 Doha Declaration. Its work will take into account the need for "coherence between trade and development aspects of the cotton issue". This is a reference to the two major components of the original proposal: trade, which is covered by the negotiations on trade barriers, domestic support and export subsidies; and development, which covers various aspects of helping the less developed cotton producers face market conditions and other needs (www.wto.org).

10.3 Expected Impact of Liberalisation on Patterns of Production, Consumption and Trade

Reviewing a variety of modelling studies, Baffes (2004) and FAO (2004) found that different studies have produced a range of different forecasts regarding the impact of trade liberalisation on world cotton markets. These differences depend on the liberalisation scenarios employed (e.g. the treatment of Chinese cotton support, whether support is removed or decoupled), assumptions about elasticities of demand and supply, assumptions about quality issues, datasets employed, whether liberalisation is restricted to cotton or occurs across commodities, and the different base years employed (given that support fluctuates according to market conditions).

The FAO study found that estimates of world price increases in response to removal of subsidies varied between 2 per cent and 35 per cent. Furthermore, while all studies reviewed predicted decreases in production in the US (of between 2 per cent and 72 per cent) and the EU (9 per cent to 71 per cent), the FAO concluded that it was difficult to predict where production would increase. Many developing countries have expanded output in recent years despite low prices, and the supply responses resulting from increases in world market prices are therefore likely to be both significant and difficult to predict. Baffes concluded that the available evidence suggested that liberalisation of cotton markets would increase prices by around 10 per cent.

ICAC (2002) used a short run partial equilibrium model to assess the affect of subsidies on world prices. The study concluded that average prices between 2000/01 and 2001/02 would have been 30-72 per cent higher if all subsidies had been eliminated.

Goreux (2003) adapted the ICAC model and found that world prices would have been 3-13 per cent higher between 1998 and 2002 in the absence of intervention, depending on the value of supply and demand elasticities used. The study estimated that West and Central African (WCA) countries would have produced 0.4 per cent to 11.2 per cent more cotton in the absence of intervention in industrialised countries, increasing their annual export earnings by $37m to $254m.

Gillson et al (2004), using a similar model, estimated that removal of subsidies by the US, EU and China would increase the world cotton price by 18-28 per cent, depending on the assumptions employed. Cotton production would fall by 1.5 per cent-15.2 per cent in the US, 2.6 per cent-7.1 per cent in China, 9.0 per cent-26.3 per cent in Greece and 8.5 per cent-28.2 per cent in Spain. World production would decline by between 0 per cent and 1.7 per cent. The model predicted increases in production of between 3 per cent and 12 per cent in West and Central Africa, 0 per cent to 9 per cent in Australia, 1 per cent to 13 per cent in Brazil, 2 per cent to 11 per cent in India, 9 per cent to 23 per cent in Mexico, 1 per cent to 11 per cent in Pakistan, 6 per cent to 11 per cent in Turkey and 0 per cent to 9 per cent in Uzbekistan.

Sumner (2003) used an econometric simulation model based on the FAPRI model to assess the export and world price effects of removing US cotton subsidies, finding that the effect would be to reduce US exports by 41 per cent and increase world prices by 12.6 per cent. He estimated that US cotton subsidies reduced the revenues of Brazilian farmers by $478 million between 1999 and 2002.

Reeves et al (2001) used a simple CGE model to predict that removal of production and export subsidies by the US and EU would reduce US cotton production by 20 per cent and exports by 50 per cent, and have an even greater impact in the EU. World cotton prices would increase by 6 per cent.

FAPRI (2002) found that complete global trade liberalisation and removal of all domestic supports for all commodities would result in a 18 per cent increase in the world cotton price after 3 years, with this increase declining to 6 per cent after 10 years. By 2011/12, exports would increase by 12.3 per cent in Africa, 6.2 per cent in Uzbekistan and 2.1 per cent in Australia, but decline by 60 per cent in Pakistan. In the US, exports would decline initially before recovering. Production in 2011/12 would decline by 79 per cent in the EU and 2 per cent in the US, while increasing by 6 per cent in Africa, 4 per cent in Uzbekistan and 2 per cent in China.

Tokarick (2003) used a partial equilibrium model to predict that multilateral trade liberalisation in all agricultural markets, including cotton, would increase the world cotton price by 2.8 per cent, with 0.8 per cent of this increase resulting from the removal of market price support and 2.0 per cent from the removal of production subsidies.

Poonyth et al (2003) used the ATPSM model, a standard comparative static model, to estimate that the removal of cotton subsidies would increase the world price by between 3.1 per cent and 4.8 per cent, depending on the assumptions employed about supply and demand elasticities. Under full liberalisation, production was found to decrease in all countries that reduce subsidies, declining by 14 per cent and 32 per cent in the US and EU respectively. Cotton production was forecast to increase in non-subsidising countries, with a collective increase of 2.4 per cent in Benin, Burkina Faso, Chad and Mali.

Pan et al (2004) used a partial equilibrium structural econometric model of the world fibre market to model the effects on world markets of removal of US cotton subsidies. The model predicted a 5 per cent reduction in US cotton acreage, with the biggest drops occurring in the Southwest dryland (-8 per cent) and irrigated (-6 per cent) areas. The world cotton price is estimated to increase by 2.1 per cent, as a result of a 5 per cent reduction in US exports. Brazil is the biggest beneficiary, increasing exports by 2 per cent, followed by Australia (1 per cent) and Africa (<1 per cent). Production responses mean that the effects on world price decline over time.

Shepherd (2004) predicted that removing subsidies would have a negligible impact on world cotton prices.

Karagiannis (2004) modelled the effects of the proposed EU reforms to the cotton sector. Compared to the current regime, the proposals to move to a combination of decoupled and area-based payments was forecast to result in a reduction in the quantity supplied by between 9.4 per cent and 25.8 per cent in Greece, and 10.9 per cent to 27.6 per cent in Spain, depending on the assumptions employed.

The key findings of the above studies are that liberalisation of world trade in cotton will:

- Increase world prices, with estimates of price increases varying widely between studies;
- Increase production in Central and West Africa, Brazil, Australia, India, Mexico, Pakistan, Turkey and Uzbekistan, with most studies predicting moderate increases of up to 10 per cent;
- Decrease production in the US and the EU. Most studies predict substantial declines in output in Greece and Spain, with more variable forecasts for the US.
- Have an uncertain effect in China, with various studies predicting both increases or decreases to production.

Since reform of cotton trade is prominent on the WTO agenda, liberalisation can be expected to have significant impacts in the medium term (5-10 years, depending on the progress of the negotiations).

9.3 Environmental Impacts of Trade on the Cotton Sector

The major environmental issues in the cotton sector are water mismanagement and the use of pesticides. Pressures have been exacerbated as production has intensified in order to meet global demand.

10.3.1 Land use/landscape

The most dramatic changes to landscape as a result of cotton production are those that have occurred as a result of building dams to provide a freshwater source for irrigation. Although it is difficult to estimate the significance of cotton production as a rationale for dam building (Soth, 1999), dams destroy ecosystems in flooded areas and affect freshwater ecosystems downstream of the dam. One of the largest dam building exercises in recent years for the purpose of irrigation, the Ataturk Dam in Turkey, provides water for the cotton growing southeastern Anatolia region. In Greece and Spain, cotton has been sown under plastic in order to improve water management, but this in turn affects the look of the landscape and poses problems for waste material recovery and recycling (DG Agriculture, no date).

In some irrigated areas, the salinisation of agricultural land has occurred as a result of water mismanagement arising from cotton production. This has led to land abandonment and the subsequent expansion of cotton growing into newly cultivated areas. Monocultural cotton production significantly alters the natural habitat and fragments pre-existing ecosystems. In the past slash and burn techniques have been used to clear vegetation in order to convert forests into agricultural land for cotton production in some countries. This has contributed to the fact that only two per cent of the original forests in the Central American cotton producing areas remain (Clay, 2004).

10.3.2 Soil

The main way in which soil is degraded in drier cotton growing areas is through salinisation. Salinisation is a severe problem and can be difficult to avoid in dry climates where evapotranspiration exceeds both rainfall and the amount of freshwater used for irrigation (Soth, 1999). Salinisation occurs when irrigation runoff passes into groundwater, which leads to rising water tables. The rising water table dissolves salt present in the soil and carries these to the surface. In dry climates, this water is pulled to the surface where it then evaporates, leaving salt behind (Clay, 2004). About 50 per cent of the irrigated area in Uzbekistan is affected by salinity and in Pakistan 15 per cent is affected (Soth, 1999).

In order to decrease the prospect of salinisation, additional freshwater may be used to establish a water flow to remove salt from the soil. China, Egypt and Uzbekistan are known to employ these methods (Gillham, 1995). However, this salt enriched water often contaminates waterbodies downstream of the cotton plantation.

Another problem is created by the intensive use of pesticides and fertilisers in areas of cotton production. Constant pesticide and fertiliser use results in a decline in soil quality and fertility through the breakdown of organic matter in the topsoil and damage caused to soil microorganisms (Clay, 2004). Also, because cotton is also often produced as a monoculture, the lack of a crop rotation risks both exhausting the soil and intensifying soil erosion in fragile areas (DG Agriculture, no date).

10.3.3 Water quality and supply

One of the greatest environmental issues associated with cotton production is its dependence on freshwater, raising sustainability concerns in many production regions. In order to produce one kilogram of cotton (whether it is grain or lint), between 7,000 and 29,000 litres of freshwater are required, with the figure varying according to the efficiency of the irrigation system used (Soth, 1999). Irrigated fields, which account for 53 per cent of the total global cotton growing area, provide 73 per cent of the overall global cotton harvest (Hearn, 1995 cited in Soth, 1999). In comparison, only 27 per cent is grown under rain-fed conditions (Soth, 1999). Highlighting the improved yields that irrigation offers, areas of rain-fed cotton yield 391kg per hectare on average whereas areas of irrigated cotton yield 854kg per hectare (Soth, 1999).

The huge demand that cotton production places on water resources means that both surface and groundwater resources must be intensively used (Soth, 1999). Unsustainable levels of groundwater abstraction appear to be widespread. Some capped aquifers are non-renewable and can take thousands of years to be refilled once they have been drained (Clay, 2004) Groundwater can be contaminated by both pesticides and fertilisers as a result of the deep percolation of runoff caused by irrigation, leading to low water tables, decreased productivity and the salinisation of soils in dry climates. (Soth, 1999). The water which replenishes the aquifer may also be unusable. In Pakistan, 31 per cent of all irrigation water is drawn from groundwater resources. In the Yellow Valley in China, large withdrawals from groundwater have caused a fall in the level of groundwater tables and a shortage of water for irrigation (Gillham, 1995 cited in Soth, 1999). Any problems elsewhere will show regional variation due to differences in climate, soil characteristics and irrigation systems.

Excessive exploitation of surface water is much less widespread, although there have been severe problems caused by irrigation with surface water in Uzbekistan (see Box 10.1). The other largest producers seem to have sufficient renewable freshwater resources to fulfil their annual freshwater withdrawal in most cases (Soth, 1999).

Box 10.1: Unsustainable Irrigation in Uzbekistan

The most severe example of water mismanagement and related ecological devastation associated with cotton occurred in the region of the Aral Sea in Uzbekistan. Cai et al (2002) explain that cotton growing in Uzbekistan is a prime example of unsustainable irrigation development, the key features of which are: rapid, large-scale expansion; a sole reliance on high-water-use production systems for cotton (and also rice); poor water distribution and drainage; inefficient irrigation techniques which result in enormous losses of irrigation water; and the large-scale use of fertilisers and pesticides. Water for irrigation was sourced from the rivers Amu-Darja and Syr-Darja, which are tributaries of the Aral Sea. As a result, the surface level of the Aral Sea declined by nearly 13m and its area decreased by 40 per cent between 1960 and 1987 (Micklin, 1988). Another report states that the sea level fell by 17m and the surface area diminished by 75 per cent (EEA, 2003). Figure 9.1, gives a visual representation of the effect that unsustainable irrigation practices have had on the total area of the Aral Sea.

A number of environmental problems developed, including the desiccation and surface salinisation of the Aral Sea, water and soil contamination, dust storms and a range of environmental health problems for those that live in the Aral Sea basin (Spoor, 1998). Water salinity increased from 10g/l in 1965 to 40-50g/l in 2000 (EEA, 2003). Previously fertile, humus-rich, meadow-swamp soils in the zone of influence of irrigation were transformed into low-productivity, sandy-desert soils of much lower fertility (Cai et al, 2002). The total area of marshes and wetlands reduced from around 550,000 ha in 1960 to only 20,000 ha in 1990 (EEA, 2003). Between 20 and 24 native fish species are believed to have disappeared (Soth, 1999). Meanwhile, maintaining current irrigation practices is expected to lead to further degradation (Cai et al, 2002). Moreover, the continued production of cotton in the Aral Sea region remains important economically for Uzbekistan as cotton accounts for about 40 per cent of total merchandise export earnings (Baffes, 2004).

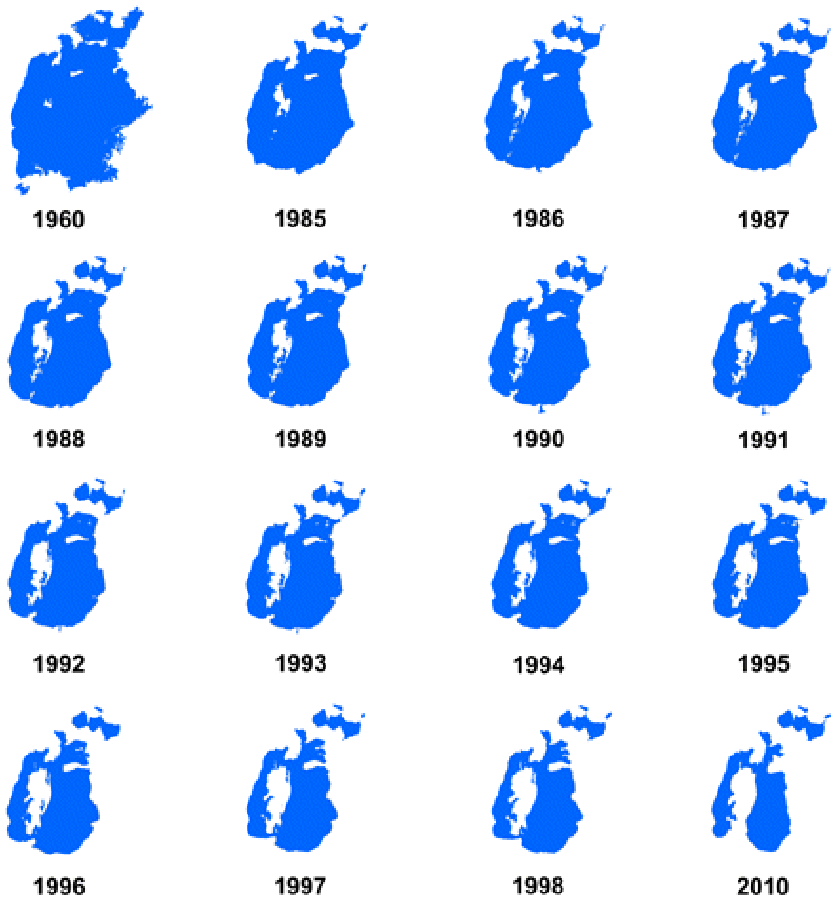

Figure 10-1: Chronology of the desiccation of the Aral Sea. Source: DFD 1998.

The efficiency of irrigation systems worldwide is thought to be lower than 40 per cent (Gleick, 1993 cited in Soth 1999), and can be attributed to evaporation, the disrepair of older irrigation channels and canals, run-off and lack of training. However, the level of irrigation efficiency can be improved where more sophisticated techniques are employed. In Israel, drip irrigation systems mean that the freshwater demand is a comparatively low 7,000 litres per kilogram of lint cotton (Rellner, 1997 cited in Soth, 1999); this efficiency is underlined by the fact that Israel has the highest yield of cotton in the world at 1,851 kgs per hectare (USDA, 2004), although this can partly be attributed to other factors, such as pesticide usage. However, globally, drip irrigation systems only account for a small proportion of the total. In 1992, only 0.7 per cent of the worldwide irrigated area was under a drip irrigation system (Postel, 1992 cited in Soth, 1999).

The Southeast Anatolia project in Turkey will result in 1.7m ha of land being irrigated upon completion (Tomanbay, 2000). Between 1994 and 2001, the total area of cotton in the newly irrigated area increased from 160,000 to 341,000 hectares, and the region which once produced 25 per cent of the nation's cotton in 1994 produced nearly 50 per cent in 2001 (FAS, 2001). The project involves the construction of 22 dams and two irrigation tunnels on the Euphrates and Tigris rivers and their tributaries. The project is being driven by a need to address socio-economic imbalances in Turkey and to provide employment and growth in a less developed area of the country. The authorities behind the project have undertaken studies to identify existing and possible future environmental problems in order to make recommendations to limit environmental damage (Tomanbay, 2000). It remains to be seen what the environmental problems could be and how effective these recommendations will be in overcoming them.

The cultivation of cotton also contributes to the pollution of surface water with nitrates and pesticides.

10.3.4 Resource use/waste (including pesticides)

Pesticide use on cotton plantations is generally heavy. Whilst 11 per cent of global pesticide sales and 24 per cent of global insecticide sales are purchased for use on cotton plantations, the global cotton acreage amounts to just 2.5 per cent of the world's total arable land (Soth, 1999). In addition to insecticides, large amounts of herbicides, fungicides and synthetic fertilisers are all used in cotton production (Myers, 1999). The use of a defoliant on mature cotton plants to facilitate mechanical harvesting is another of the main uses of agrochemical inputs (DG Agriculture, no date) and the insecticides used, consisting of organophosphates and carbamates, have acute toxicological properties.

In California in the late 1990s, an average of 9.1 kilograms of pesticides were used each year per hectare of cotton production (Clay, 2004). Aldicarb is the pesticide most frequently used on cotton in the USA, and has been detected in the groundwater in 16 states (Clay, 2004).

In developing countries, half of all pesticides applied to all crops are used on cotton (Clay, 2004). In Pakistan, cotton is grown on 15 per cent of the total arable area, but consumes about 20 per cent of all the agrochemicals used in the country (Banuri, 1998). In the Punjab up to 98 per cent of the total cotton growing area was treated with pesticides in 1991 (Banuri, 1998).

The use of pesticides at this level is widely associated with damage to ecosystems, and is discussed in more detail in the section on biodiversity. These problems are likely to become more significant over time due to the ‘treadmill effect’, whereby escalating doses of pesticides are required to control pest populations which have developed resistance to certain pesticides and are no longer threatened by natural pest predators (Banuri, 1998). It is believed that two of the major cotton pests, the American bollworm and the whitefly, have developed resistance to common pesticides (Banuri, 1999). In Pakistan in the 1990s an attack by the leaf curl virus and its disease vector, the whitefly reduced yields by around 200kg/ha (Banuri, 1998). The Pesticides Action Network (1998) exemplifies the problems associated with secondary pest outbreaks. In 1995 farmers in the Rio Grande Valley in Texas lost $150 million worth of cotton due to widespread malathion spraying. This led to massive secondary pest outbreaks as the malathion destroyed not only its intended target, the boll weevil, but also spiders, wasps and other predatory insects, allowing beet army worms and aphids to flourish.

The environmental problems associated with pesticide use have led to the development of alternative methods of cotton production. The main method has been the increased use of GM cotton, but the adoption of integrated pest management and the cultivation of organic cotton have also occurred, albeit on a much smaller scale.

The use of genetically modified cotton could reduce the need to apply pesticides. The most common type of GM cotton is Bt *(Bacillus thuringiensis)* cotton. The gene within Bt, a naturally occurring soil bacterium, produces an insect toxin that has been transferred into cotton plants, meaning that there is no need for the grower to apply certain pesticides (Baffes, 2004). Bt cotton is believed to be one hundred per cent effective in controlling two major pests, pink bollworm and tobacco budworm, and is highly effective in controlling cotton bollworm (Traxler et al, 2004). The use of Bt cotton in China resulted in a substantial reduction in the application of pesticides between 1999 and 2001 (see Table 10-5). In 2001 the reduction in pesticide use was 78,000 tons, or about a quarter of all the pesticide sprayed in China in the mid-1990s (Pray et al, 2002). The use of GM cotton in China has allowed farmers to increase their yield per hectare, to reduce their pesticide costs and to reduce their exposure to hazardous pesticides (Pray et al, 2002).

Year	Bt cotton	Non-Bt cotton
1999	11.8	60.7
2000	20.5	48.5
2001	32.9	87.5

Table 10-5: Pesticide application (kg ha-1) on Bt and non Bt cotton, 1999-2001 in selected Chinese provinces (Source: Pray et al, 2002).

Similarly in Mexico, the use of Bt cotton has resulted in cotton being declared a low pesticide crop (Traxler et al, 2004). GM cotton was planted on one third of Mexico’s cotton growing area (totalling 200,000 hectares) in the 2000 growing season. However, the area of Bt cotton has declined worldwide since the late 1990s in favour of herbicide-tolerant and insect-resistant varieties (Thalman, 2000).

Bt cotton trials have begun throughout Africa. Although South Africa is the only African country in commercial production of GM cotton, trials have begun in Tanzania, Tunisia, Zimbabwe, Egypt, Burkina Faso and Kenya (GRAIN, 2004a).

Adverse agronomic and environmental impacts of the use of Bt cotton have been reported in papers published by GRAIN, Greenpeace, WWF and the Pesticide Action Network. The GRAIN paper (2004b) shows that in the US, despite using supplementary insecticides, farmers growing Bt cotton lost 7.5 per cent of their crop to cotton bollworms in 2002. In a paper written for Greenpeace, Xue (2002) explains that the cultivation of Bt cotton could significantly reduce the numbers of parasitic natural enemies of cotton bollworm, is ineffective in controlling secondary pests which may replace the bollworm as primary pests, and eventually results in the cotton bollworm developing resistance to the Bt toxin after eight to ten years of continuous planting. WWF state that, according to data collected in the late 1990s in the USA, there is little evidence that transgenic cotton can contribute to more sustainable and environmentally friendly cotton production. The report states that statistical data reveals no correlation between the transgenic cotton adoption rate and the overall amount of insecticides and herbicides used in the US (Thalman, 2000). In a paper for the Pesticides Action Network, Coan (2004) highlights research which indicates that Bt cotton use in India has led to higher pesticide use and lower yields. According to one study, farmers needed to spray approximately the same amount of pesticides to control the Cotton Bollworm on both Bt and non-Bt varieties of cotton. Bt farmers also experienced increased attacks by secondary pests. Furthermore, underlining Xue's comments, the protection offered by the Bt gene is likely to last for only six years, at which point the bollworm is expected to develop resistance to the toxin. Another study shows that the release of the Bt toxin from cotton roots into the soil by Bt cotton varieties has been significantly underestimated and the impacts of this toxin input on soil biota are yet to be fully investigated (Vadakattu, G. and Watson, S., 2004).

Whilst the planting of GM cotton has developed on a large scale in both developed and developing countries, the current momentum to expand the cultivated area of organic cotton seems limited. According to Baffes (2004), the reasons for this are the costs of establishing a certification system and the lack of consumer demand for organic cotton in comparison with other commodities, such as coffee.

The third alternative approach is the use of integrated pest management (IPM). An FAO-EU study (Cotton IPM Newsletter, 2004) conducted in Asia between 1999 and 2004 found that an IPM programme resulted in improvements to biodiversity. Farmers who received specialised training reduced their use of pesticides by an average of 39 per cent relative to control farmers, resulting in an accumulated insecticide reduction of 1,600 tons over an area of approximately 250,000 ha. The results also demonstrated that farmers who practised IPM had more natural pest enemies and a higher species diversity in their fields compared to control farms. Targeted pest management practices have also been developed in West Africa, primarily through the longstanding *lutte étagée ciblée* (LEC) method which encourages farmers to adjust the dosage of pesticide treatments according to pre-determined pest threshold levels. In Mali, farmers who used this method reduced their use of pesticides by 70 per cent (GRAIN, 2004b).

10.3.5 Biodiversity

The intensive application of pesticides to cotton fields is hazardous for flora, fauna and ecosystems, both directly and indirectly. Direct problems include the poisoning or killing of wildlife, including non-target organisms such as migratory species of birds, insects and mammals that feed in fields that have had pesticides applied to them. Neighbouring fields and aquatic habitats can be adversely affected by pesticide spray drift, which can directly poison wildlife species. Indirect problems result from diffuse pollution. Modern pesticides are particularly toxic to water dwelling insects, plankton, crustaceans and fish (Clay, 2004). The runoff of fertilisers further affects the nutrient balance of ecosystems through eutrophication. It is difficult to gauge the precise scale of the problem, which varies regionally, but some examples of the environmental effects of diffuse pollution are considered in more detail below.

In 1995, runoff contaminated by the pesticide endosulfan, which had been applied to cotton fields, resulted in the death of more than 240,000 fish along a 25km stretch of river in Alabama (Soth, 1999). In 1994, Australian beef was contaminated with the cotton insecticide chlorfluazuron because cattle are likely to have been fed contaminated cotton straw. As a result several countries suspended beef imports from Australia. In a similar case, more than 100 laughing gulls and 25 per cent of all chicks were killed near Corpus Christi in Texas when methyl parathion was applied to cotton fields three miles away (PANNA, 1998). The extent to which national legislation, good practice, training and other forms of support are leading to the reduction in pesticide pressure is not clear from the literature. Hazards tend to be more severe in developing countries, not least because of limited institutional capacity.

The adoption of new areas for monocultural cotton plantations can destroy and fragment natural habitats (Soth, 1999). The example of the Aral Sea in the above section on water supply also demonstrates some of the implications for biodiversity of unsustainable water extraction for irrigation purposes. Biodiversity is seen to increase where cotton is grown in rotation with other crops. The rotation system boosts the variety of flora in production areas which provide refuges for beneficial insects which help to divert pests away from crops (Myers, D, & Stolton, S. (eds), 1999).

Table 10-6 summarises some of the major impacts of cotton cultivation on freshwater ecosystems and biodiversity. The table shows the main environmental problems and the impacts of those problems.

Mechanism	Pollutant/Change	Impact	Cases
Run off from fields	Fertiliser Pesticides Sediments	Eutrophication and pollution Wildlife contamination	
Drainage	Saline drainage water Pesticide or fertiliser contaminated drainage water	Salinisation of freshwater Pollution of freshwater	China, Egypt, Uzbekistan

Application of pesticides	Insecticides, fungicides, herbicides and defoliants Spray drift (e.g. aerial application) Leakage of equipment	Wildlife contamination Contamination of adjacent wetlands, surface and ground water Contamination of surface and ground water	
Water withdrawal for irrigation	Use of ground water Use of surface water	Change of water table or depletion of ground water Degradation of wetlands and lakes	New South Wales, Australia Aral Sea, Yellow River Valley
Extensive irrigation	Water logging	Raising water tables and salinisation of soil surface	Australia, Indus River Valley, Uzbekistan, Pakistan
Dam construction for irrigation	Regulated water flow	Habitat destruction, change of water table and change of water flow	
Land reclamation	Change of vegetation	Habitat destruction	

Table 10-6: Major impacts of cotton on freshwater ecosystems and freshwater biodiversity. Source: Soth 1999.

10.3.6 Air quality

There is little to no discussion in the literature of the issue of air quality in relation to cotton cultivation. However, dust storms are a problem in areas where soil quality has been severely degraded. This is an issue that has been highlighted by literature on the Aral Sea.

10.3.7 Climate change/greenhouse gas emissions

Again, there is little, if any, discussion in the literature on climate change and greenhouse gas emissions specifically from cotton, but the impact of high levels of nitrogen use over a sizeable area will be significant.

10.3.8 Plant and animal health

Cotton is severely affected by pests such as the boll weevil which have the potential to destroy entire crops. The use of pesticides is therefore widespread, and the environmental issues related to this have been summarised.

10.3.9 Distributional impacts

The environmental impacts of cotton production are widespread, but clearly vary geographically depending on the production system in place, natural conditions, local legislation etc. Whilst the available literature focuses on the environmental issues caused by cultivation in the largest producing countries, the literature on developing countries, such as Pakistan and countries in West Africa, and developed countries, such as the USA and Australia, suggests that similar environmental impacts occur wherever cotton is grown. The priority environmental impacts of cotton production are unquestionably those that arise from water mismanagement in areas of irrigated cotton and intensive pesticide use, which appears to occur in all cotton growing areas.

The lack of evidence from other developing countries is a regrettable gap in the literature, but it can be assumed that the same environmental problems probably do occur if a systems based approach to potential problems is used. In certain cases, where intensive cotton production has yet to be established, more sustainable cultivation practices involving crop rotations and labour intensive pest control methods including hand-picking pests and intercropping may mean the problem of excessive pesticide use is not present. However, Clay (2004) claims that over the past 100 years these methods have been abandoned in favour of chemical pesticides in most regions. They will be less pronounced in countries where there is little or no dependence on irrigation, such as in Central and West Africa where cotton's water requirement is met by rainfall. According to the NGO GRAIN, the environmental problems of cotton production have beset several West African countries, including Benin, Burkina Faso, Mali and Senegal. The problems highlighted in the report include deforestation, soil degradation, pesticide poisonings and the neglect of food crops (GRAIN, 2004b). The conversion of land from arable food crops to cotton production is a clear concern that has not been approached in much detail in the literature consulted.

Some attempts in different regions have been made to mitigate these two key problems, but the growth of organic cotton is minimal, the environmental benefits of GM cotton debatable, and the use of a system of integrated pest management expensive and time-consuming to introduce. Advanced irrigation systems, such as the drip technique used in Israel, offer some scope for the sustainable management of water resources, but uptake at the present time appears to be minimal. Cotton production continues to expand and newly irrigated areas continue to be developed, as in Turkey.

9.4 Analysis of Impacts of Current/Forecast Liberalisation Proposals

The environmental impacts arising from the liberalisation of the cotton sector will follow the expansion of output in some countries and contraction in others. Where expansion is occurring, experience suggests that much of this will be achieved through higher yields, more efficient and perhaps intensive production, with more limited increases in production area. The key environmental issues at a global level are likely to be:

- Intensive pesticide usage and the resulting problems of:
    - Decreases in biodiversity, through both direct inputs and contamination of water resources by diffuse pollution;
    - Reduction in soil fertility.

These are problems that could be exacerbated and intensified by trade liberalisation in all countries where production is expected to increase, but with differing degrees of severity. The greatest problems are likely to occur in those countries where production is forecast to increase: Australia, Brazil, Uzbekistan, Turkey, Pakistan, Mexico, India, West and Central Africa (e.g. Benin, Burkina Faso, Chad and Mali). It is unclear how far they will be mitigated by national measures.

- Irrigation and the resulting problems of:
  - Salinisation;
  - Unsustainable use of freshwater resources.

These problems could increase in severity through liberalisation in areas dominated by irrigated, as opposed to rain-fed cotton production: Turkey, Pakistan, Uzbekistan, Australia, Mexico. The most severe problems are likely to occur where the irrigated area is set to expand even further – as is the case for Turkey. Rain-fed cotton production dominates in Brazil, India and in West and Central Africa, and therefore these problems should be very much less.

- Land reclamation and the resulting problems of:
  - Habitat destruction and fragmentation.

These problems are likely to increase in severity in those areas where cotton production occupies a larger area in the future and in those areas with the most fragile, previously undisturbed habitats. Countries of the most concern are those in West and Central Africa and Brazil.

The above geographic pattern of problems could change over the next ten years. The data produced at the start of this chapter shows the rapid growth in cotton production that has occurred in Brazil since the early 1990s. New global players could therefore emerge unexpectedly in the future, especially in those countries and regions where production is expected to rise.

Environmental impacts could be reduced by liberalisation in the following countries due to a reduction in production:

- USA;
- Greece;
- Spain.

However, the environmental outcome will depend on what, if anything, is produced as a replacement in former cotton growing areas. Given that the cotton growing areas will have irrigation systems in place, substitute crops could also be intensively produced, causing similar pressures. However, as cotton production is set to decline rather than be eliminated by liberalisation, production is likely to continue on the same areas, but could be less intensive. The above three countries perhaps have the greatest opportunity to rectify environmentally damaging production practices because they each have a relatively strong regulatory and institutional capacity. For example, if production were to decline in Greece and Spain, the large subsidies directed at the sector through the European Union could be utilised to introduce more sustainable production practices and adapt the local infrastructure.

Since reform of cotton trade is prominent on the WTO agenda, liberalisation can be expected to have significant impacts in the medium term (5-10 years, depending on the progress of the negotiations). There is likely to be a step-change in impacts in countries where production declines (Greece, Spain, US), while the impacts of production increases are expected to be more gradual and widely spread.

10.4 Analysis of Potential Flanking Measures

Table 10-7 below summarises the main impacts of liberalised trade in cotton products in and outside Europe, and suggests flanking measures to deal with negative impacts where appropriate.

The three most appropriate flanking measures for developing countries outside Europe appear to be technical assistance, the development of a code of practice, and the more widespread introduction of a labelling initiative to encourage the growth of organic cotton. These measures are also applicable for Australia, where production is also likely to grow, Turkey and for countries in the EU and the USA as production will continue, albeit on a less intensive scale then previously. The role of the UK in these measures is likely to be minor, except perhaps with regard to the labelling initiative.

1. <u>Technical assistance</u>

The dispersion of knowledge of more sustainable management practices such as IPM and organic growing could be one of the more effective ways to reduce the environmental impacts that could result from further liberalisation of the cotton sector. Capacity building by technical assistance at the local level is an important way to implement more sustainable practices. The methods used within IPM have had success where funded, targeted work programmes have been put into place. Expert knowledge would also be required on those farms that have chosen to pursue organic production techniques.

The efficiency of irrigation systems could be improved where expert assistance can be supplied. As irrigation systems are, on average, only 40 per cent efficient, there is scope to reduce water losses and therefore minimise cotton’s dependence on freshwater resources. The introduction of more sophisticated drip irrigation systems is another way that technical expertise could be applied, if there is sufficient funding to pay for such schemes.

Table 10-7: Summary of environmental impacts of liberalised trade on cotton products, and potential flanking measures. Key impacts in bold.

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
Land use/landscape	Landscape change and perhaps a minor chance of some land abandonment as cotton production becomes no longer viable in Greece and Spain. NB: for Turkey, impacts are as for 'outside Europe'.	In Greece and Spain alternative management of the land could be ensured through cross compliance measures (e.g. GAEC) and Rural Development measures such as support for organic cotton farming. Outright land abandonment seems unlikely in most cases. No new measure needed.	Continued dam building, ecosystem destruction and changes in water flow in areas of irrigated production. Increased land reclamation and habitat destruction, especially in West and Central Africa and Brazil.	Best addressed through local regulation - no new measures needed. Softer measures such as technical assistance may be useful.
Soil	Decline in salinisation; longer term improvements to soil fertility; decreased soil erosion in Greece and Spain. NB: for Turkey, impacts are as for 'outside Europe'.	Not needed.	**In irrigated areas: increased salinisation, leading to land abandonment.** **In all areas where pesticides and fertilisers are used intensively: decline in soil fertility, increased soil erosion leading to land abandonment.**	**Largely to be addressed locally – it does not seem appropriate for the UK to seek regulatory flanking measures to address this issue.** **Some issues could be addressed through certification schemes and provision of technical assistance.**
Water quality and supply	In Greece and Spain, decreased reliance on surface and groundwater resources if cotton production is not replaced by	Not required so long as cotton production is not replaced by another equally water intensive crop.	**In irrigated areas: Increased chance of water resource mismanagement through the intensive and unsustainable**	**Largely to be addressed locally – it does not seem appropriate for the UK to seek regulatory flanking**

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
	another irrigated crop. NB: for Turkey, impacts are as for ‘outside Europe’.	Assuming Turkey accedes to the EU cotton production could be required to meet cross compliance measures (e.g. GAEC) and Rural Development measures which support more sustainable irrigation methods (e.g. the drip method).	**use of surface and groundwater resources. Leads to low water tables, salinisation, ecological disturbance to water sources. In non-irrigated areas: Chance that farmers in areas of rain-fed cotton may look to irrigation systems to increase yields. In all areas: contamination of water supplies with pesticides and fertiliser runoff.**	**measures to address this issue.** **Some issues could be addressed through certification schemes and technical assistance.**
Resource use/waste (pesticides)	As cotton production no longer becomes viable in Greece and Spain there will be a reduction in pesticide application and associated problems of runoff and contamination, as cotton production is unlikely to be replaced by an equally pesticide intensive crop. In Turkey, impacts are as for outside Europe.	Not required so long as cotton production is not replaced by another equally pesticide intensive crop. When Turkey accedes to the EU, cotton production could be required to meet cross compliance measures (e.g. GAEC) and Rural Development measures which support more sustainable pesticide application.	**Increase in pesticide application to combat pests, leading to increase in poisoning incidences, increased runoff and contamination of soils and water.**	**Largely to be addressed locally – it does not seem appropriate for the UK to seek regulatory flanking measures to address this issue.** **Some issues could be addressed through certification schemes and technical assistance.**

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
Biodiversity	Reduced chance of poisoning of wildlife and contamination of habitats by direct application of pesticides and fertilisers, indirect application of pesticides and fertilisers, (e.g. spray drift) and diffuse pollution into water sources, leading to problems such as eutrophication. The above will not be true for Turkey, if it accedes to the EU.	Not required so long as cotton production is not replaced by another equally pesticide intensive crop. If Turkey accedes to the EU, cotton production could be required to meet cross compliance measures (e.g. GAEC) and Rural Development measures which support more sustainable pesticide application.	**Increased chance of poisoning of wildlife and contamination of habitats by direct application of pesticides and fertilisers, indirect application of pesticides and fertilisers, (e.g. spray drift) and diffuse pollution into water sources, leading to problems such as eutrophication.** **Decrease in biodiversity in areas of monocultural production.** **Fragmentation and destruction of habitats through expansion of growing area and through damming.**	**Largely to be addressed locally – it does not seem appropriate for the UK to seek regulatory flanking measures to address this issue.** **Biodiversity considerations could be added to certification schemes, and technical assistance could provide farmers with knowledge of more sustainable farming techniques such as IPM.**
Air quality	No associated changes as a result of trade liberalisation	No flanking measures are needed.	Increased chance of dust storms caused by soil erosion in areas of monocultural production.	Development of a code of good practice to manage pesticide application, sustainable agricultural techniques etc.
Climate change/greenhouse gases	No associated changes as a result of trade liberalisation.	No flanking measures are needed.	Unclear.	Code of good practice.
Plant and animal health	Decreased chance of pest invasion as cotton production declines in Greece and Spain. Pests will continue to pose a problem for cotton growing areas in Turkey.	No flanking measures are needed if cotton production declines. Organic and IPM techniques should be encouraged. Technical assistance to provide farmers with knowledge of more sustainable farming	Increased chance of pest invasions in areas of cotton production.	Largely to be addressed locally – it does not seem appropriate for the UK to seek regulatory flanking measures to address this issue.

Type of impact	In Europe	European flanking measures	Outside Europe	Flanking measures for effects outside Europe
		techniques such as IPM; development of organic cotton farming and labelling initiative; development of a code of good practice to reflect more sustainable farming techniques; further research into GM varieties.		
Distributional impacts	Greece and Spain will experience reduced environmental problems as a result of the reduction in production. The impacts in Turkey are likely to be similar to those outside Europe.	Flanking measures will need to mitigate against any problems that occur as a result of pesticide usage and irrigation or the growth of replacement crops. The EU can provide the framework to ensure cotton production in Turkey becomes sustainable, especially given the drive to increase production through the extensive irrigation of the south-east Anatolia region.	All of the above problems could occur in areas dominated by irrigation i.e. Turkey, Pakistan, Uzbekistan, Australia, Mexico. All other problems could occur in West and Central Africa, Brazil and India. The environmental impacts above could be less severe in the USA as production declines.	Flanking measures should reflect issues specific to developing countries and whether cotton is irrigated or rain-fed. The most important measure for developing countries is to manage the use of pesticides, either by reducing (IPM) or eliminating (organic) their usage. Flanking measures will still need to mitigate against problems as production is not likely to cease completely.

This measure has a successful track record for projects led under the IPM banner. It requires a significant resource input at the initiation phase, but this should diminish over time as low impact production techniques become self-sustaining as local people transfer knowledge between one another. The measure could be effectively introduced in both developed and developing cotton growing countries. Extension services can be introduced by government, or by other groups such as NGOs and commercial enterprises, preferably with government support.

2. Voluntary codes of practice

Initiatives led by either government, intergovernmental organisations or NGOs could lead to individual farmers or groups of farmers subscribing to the idea of a voluntary code of practice for sustainable cotton cultivation. This approach overlaps with the other measures described for technical assistance and labelling initiatives. Farmers could be educated to utilise an approach such as integrated pest management. Knowledge transfer regarding this technique, provided under the flag of certain intergovernmental organisations, has proven to be a success in areas in West Africa and Asia. The two examples identified in this study are the FAO-EU programme for cotton in Asia which ran from 1999-2004 and the LEC scheme which has been introduced through different projects in West Africa since the early 1990s. Irrigation management practices could also be the subject of a code of practice, although examples have not been discernible from the literature consulted. The code could, for example, instil the need to undertake good canal management in order to reduce the loss of freshwater.

On a broader scale, the cotton industry could commit to establishing a code of practice for all major cotton companies to follow voluntarily. Such an approach could learn from the success of the Forest Stewardship Council which provides chain of custody certificates for sustainable timber production. However, due to the size of the industry and vested interests such an approach is only likely to be effective in the medium to long term. The implementation of this measure is dependent on a certain level of pressure by either government or NGOs.

This measure could be effective in developed cotton growing countries where NGOs, for example, could lobby both industry and government to develop a code of practice. The introduction of the measure in developing countries is more difficult where political will could be considered to be weaker. Here it would be the responsibility of international initiatives, such as the projects mentioned above, to develop good practice. However, the application of the measure could be inhibited by the fact that these projects have, in the past, only covered a certain geographic area, and have only been financed for a certain period.

3. Labelling initiative

A labelling scheme, to certify the authenticity of organic cotton, is a key measure to improving the long-term sustainability of cotton production. Certification adds credibility to the product and promotes marketing at a premium price (Rundgren, 1999). The environmental benefits of organic cotton production are the elimination of pesticide inputs, the elimination of pesticide spray drift, an increase in biodiversity through, for example, crop rotations, and an increase in beneficial insects to control pest populations.

As reported earlier in this chapter organic cotton production accounts for a miniscule proportion of overall production. However, there is history of organic conversion dating back to the 1980s. The development of a globally recognised certification scheme for cotton production (as opposed to processing), akin to the Forestry Stewardship Council label, has the most scope of all the flanking measures for eliminating pesticide inputs. In the past schemes have been established by a range of organisations, including NGOs, government agencies and the commercial sector (Elzakker, 1999). The measure would be bolstered if used in conjunction with other measures, in particular incentive or compensation payments and technical assistance, for example for the supply of farmer extension services. However, it does not offer similar assurance for sustainable water use, and an associated mechanism, such as an irrigation tax, could provide a more holistic approach for sustainable cotton production.

The main disadvantages of a labelling scheme relate to the apparent low demand amongst consumers for organic cotton (Baffes, 2004). It remains a niche market, with only a minority of clothing manufacturers such as Patagonia and Howies using cotton that has been produced and then processed organically. The introduction of one internationally-recognised cotton certification logo could however rectify this and raise the profile of organically produced cotton. A certification scheme is also costly to implement in relation to the value of the product. However, it has been reported that such overheads should not add more than ten per cent to the cost price after a period of two to three years has elapsed (Elzakker, 1999). Other potential costs include the associated outlay for extension services, and a potentially bureaucratic certification process.

An organic cotton certification scheme can be more widely implemented in both developed and developing countries, although the method of implementation would differ. For example, WWF developed the first organic cotton production in Greece (Elzakker, 1997), whilst projects in developing countries such as India and Uganda have been designed especially for farming systems involving many smallholders. The International Federation of Organic Agriculture Movement (IFOAM) has also accredited a number of organic farming certification organisations which can be applied to cotton production. Awareness raising of the benefits of growing organic cotton should take precedence over any proposal to give greater exposure to GM cotton, the environmental benefits of which remain unclear.

9.6 Conclusions

Based on the above analysis, the UK could consider the following flanking measures in order to minimise the environmental impact of any further trade liberalisation:

- Technical assistance schemes
- Development of an organic labelling initiative
- Development of a code of good practice for sustainable cotton production

These three measures would help to either reduce or eliminate the unfavourable environmental conditions which emerge from unsustainable pesticide usage and excessive irrigation. The merit of using these measures is bolstered by the fact there has been some success in applying them in the field e.g. the FAO-EU cotton IPM initiative in Asia. They could be implemented multilaterally by involving partner organisations or through funding the activities of an NGO. The development of an internationally recognised organic labelling initiative and/or code of good practice would involve many partner organisations, including government departments, industry and NGOs and would achieve identifiable environmental rewards. The three measures are particularly appealing for implementation in developing countries and Australia where production is expected to increase, but should also be considered for the US and the EU where production is expected to decline.

However, these measures do not tackle the remaining priority environmental impact of land reclamation. This is predominantly a national concern with limited scope for the three flanking measures identified here. This issue is and will be a major concern for Brazil and countries in West and Central Africa. A multilateral approach to approaching this issue may be the answer.

10.5 Future research needs

A number of gaps in the literature are evident. There is a lack of knowledge about certain geographical pockets, mainly Brazil. Brazil has experienced a huge acceleration in production in recent years, but the environmental side-effects of this appear to remain undocumented. Also, whilst there are case study examples of cotton production in countries such as Pakistan, little appears to have been written on the precise environmental impacts that are occurring in West and Central Africa. A detailed breakdown of the area of cotton that is rain-fed and the area that is irrigated would be extremely helpful. More data on cotton growing in China is required, as well as more modelled data on the effects of trade liberalisation in this country as the literature reviewed predicts both increases and decreases to production there. More knowledge is also required on changes to farming systems that could result from the adoption of flanking measures. The main example identified in this case study is the possible environmental problems arising from an increase in the area of organic production (i.e. potential increase in land reclamation and irrigation in order to increase overall output to make up for the lower yields associated with organic production.

11 OVERALL CONCLUSIONS AND RECOMMENDATIONS

11.1 Introduction

The analysis in this report is based on five case studies of individual agricultural commodities with different characteristics. These illustrate the spread of issues and concerns that potentially arise as a result of trade liberalisation. Of necessity, the focus has been on the global level rather than examining likely developments and impacts in individual countries. This has the effect of offering a global perspective, enabling some comparison between commodities, but it does obscure the potentially significant effects that may arise in specific countries and regions.

In trade terms, liberalisation has been explored primarily through a literature focussed on global rather than regional adjustments and multilateral rather than bilateral trade agreements. In particular, the WTO Agreement on Agriculture is the starting point for many liberalisation studies. It has not been possible to examine all aspects of liberalisation. For example, there is an important issue regarding the extent to which developing countries may be required to reduce levels of protection for agricultural commodities entering their domestic markets. This could have the effect of reducing production levels of some of the traded commodities considered in this study, as well as others such as rice (Oxfam 2005). However, it is difficult to forecast the extent to which developing countries are likely to have to make such commitments as a result of the WTO or other negotiations. Nor have we found models providing useful and credible quantitative estimates of the impact of this aspect of liberalisation. Consequently, this important issue is not considered to any significant degree in the case studies.

The focus on commodities allows environmental impacts to be identified at a global level, whilst underlining that some of these effects are associated with particular production systems or geographical regions. It is possible to set environmental costs and benefits alongside one another. The drawback, however, is that it provides little sense of how liberalisation as a whole effects the pattern of production and consequently the environment in a particular region. For example; it is not immediately apparent how land use will change following a reduction in output of one commodity. In many cases, producers will switch to other commodities with their associated environmental implications. In some places, production may cease altogether. To capture these effects requires a sizable set of geographical case studies to complement the commodity-based analysis.

Environmental issues have been considered independently of social, cultural and economic concerns as far as possible in this report. Clearly, however, there are links between them and policy decisions will need to be made in the light of objectives beyond the strictly environmental.

These considerations should be borne in mind in the conclusions that follow.

11.2 The Environmental Impacts of Trade Liberalisation

For most of the commodities, the study has been able to draw on a body of evidence relating both to the environmental impacts of production, and the expected broad impacts of trade liberalisation on patterns of production and trade. However, there are significant limitations to this literature and some significant gaps are apparent. While there have been several studies of the effects of liberalisation of trade for some commodities – particularly those where intervention is greatest such as sugar, cotton and dairy – the evidence base is much thinner for others, such as poultry and vegetables. Evidence of the environmental impacts of production in different countries and settings is also variable and incomplete, particularly for certain commodities in certain parts of the world. For example, evidence of the environmental impacts of poultry systems in developing countries is, at best, patchy.

The exercise of predicting environmental impacts on the basis of projected changes in output at a national or even regional level is unavoidably speculative and adds further uncertainties. Examples of these uncertainties include:

- The regional location of production changes, and distribution between different farm types.
- The extent to which changes in production will be reflected in changes in cropped area and changes in yield, often associated with intensification.
- The likely impacts on land use, through, for example, substitution of one crop for another, clearance of non-agricultural habitats (of different types) and potential abandonment of agricultural land.
- The effects of liberalisation on different production techniques and systems, given that these may vary by location.
- The precise direction and magnitude of new trade flows.

Putting these considerations on one side, it is clear that the environmental impacts of trade liberalisation vary by commodity. These variations depend on:

- **The degree of support and protection in place and scope for further liberalisation.** For example, liberalisation usually will have greater impacts on the economics of production for commodities where current levels of protection and support remain high (such as sugar, dairy and cotton) than for those where they are low (such as eggs and poultry meat).
- **The extent to which products are internationally traded**. The most traded commodities such as sugar and cotton are likely to be more sensitive to the effects of liberalisation than those that are more difficult to store and transport (e.g. vegetables and eggs). The dairy sector lies somewhere in between these groups in that some products (butter, cheese and milk powder) are more easily stored and traded than others (fresh milk).
- **The extent to which methods of production (and hence environmental impacts) vary by country.** For some commodities, production systems are remarkably similar between countries, intensive poultry systems being a prime example, albeit one subject to widely varying regulatory standards. In other cases, profound differences in production systems result in greatly differing environmental impacts, examples being cotton (which may be irrigated or rain fed) and sugar (grown from cane or beet). Vegetables vary in the use of irrigation and greenhouses, while dairy systems use varying degrees of supplementary feed and housing of animals.

- **A variety of climatic, environmental and regulatory conditions in the producing country.** The case studies suggest that the impacts of changing trade patterns are likely to vary according to the sensitivity of the environment in the countries affected (e.g. importance of habitats, need for irrigation, sensitivity of water resources to abstraction or pollution). Variations in regulatory conditions (e.g. animal welfare standards for chickens, degree of protection of habitats at risk from conversion to agriculture) will also lead to differences in impact.

Clearly trade related developments are only one of a number of factors driving changes in agricultural production and processing. Most sectors of agriculture are experiencing changes arising from technological development, changing market conditions, a rising tide of legislation, rising labour costs and structural change. In order to measure trade effects in these case studies, an anticipated rise or fall in the level of output in a country has been taken as the principal indicator. It has been necessary to rely on models for such estimates but it would be desirable to validate the outputs of these models by means of independent work, including detailed sectoral studies. Without this, it would be unwise to put too much confidence on the scale of trade effects relevant to other factors shaping patterns of production.

In some cases it is clear that the impacts of trade liberalisation are likely to be less significant than the effects of changing domestic patterns of production and consumption. This is especially true for relatively less traded commodities experiencing strong worldwide demand growth (such as vegetables). The projected effects of trade liberalisation are more prominent in markets like sugar and cotton where demand growth is more moderate, trade relatively more significant, government intervention substantial and differences between production methods and costs pronounced.

Table 11-1 provides a summary of the scale of expected global environmental impacts of liberalisation of trade in the five commodities.

	Dairy	Sugar	Vegetables	Poultry	Cotton
Land Use and Landscape	**	**	*	*	**
Soil	**	**	*	*	***
Water Quality and Supply	***	***	**	**	***
Resource Use/Waste (including pesticides)	**	**	**	**	***
Biodiversity	**	**	*	*	**
Air Quality	*	**	*	**	*
Climate Change	**	*	**	**	*
Plant and animal health and Welfare	**	-	*	***	**
Key: - no impact identified * minor impact possible					

** potentially significant impact, at least locally *** substantial impact expected.

Table 11-1: Summary of Environmental Impacts by Commodity

Increased trade itself could be expected to have environmental impacts, irrespective of the commodity. Perhaps the most prominent is expanded international transport of foodstuffs, associated with energy consumption, greenhouse gas emissions, infrastructure development etc. Air freight is expanding rapidly and has the highest environmental impact of the different modes, although, according to recent work by Pretty et al, the scale of air freight is still small by comparison with domestic road transport within the food sector. UK air freight imports and exports amounted to about two million tonnes in 1998 of which imported fruit and vegetables contributed just over 5 per cent. Air freight has increased subsequently and should not be underestimated given the multiple environmental impacts but the much greater scale of domestic road transport should be borne in mind.

Table 11-2 provides a summary of the expected environmental impacts that give greatest cause for concern or offer potential benefits, and the key locations of these impacts.

Commodity	Impact	Location
Dairy	1. Intensification, where production increases, causing range of impacts, especially water pollution	Australia, New Zealand, Argentina, Brazil
	2. Expansion, particularly forage area, threatening semi-natural habitats and more extensive livestock systems	Australia, New Zealand, Argentina, Brazil
	3. Risk of abandonment of dairy systems in high nature value areas.	Parts of Central and Western Europe
	4. Reduced water pollution and fertiliser use in areas where dairy farming scaled back.	Parts of Central and Western Europe
Sugar	1. Expansion of production, placing increasing pressure on biodiversity, soil and water resources	Brazil, Thailand, India, Australia
	2. Reduced sugar beet production, eases pressure on soil and water resources but with some offsetting disadvantages e.g. less variety in arable crop rotations which affects some ground nesting birds.	Less competitive EU countries
	3. Likelihood of abandonment of some cane plantations in ACP countries, resulting in landscape change, significant rural development impacts but opportunities for habitat recreation	ACP countries, especially Barbados, Cote d'Ivoire, Jamaica, Madagascar, St. Kitts and Nevis.
Vegetables	1. Increased greenhouse gas emissions due to increased vegetable trade	Global
	2. Variety of potential impacts on soil, water, landscape, biodiversity, due to export related expansion including increased water abstraction and pesticide use in developing countries. Some offsetting reductions in pressure in Europe; depending on alternative land uses.	Middle East, Africa, Central and South America, China.
Poultry	1. Expansion of intensive poultry systems in low cost exporting countries, with varying environmental and animal welfare standards. Impacts on water, air, animal welfare.	Brazil, Thailand and US
	2. Environmental benefits of reduced poultry production	EU

Cotton	1. Increasing pesticide use in areas where production expands, with impacts on biodiversity and soil fertility.	Australia, Brazil, Uzbekistan, Turkey, Pakistan, Mexico, India, West and Central Africa
	2. Increased irrigation, with pressure on water resources and risk of salinisation.	Turkey, Pakistan, Uzbekistan, Australia, Mexico
	3. Land reclamation and the resulting problems of habitat destruction and fragmentation.	West and Central Africa and Brazil.
	4. Reduced environmental problems as production declines; any replacement crops likely to be less resource intense.	Greece, Spain, US

Table 11-2: Summary of Principal Expected Impacts and their Location

As noted above, it is equally necessary to consider impacts in geographical locations taking account of a range of commodities as well as on a commodity-by-commodity basis. For example, Brazil is expanding production and exports of a variety of commodities (including sugar, cotton, dairy, poultry and vegetables) and trade liberalisation is expected to further increase the country's share of these markets. Some of the key potential environmental impacts – such as the risk of clearance of natural habitats – and potential policy responses - are not merely specific to individual commodities but relate to wider issues of the inter-relationship between agriculture and the environment. The level of environmental risk and opportunity depends considerably on the political choices and institutional capacity of the country in question. It is difficult to generalise about the likelihood that valuable habitats will be damaged by expansion of a particular crop. Factors such as land use planning, environmental regulations and local traditions will have an important influence.

11.3 The Role of Flanking Measures

The range of potential environmental impacts identified as a result of trade liberalisation and our limited capacity to forecast exactly how and where they arise creates challenges for any policy response strategy. A variety of measures and ability to respond flexibly are both valuable. In selecting an appropriate group of flanking measures we have been conscious of a number of factors, including:

- **The need to distinguish between trade flanking measures and wider policy responses**. For some commodities, trade effects are likely to be outweighed by the effects of supply and demand at the national level, and policy responses (such as national regulatory developments) need to reflect this.
- **The ability of the UK government and EU to address the environmental impact in question**. Some measures – especially those to deal with impacts of primarily local or national significance – are likely to be beyond the influence of the UK and EU. Examples might include regulations or economic instruments concerned with water pollution in the producing country. In other cases, such as measures targeting UK consumers, setting international standards, or adapting UK international development programmes, the UK and EU clearly have a role to play.
- **The scope for action to address a variety of commodities or impacts**. Given the variety of different commodities and impacts expected to result from trade liberalisation, there is value in considering umbrella measures that are able to deal with these impacts collectively, reducing the need for many

small individual actions. For example, programmes to raise consumer awareness could cover a variety of different impacts and potentially different commodities. The issue of land clearance for commodity production might be best tackled on a cross-commodity rather than single commodity basis.

Table 11-3 provides a summary of the most appropriate flanking measures to deal with the key environmental impacts identified for the five commodities.

Commodity	**Impact**	***Flanking Measure***
Dairy	1. Localised water pollution impacts, most significant in countries where production is predicted to increase.	*Best dealt with by national legislation – limited UK role, except in encouraging UK compliance with the Nitrates Directive..*
	2. Risk of abandonment in Europe	*Agri-environment schemes and national envelopes. No new measures needed.*
	3. Global, non-sector-specific issues (e.g. greenhouse gases, risk of habitat clearance)	*Best addressed by existing international agreements (Kyoto, CBD).*
	4. Variety of global and local environmental and animal welfare issues	***Consumer awareness, certification and labelling schemes. Scope for new UK or EU initiatives.***
Sugar	1. Worldwide impacts on biodiversity, soil, water resources	***Consumer awareness, certification and labelling schemes. Scope for new UK or EU initiatives.***
	2. Localised impacts in Brazil, Thailand, Australia	*National regulations – limited UK role. Potential role for international agreements if globally important habitats affected. UK/EU overseas development programmes could seek to mitigate negative impacts and reinforce positive impacts.*
	3. Likelihood of reduced area of sugar beet, with some environmental costs as well as benefits in arable areas.	*EU agri-environment programme has role in managing impacts. No new measures needed.*
	4. Risk of abandonment of developing country sugar cane plantations	***UK/EU overseas development programmes could seek to mitigate negative impacts and reinforce positive impacts***
Vegetables	1. Greenhouse gas emissions caused by food miles	*Taxation of aircraft fuel, which is subject to ongoing discussion in the EU (or inclusion of kerosene in the EU emissions trading system)* ***Consumer awareness programmes linked to existing labelling of country of origin***
	2. Variety of potential impacts on soil, water, landscape, biodiversity, due to export related expansion.	*Regulations within producing countries. Limited scope for UK influence.* ***Market based measures, including consumer awareness programme, labelling and certification.***
Poultry	1. Air and water pollution, animal welfare concerns from intensive systems	*National regulations, with little scope for UK influence.* ***Attempts to introduce product standards harmonising animal welfare and environmental standards for imports and domestic production (problems of WTO compatibility)*** ***Market measures, including consumer awareness, product labelling, certification***
Cotton	1. Impacts of pest management and irrigation in developing countries	***Technical assistance programmes, designed to promote integrated pest management, organic production etc. and improve the efficiency of irrigation.***
	2. Wide ranging environmental	***Voluntary code of practice.***

	impacts caused by cotton production	***Labelling and certification schemes, especially the development of an internationally recognised organic cotton standard.*** ***Consumer awareness building of key environmental problems and importance of above two measures.***
	3. Risk of land clearance for cotton production, e.g. in West and Central Africa	***Need for careful monitoring. Possible role for multilateral agreement.***
Bold indicates areas where new initiatives may be required, and where the UK and EU potentially have a role to play.		

Table 11-3: Summary of Key Potential Flanking Measures

The table indicates that, given sufficient political will, many of the expected environmental impacts of trade liberalisation can either be dealt with by existing measures (such as the EU agri-environment programme) or are most readily addressed by regulations or other measures at the national level in third countries. In these cases, the UK and, more broadly the EU, have relatively limited direct influence on choices made in these countries, particularly in the shorter term.. The table highlights a number of less direct and softer measures which are available such as development assistance, training, promoting good practice, capacity building etc. These measures can be taken forward at both the national and the EU level. There are also opportunities for pursuing this through international bodies, such as the FAO.

In principle, there is also scope for working at the global level, both to improve compliance with existing multilateral agreements, such as the Convention on Biodiversity and to negotiate new agreements. Measures to strengthen the multilateral framework, which might include agreeing environmental standards in certain areas, such as pesticide use on foodstuffs or minimum standards for farm animal welfare. Multilateral initiatives would be valuable but have not been discussed in any detail because of the long timescale involved in launching international agreements of this kind and the high level of opposition by many developing countries to more stringent environmental standards of this kind in the current climate. Nonetheless, they represent a key measure in a longer term suite of flanking policies.

More radically, a tighter linkage between trade policy and environmental sustainability can be envisaged. There is room for a debate on whether it would be possible to develop a sustainability index or a set of sustainability indicators which could be used to classify different products and production systems. This could be deployed through voluntary or mandatory labelling systems or through a direct linkage between tariffs and other trade policy instruments and a products' sustainability. This is not an immediately available flanking measure but could be seen as an issue to investigate further.

The principal shorter-term potential UK/EU policy responses are highlighted in bold in Table 11-3 and can be grouped as follows:

1. **Consumer awareness programmes**. Consumers in importing countries have a key role to play in mitigating the environmental impacts of trade liberalisation, by choosing products with benign impacts on the environment in preference to those produced in an environmentally damaging way. Raising the awareness of food processors, retailers, caterers and individual consumers

is a key step in informing such choices. Since the variety of environmental impacts relating to different production systems and locations represents a major challenge for the consumer, such awareness programmes are dependent on ability to present clear and unambiguous information about the relative merits of different products. These messages may be linked to certification schemes (e.g. organic), or readily understood concepts (such as food miles, intensive vs. free range chicken etc.). They therefore complement initiatives to develop labelling and certification schemes. Concepts and standards that apply across commodities, such as food miles and organic standards, have the advantage in that they simplify the message and have the potential to influence demand for different commodities through a single campaign.

2. **Labelling and certification schemes**. For several commodities, the case studies identify the potential benefits of developing and/or harmonising certification and labelling schemes. Organic standards are internationally recognised and offer the potential to reduce the negative impacts of each of the commodities examined in this report. For some, such as cotton, organic production currently accounts for only a tiny proportion of the total, and there is a need both to encourage the development of internationally recognised standards and to raise consumer awareness of the benefits of organic production. Certification and labelling schemes linked to other systems such as integrated crop management also offer potential to improve environmental performance. UK food processors and retailers have a key role to play in promoting the uptake of sustainable production methods, and, by working with the food industry, the government could help to galvanise more initiatives in this area.
3. **UK/EU development assistance programmes**. Where regions affected by trade liberalisation are subject to development assistance programmes, there will be at least some cases where opportunities to promote sustainable food and agriculture systems and enhance the environmental impacts of trade liberalisation arise. Examples highlighted by the case studies include the role of technical assistance programmes to support integrated pest management and more efficient irrigation methods in the cotton sector, and rural development programmes to manage the effects on sugar growing areas in ACP countries.
4. **Regulations related to process and production methods**. The poultry case study, in particular, highlights concerns about imports to the UK and Europe produced to lower environmental and animal welfare standards than those that apply to domestic production. This remains a contentious issue, with WTO rules limiting the scope to enforce regulatory standards based on process and production methods. Further investigation of the feasibility of progress in this area would be required. The scope for seeking multilateral agreements to raise standards needs to be explored, even if progress may be expected to be slow.
5. **Multilateral environmental agreements**.
   Multilateral environmental agreements are most likely to be appropriate in addressing impacts of global significance, such as climate change and biodiversity loss. The sugar, cotton and dairy case studies, in particular, highlight the risk of clearance of new land for farming, including natural habitats as a result of expanding production. The extent to which internationally important habitats are threatened in this way is highly uncertain but large scale forest clearance is taking place in several countries with potential to increase their exports. Further research would be beneficial, and

would help to inform appropriate responses (e.g. under the Convention on Biological Diversity). Climate change impacts may arise both as a result of increases in production and trade, and, in principle, can be addressed through the Kyoto process.

6. **Reducing negative externalities of transport**
   Some of the environmental pressures arising from liberalisation are linked to activities which could be influenced through public policy, such as the growing scale of air freight. The external costs of air freight in particular could be reduced by a means of a tax or emissions trading regime for aircraft fuel which would need to cover long distance freight as well as flights within Europe.
7. **Incentives for appropriate agricultural production in the EU**
   Some of the concerns arising within Europe because of liberalisation arise from the potential abandonment of production systems with environmental benefits or growing pressure to intensify and increase scale to compete with foreign suppliers. These pressures equally apply to farm animal welfare. Within the CAP, there are measures allowing incentives to be paid, through agri-environment schemes, support for Less Favoured Areas and support for meeting high environmental and animal welfare standards. Targeting measures in an appropriate way is the responsibility of EU member states, although the rules determining the acceptable payment levels are set in EU regulations and the funds available rely heavily on the CAP budget in nearly all Member States. The scale of the CAP Pillar II budget for 2007-2013 is currently uncertain. Pillar II measures can target issues thorough voluntary incentive payments but are not designed to tackle large scale structural change in agriculture, which will itself generate environmental consequences.

11.4 Further Research Needs

The case studies have highlighted a number of significant gaps in the evidence base, relating to:

- **The environmental impacts of commodity production**. There are substantial gaps in the evidence base for a number of commodities in different parts of the world. Further research could profitably focus on the environmental impacts of production of commodities in regions where it is expected to be affected by liberalisation. Examples include sugar in Brazil, dairy systems in Argentina and Brazil, poultry production in Brazil and Thailand, cotton growing in West and Central Africa and Brazil, and vegetables in many developing countries. The impacts of declining production and potential abandonment – e.g. of sugar systems in ACP countries, dairy in parts of Western Europe – would also benefit from further research. Some more generic issues – such as the impact of food miles resulting from trade in vegetables – would also benefit from further study.
- **The effects of trade liberalisation.** A general limitation of the literature is that the outputs of modelling studies are insufficiently detailed to enable an assessment of environmental impacts. Many studies make predictions about liberalisation effects on aggregate output at the national level, but most do not attempt to distinguish between effects on yields and area, to consider the effects on land use, or to assess the regional distribution of changes in production. Further studies considering some of these key changes would help to inform assessments of environmental impact. Once again, focusing on those

regions where greatest potential change is predicted (e.g. sugar and cotton in Brazil) would be worthwhile.

- **The use of flanking measures**. In a study of this size, it has been impossible to investigate in any detail the feasibility of introducing the potential flanking measures identified, or to consider what actions would be required to develop and implement them. This is an area that requires further research.

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ANNEX 1 EXAMPLES OF BEST MANAGEMENT PRACTICE IN SUGARCANE GROWING

Code of Practice for Sustainable Cane Growing: Canegrowers Association, Queensland, Australia

The challenge of meeting obligations under Queensland's Environmental Protection Act 1994 inspired the Canegrowers Association to develop a Code of Practice for Sustainable Cane Growing in 1998. The Code covers both establishment of new cane growing areas and cane growing on existing farms. The Association promotes the Code amongst its members as a means by which they can comply with the requirements of environmental legislation, and improve their chances of avoiding any legal action brought against them in relation to environmental damage (Canegrowers, 1998).

The Code covers all main activities related to cane growing that can have environmental impact. Emphasis is given to avoiding clearing of riparian vegetation and draining that may affect wetlands. For existing farms the Code suggests measures related to native vegetation management (including riparian vegetation); soil management (erosion, use of fertilizers and soil ameliorants - including sugar mill by-products, managing saline soils); irrigation; drainage; weed, pest and disease control; fire management; timing of operations; use, storage and disposal of fuel and dangerous substances; waste management; and on-farm monitoring and record keeping. The Code provides references to all relevant environmental legislation

Development of the Code of Practice was followed in 2001 by an additional awareness raising and training programme of one day workshops for sugarcane growers in Queensland and New South Wales. The programme is based on a self-assessment tool for cane growers, which helps them to benchmark their performance against the Code of Practice, in areas such as: nutrient management and fertilizer use, soil health and conservation, irrigation best management, drainage, the business of farming, riparian vegetation, pest management, planting, use and disposal of chemicals and dangerous goods, and harvesting.

By the beginning of 2004, participation rate of the workshops had reached 31 per cent of sugarcane growers, although farmers who did not participate in the workshop could have adopted the Code of Practice too. Although self-assessment cannot be relied upon as an independent measure of farmers' environmental performance the programme has significantly contributed to the uptake of the Best Management Practices in sugarcane growing (C4ES Pty Ltd, 2004).

Environmental guidelines for sugar production in South Africa

In South Africa, two sets of environmental guidelines on sugarcane growing were developed: Managing Natural Resources: A Cane Grower's Handbook for use by cane growers (South African Cane Growers), and Standards and Guidelines for Conservation and Environmental Management in the South African Sugar Industry. The Handbook covers management of basic environmental issues relating to land use planning, production of sugarcane (cultivation techniques, nutrients management, irrigation, drainage, plant protection products application, harvesting), transport of the crop, and managing biodiversity.

The Standards and Guidelines are primarily intended for extension officers, environmental consultants and members of Local Environment Committees (SASA, 2002). They are regarded the most comprehensive set of Best Management Practices for sugar production (IEED, 2004). In addition to regular environmental issued related to production, such as field practices, water management, air pollution, soil management and waste management, the Standards and Guidelines cover also broader natural resources and public recreation facilities management, transport regulations including cane spillage issues, facilities for employees, and system of environmental audits, as well as references to all relevant international convention and local legislation.