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Re Minister  
there's rather a lot

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2 or 3 corrections of jargon. 30 June 1989  
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Dear Charles  
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**GLOBAL ENVIRONMENT: ECONOMIC ISSUES  
PAPER FOR THE PRIME MINISTER**

At her meeting on global climate on 19 April the Prime Minister called for 'further work on the economic aspects of international environmental issues to help prepare a well researched UK paper in good time for the Economic Summit' in July. The Department of the Environment with ODA were put in the lead, with support from other Departments.

I attach a paper that has been drafted by officials, on this basis. My Secretary of State and the Minister for Overseas Development have seen it and are content for it to be sent forward.

Copies of this letter and attachment go to Alex Allen (Treasury), Stephen Wall (FCO), Neil Thornton (DTI), Myles Wickstead (ODA), Stephen Haddrill (DEN), Roy Griffiths (DTP), Shirley Stagg (MAFF), Trevor Wooley (Sir Robin Butler's office) and to Nigel Wicks at the Treasury.

*Yours sincerely,*  
*Roger Bright*

R BRIGHT  
Private Secretary

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## THE GLOBAL ENVIRONMENT: ECONOMIC ISSUES

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## THE GLOBAL ENVIRONMENT: ECONOMIC ISSUES

### 1. INTRODUCTION

1.1 There are a number of major global environmental concerns on which the need for urgent international action is now widely recognised. These include, inter alia, climate change and global warming (see Annex 1); CFCs and the ozone layer (see Annex 2); and deforestation, desertification and loss of genetic diversity (see Annex 3). Acid rain and marine pollution issues are further examples. Such concerns raise difficult scientific, technological and economic issues, not least of analysis and policy. The more advanced industrialised nations have an essential role to play in addressing these challenges. Developing countries are deeply affected by all of them. This paper addresses some of the key economic issues involved.

1.2 Explicitly or implicitly decisions are continually being made about trade offs between the environment and economic development. A major purpose of economic analysis is to try to ensure that such decisions are fully informed about the economic value and functions of the environmental assets affected. This is essential if priorities in resource use are to be established and assessed, and a proper balance struck between policies of prevention and adaptation. Economic progress need not be at the expense of the environment. Indeed, in many developing countries, the prospects for long term economic development depend on the careful management of natural resources such as pasture, water, fertile soil and forest. Environmentally sustainable development is now recognised as both possible and essential.

### 2. ECONOMIC ISSUES

#### Common property resources: the global commons

2.1 Industrialised countries are dependent for their raw material and energy on the international exploitation of forests, fisheries, fossil fuels and mineral reserves. Many of these resources - tropical and temperate forests, coastal and shelf fisheries, mineral and fossil fuel reserves - fall within or across national boundaries. The countries having sovereignty over them exercise exclusive property rights over them and can therefore determine whether they are exploited or conserved, although a major factor in the pace of exploitation will be international demand.

2.2 For resources that lie outside national boundaries, such as ocean fisheries, no country has exclusive property rights and these resources may therefore be seen as common property resources - the global commons. In the absence of international agreement to ensure cooperation among all users, no country has a strong incentive to manage such common property resources sustainably. On the contrary individual countries will tend to exploit such resources, possibly regardless of the long term consequences.

2.3 Economic progress has also become dependent on the atmosphere and stratosphere and oceans for disposing of pollutants. There is a widely recognised need to control or limit the use of this capacity through international agreement, since individual countries do not face the costs of using the assimilative capacity of the environment until it becomes overloaded. Only when pollution gives rise to threshold effects - changes in climate, ozone depletion, pollution hazards and so on - do the costs of thus treating the global commons become apparent. At this point, everyone has to face the consequences regardless of whether they are major polluters or not.

2.4 To avoid this problem there is a need to place proper values on the services provided by the environment and to ensure that users are faced with the true costs involved. Many of these services are currently provided at zero price simply because no market exists in which their true values can be revealed through the acts of buying and selling. Obvious examples are the services provided by the atmosphere and the oceans as pollution 'sinks'. If something is provided free, more of it will be demanded than if it is priced. The danger is that this greater level of demand will not be matched by a sustainable supply. The stock of natural resources should ideally be analysed in a manner analogous to the way that the stock of man-made capital is in national and international accounting systems, but more progress in developing and applying this principle is needed.

#### Sustainable development

2.5 The Brundtland report established the concept of sustainable development as the basis for integrating economic and environmental policy. The message of Brundtland is that it is possible to achieve a path of economic development which meets the needs of the present without compromising the chances of future generations to meet their own needs. The implication is that the present generation should leave future generations a wealth inheritance - a stock of knowledge and understanding, of technology, of man-

made capital and, last but not least, of environmental assets - no less than that inherited by the present generation. Consideration is currently being given by the UN Statistical Office to the possibility of modifying the present national accounting conventions to accommodate sustainability concerns. The issues involved in translating the concept of sustainable development into operational language are being explored by Professor Pearce in research undertaken for UK Department of the Environment.

2.6 It is desirable that the Brundtland concept of sustainable development should be translated into practice, measured and progress towards its achievement assessed. The relevance of resource accounting procedures in monitoring progress towards sustainable development is now widely recognised and is the subject of OECD and UNECE work. This involves assembling statistics on the stocks and flows of natural resources and drawing up balance sheets setting supply against the rate of use.

### 3. GENERAL AND METHODOLOGICAL ISSUES

#### Anticipatory versus adaptive policies

3.1 A feature of environmental policy making is a high degree of uncertainty about the precise extent of the environmental damage caused by economic activity. In some cases - eg the extinction of wildlife species through habitat destruction - it is irreversible. In other cases - eg the damage to the ozone layer caused by CFCs - it is potentially catastrophic. In many cases, of which climate change is an obvious example, despite major scientific research efforts - and it is important that countries examine the science thoroughly - there is a high degree of uncertainty about the extent or even the nature of environmental damage.

3.2 There are no firm rules for choosing which policy to adopt in the face of uncertainty. But most people are risk averse: they do not like uncertainty. Most people would also argue that taking risks is not worthwhile when the negative 'pay off' - what happens if they lose - is very large. Some current environmental problems risk very large losses. In these circumstances a risk averse strategy favours anticipatory rather than adaptive environmental policy; the Montreal Protocol designed to phase out the use of CFCs is a case in point. However, to the extent that environmental damage has already arisen, there may be no alternative to adaptive policies, and the response to sea level rise is a striking example. Clearly it is important that an early

*it is better*  
*to anticipate the risk and with the right collective policies*  
*which adapt to the new situation*

assessment of the relative costs of prevention and adaptation is made. Measurement of the costs of various forms of environmental degradation and of policy options should therefore be one of the main objectives of research.

#### Measuring environmental benefits

3.3 It is important to try to place monetary values on environmental gains and losses partly for the reasons outlined in para 2.4. For analytical purposes cost benefit analysis (CBA) makes operational the simple, and rational, idea that decisions should be based on some weighing up of the advantages and disadvantages of an action. CBA is the only technique of evaluation which explicitly makes the effort to compare like with like using a single measuring rod of costs and benefits, ie money. Techniques of research into 'willingness to pay' for environmental improvement are now well established and have an important part to play in improving the estimation of benefits in money terms. However even where the process of environmental degradation is well understood, an agreed assessment, in monetary terms, of the likely environmental benefits of policy options may not be possible. In these circumstances policy evaluation can nevertheless make good use of cost effectiveness analysis - the determination of the most cost effective way of achieving an environmental quality standard - for example the effectiveness of afforestation as against investment in energy efficiency as a means of removing a given amount of carbon dioxide from the atmosphere.

#### Intergenerational dimensions

*Future Generations*

3.4 There is considerable uncertainty about how best to value the interests of future generations in economic appraisal. Sustainable development effectively involves compensating future generations for losses they might otherwise incur because of action by the present generation. As has been argued above in para 2.5, to ensure that future generations have the capability to meet their needs, it is essential to leave the next generation a stock of wealth no less than that inherited by the present generation. This requirement is likely to feature in environmental economic research programmes as they develop.

#### 4. ECONOMIC PRINCIPLES FOR POLICY FORMULATION

##### The need for international regulation

4.1 When governments enter into international negotiations in order, for example, to protect the ozone layer by regulating the production of CFCs or to reduce pollution in the North Sea by regulating dumping of pollutants, those negotiations involve bargaining designed to ensure that each country derives a fair share of the expected benefits and incurs a fair share of the anticipated costs. This implies recognition of the fact that the use of the ozone layer and of the North Sea need to be regulated if these resources are to be saved from destruction. Previously unlimited rights to use, particularly as regard pollution, are now being restricted and it is no accident that international organisations, such as OECD, UNECE and UNEP, are playing an ever more important role in the process. The reason for the restrictions is the recognition that the capacity of the ozone layer to absorb CFCs, and of the North Sea to absorb a range of pollutants is limited. They are therefore scarce resources and free access to them by all, including those with no responsibility for their conservation - the so-called free rider problem - is increasingly seen as intolerable.

4.2 The nature and scale of some problems requires that we seek internationally agreed measures to reduce regional and global pollution, and raise public awareness of the need for action. Unilateral action in such cases is ineffective and can easily become self defeating. Pollution control brings costs and unless international agreements are reached on common goals or standards the measures necessary to reduce pollution may make individual countries industry uncompetitive in world markets if these countries alone incur these costs. Every country needs to participate in the regulation process.

##### The Polluter Pays Principle

4.3 One way of dealing with pollution problems is through the Polluter Pays Principle (PPP). This ensures that the costs of pollution fall upon the economic agent causing that pollution, and would, if consistently applied, avoid the free rider problem. Application of PPP has the advantage that it establishes a clear framework of property rights in favour of those suffering from the effects of pollution. PPP is already put to good use for the

purposes of national environmental policy. There are however difficulties in applying the principle at international level.

4.4 These difficulties may be illustrated by reference to the analogous issue of free trade. Free trade policies maximise global welfare and national interest by allowing resources to be more effectively allocated, in line with underlying comparative advantage and encourage the growth of both the volume of trade and GDP. These objectives are being advanced both through the multi-lateral negotiations on reducing tariffs in the current GATT round and through the completion of the internal EC market. For the same reasons elimination through multilateral negotiations of export finance subsidies will <sup>provide a</sup> ~~preserve a~~ <sup>fair basis</sup> level playing field on which export contracts are awarded according to underlying comparative advantage rather than subsidisation.

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to have fairness!

4.5 Conceptually the same approach is relevant to say global climate problems. The objective should be to "internalise" environment costs into the market process of the efficient allocation of resources. An exporter who wins a contract, because his costs do not reflect the wider costs for society of the gases emitted by his processes, has won a contract "unfairly" in exactly the same way as an exporter who has won a contract through a mixed credit provided by his Government. In the latter case the cost of the subsidy has visibly fallen on the country providing it is "internalised" but in the former case the cost is "externalised" to fall on someone else.

#### Compensation payments

4.6 Whatever the merits of the Polluter Pays Principle, it will be no easy task to apply it between countries on an international basis. It would depend on world wide consent which may take considerable time to achieve. In the meantime, because property rights in pollution rest with the polluter it may be in the interests of third countries <sup>of others</sup> to pay the polluter to stop. Everyone will be better off if the costs of payment are less than the avoided costs of pollution which would otherwise have occurred (in the paying countries). For this reason, certain countries such as the Netherlands and West Germany are having to contemplate paying East European countries to curtail their emissions of sulphur dioxide.

4.7 In the case of the Eastern bloc, there are obvious arguments against these kind of payment arrangements, not least that it should be in their own long term interests to address their own environmental problems. On the other



hand, in certain cases such payments may represent a relatively cheap means of persuading these countries to do something about environmental pollution to the benefit of all countries.

#### Developing countries

4.8 In the case of developing countries, it is necessary to recognise the resource limitations imposed on them by their poverty and that their priorities for this reason give a much greater weight to economic development relating to growth and poverty than global environmental protection. The notion that developed countries should make financial amends to developing countries for past environmental pollution is not acceptable. However, external resources, both concessional aid and commercial investment, have an important part to play in encouraging developing countries to give higher priority to solving their environmental problems and to ensure that priorities for action include things of global as well as local importance. Additional public (and private) resources channelled to developing countries could represent a worthwhile investment in the protection of the global environment to the benefit of all countries.

#### The framework of international negotiations

4.9 In the international negotiations on climate change ahead, free riders will need to be dealt with, through a combination of possible concessions and inducements. To participate effectively in the negotiations of standards and on the mechanisms for ensuring environmentally sound behaviour, every country needs to be aware of the costs and benefits of different options.

4.10 It is implicit in our stance that we are willing to join other industrial countries in accepting some additional cost in the interests of the world's future. While we must not pay unnecessarily, we should be alive to the possibility that greater benefits may accrue in the future if all countries agree to pay a higher price now. Adopting an anticipatory policy stance would be an investment. An appropriate national negotiating position should logically therefore be based on a medium-term time horizon, which takes account of both costs and benefits over time.

### The role of market mechanisms

4.11 Market mechanisms such as charges, taxes and schemes allowing dischargers to trade permits are increasingly being used to complement environmental regulation. They may offer an efficient and cost effective way of achieving environmental standards, or provide a means of influencing environmental behaviour or simply raise money. Examples in the UK include the tax differential on unleaded fuel, waste disposal fees, and schemes in prospect for cost recovery charging with respect to environmental pollution generally. Potentially such mechanisms have a wide application.

4.12 The case of unleaded petrol illustrates the effects of taxes. The tax differential in favour of unleaded petrol in the UK was introduced in order to encourage a switch in consumption from leaded petrol. The impact of the differential can be seen from Table 1. However environmental aspects of petrol consumption go wider than lead. It is now recognised that petrol consumption, as with other fossil fuels, contributes to the greenhouse effect. Petrol tax has served a number of functions during its history from purely revenue raising, to charging for roads and to providing an incentive to reduce consumption when supplies threatened to dry up in the early 1970s. Most topically it can be regarded as a form of carbon tax tending to reduce carbon dioxide (CO<sub>2</sub>) emissions.

4.13 Emission trading and some forms of pollution charging offer ways of using the market to achieve environmental standards cost effectively. Allowing dischargers to sell or trade the difference between actual and allowed discharges has been extensively tested as an approach to pollution control in the US. The approach has been found to be workable and the US plans more extensive application as described in President Bush's recent new proposals. The benefits of using market mechanisms where they are appropriate to the problem and in line with the national legal and financial characteristics of the country concerned are widely recognised. This is clearly an important area for research.

## 5. ILLUSTRATIONS OF ECONOMIC ISSUES

### The problem of CO<sub>2</sub> emissions

5.1 The general problem of climate change and global warming is discussed in Annex 1. Options for reducing emissions of CO<sub>2</sub> include:

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- (i) Energy conservation - improved insulation; more efficient lighting devices, motors and appliances, and vehicles; improved building and process control; more use of combined heating and power systems (CHP) in industry and services.
- (ii) Substitution of alternative fuel in road vehicles - diesel, gas, bio-alcohol and hydrogen; electric vehicles.
- (iii) Removal of carbon dioxide from power stations' flues - (thought to be technically feasible).
- (iv) Electricity generation from renewable energy sources - bio-fuels, on-shore wind, small scale hydro, tidal energy, geothermal hot dry rocks, solar energy, and wave power.
- (v) Electricity generation from nuclear power - (to reduce carbon dioxide emissions in electricity generation).
- (vi) Alternative methods of fossil fuel generation - eg substituting gas for coal; more efficient systems of generation.

5.2 Market Mechanisms have a role to play in choosing between these options; the options themselves need to be evaluated for their cost effectiveness. Some will be much more expensive than others per unit of CO2 emission. However it is not obvious that governments, rather than the burners of fossil fuels, are best placed to carry out this evaluation. A tax on fossil fuel consumption would provide an appropriate incentive to economise on its use. Precisely what form those economies take, and who introduces them, can then be left to the market. In designing any carbon tax(es) government will however need to take a view on price elasticities - ie what level of tax would be needed to achieve the desired rate of CO2 emissions. Any such approach must be pursued on an international basis if it is to be effective, and will also need to take account of the characteristics of national energy supplies.

### Energy conservation in developing countries

5.3 Developing countries with 70% of the world's population currently contribute only 30% of total energy consumption. Total energy use including traditional forms such as woodfuel, dung and biomass waste per capita is only one-sixth of OECD levels. Nevertheless, in future the LDC demand for energy is likely to grow at least as fast as their GDP and most forecasts suggest that, by 2020, their energy use could have doubled.

5.4 In developing countries the contribution to global CO<sub>2</sub> levels from deforestation is of the same order as that from fossil fuel consumption. Deforestation occurs to accommodate agricultural (which is given added impetus by poverty and population growth) and to meet fuelwood demands as well as through the activities associated with commercial logging. Fossil fuels, particularly coal, are the major inputs for power generation. Electricity generation and distribution are often characterised by poor technical efficiency, high energy losses as well as pricing policies that fail to reflect full economic, let alone environmental costs.

5.5 From an environmental viewpoint the challenges are to use existing energy plant more efficiently, to use energy more economically and to expand capacity in systems which are more environmentally benign. There is no simple answer to these challenges but policy options are likely to include the reform of power tariffs; the introduction of levies on fossil fuels; reduction in generation and transmission losses in existing electricity systems and the installation of best practice fossil fueled and non-fossil fuel capacity.

## 6. CONCLUSIONS FOR G7

6.1 Management of global common property resources and resource systems requires a coordinated policy response involving cooperation on a global scale. As major users of the world's environmental resources and as the economically most powerful countries, the advanced industrialised countries will have to take the lead in this cooperative effort. In this G7 can play a vital role.

6.2 G7 should also use its economic and financial resources to assist the promotion of sustainable development in developing countries and to encourage them to use more of their own resources to protect their own and the global

environment. This will assist in developing the cooperation between nations with highly unequal resource bases, necessary to protect and conserve the global environment.

6.3 G7 can also give a much needed political impetus to the environmental economics research programmes of international organisations including OECD, the World Bank, United Nations Environment Programme (UNEP), Inter-Governmental Panel on Climate Change (IPCC) and United Nations Economic Commission for Europe (UN/ECE). The protocols for any international climate convention are likely to need economic analysis in their preparation, monitoring and evaluation. This is not simply a matter of applying techniques of cost effectiveness and cost benefit analysis, important though they are, but also of the design of the conventions themselves including the framework of rules and enforcement.

6.4 The aim should be to establish the relative cost effectiveness of different techniques of ameliorating the impact of human activity on the environment. The priorities for international economic research look to be as follows:

- (i) The choice between anticipatory and adaptive strategies, particularly in relation to climate change, through assessment of the costs of environmental degradation and policy options.
- (ii) The role of market mechanisms as a complement to the regulation of property rights in the global commons.
- (iii) The assessment of the effects of global environmental strategies on the economies of national states, including the identification of divergences between national and international interest.
- (iv) The cost effectiveness of different techniques of encouraging less developed countries to adopt environmental policies.
- (v) Energy policy and its implications for energy pricing and conservation.

## CLIMATE CHANGE AND GLOBAL WARMING

Background

1. The temperature of the earth's atmosphere results from an equilibrium between the radiation received from the sun and the radiation emitted by the earth. The sun's radiation is characteristic of a very hot body which tends to be of short wave length, most obviously in the form of visible light. Radiation of the relatively cool earth on the other hand is characteristically of longer wave length, infra red heat radiation. The greenhouse gases (carbon dioxide, methane, CFCs, oxides of nitrogen, and ozone) in the earth's atmosphere affect the equilibrium temperature because they are largely transparent to the incoming, short wave radiation but absorb and re-irradiate some long wave length radiation back to the earth, warming the surface.

2. Over the past century or so there has been a considerable increase in the rate which greenhouse gases have been emitted to the atmosphere. As a result there has been an increase in the atmospheric concentration of these gases. A further contributory factor may be a reduction of the earth's capacity to absorb carbon dioxide consequent upon the rapid destruction of forests. There is little dispute that this build up of greenhouse gases will lead to an increase in global temperatures. The unknown issue is by exactly how much. The consequences of a continuing increase in temperature are summarised in Table 1. They are likely to include a rise in sea level and increased risk of flooding, changes in regional meteorological conditions with effects on agriculture, natural habitats and people's living conditions; and the possibility of an increase in extreme weather events in some regions. Some regions might in fact benefit. Siberia, for example, may become a viable agricultural region with increased rainfall. However, it would be foolhardy to assume the net worldwide result will be a benefit.

3. For the mid-latitude regions of 30 to 60 N, which include the major food growing regions of North America and Europe, rising temperatures would probably have the most serious impact for forest ecosystems, and for irrigated agriculture in the semi-arid areas (eg the American mid-West), which would suffer from higher temperatures and increased drought in summer. Climatic variability has of course always been a major problem for the semi-arid tropical regions (latitudinal band 5° to 35° N and S). Reductions in

precipitation for one or more seasons, which adversely affect agriculture, would be aggravated further by any decline in soil moisture from increased mean temperatures. Also any increased rainfall intensity in the humid tropical regions would mean more tropical storms and flooding, which would affect coastal and river regions and highly erodible soils in upland areas. Thermal expansion of the oceans leading to substantial sea level rises would threaten low lying and coastal regions - such as the flood plains of Bangladesh, the US Eastern seaboard, the Netherlands, and the island countries in the South Pacific and Indian Ocean. These climate changes could pose serious adjustment problems for developed and, especially developing, countries.

#### The Economic Challenge

4. Two aspects of global warming present particular problems to any analysis of appropriate policy responses: firstly, the unpredictable nature of climatic changes and, secondly, the way in which they magnify the likelihood of so-called 'natural' disasters. Changes in the earth's climate may be sudden or gradual. Coping with sudden changes whose timing and magnitude are unpredictable is clearly a far more difficult matter than coping with a gradual change. Even gradual changes in mean climate or sea level may be manifested as large changes in the risks of extreme events. For example, threats from future sea level rise (and salt water intrusion) will increase the probability of extreme drought occurrence, whereas existing water resource supply systems are currently, but based on past experience, adjusted to only comparatively moderate fluctuations in precipitation and resultant salt intrusion.

5. These aspects of climate change will need to be incorporated into the part of the work programme of the Inter-Governmental Panel on Climate Change (IPCC) being carried out by the UK Meteorological Office which is aiming to firm up estimates of likely future climate change. They will also need to be carefully considered in analysing policy options.

6. The purpose of such an analysis should be to assess a number of important adaptive and preventative measures for controlling global warming and adaptive measures for limiting the impacts of its effects. This raises an important challenge for economics which has a key role to play in the design of efficient adaptive and preventative measures, and also in achieving an appropriate strategic balance between them.

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7. We are only in the early stages of analysing these issues and work is being progressed under the auspices of IPCC Working Groups. A full assessment of the options is not yet possible. Nevertheless, several points crucial to this analysis are worth highlighting. First, there is clearly a waiting cost for doing nothing now; the best guess is that we are already committed to some global warming in the near future (eg 1.5° to 3.1° C). Thus the longer we do nothing, the higher will be the future costs of forced adaptation and residual effects. The crucial questions are how large is this waiting cost and how fast is it growing over time?

8. Second, there is a high cost attached to a "surprise" of an extreme event suddenly occurring. The unpredictability surrounding the impacts of the greenhouse effect and the possibility of these being extreme argues for avoiding under-estimation of the probabilities involved or being inflexible on assumptions about the timing of events. The standard approach of economics in dealing with uncertainty is to weight the welfare implications of expected outcomes, thus ranking options on the basis of the expected balance between social costs and benefits. This approach is less effective with global warming problems - where there is a small chance of large scale damage from a sudden catastrophe. The tendency of society to be risk averse also lends support to options favouring prevention.

9. The essential policy comparison between prevention and adaptation involves a choice between measures with a low current cost but which may result in greater future costs and investing heavily in the control and reduction of fossil fuel emissions, and also in more sustainable management of tropical forests, in order to reduce those anticipated future costs. Thus a concerted effort to limit the greenhouse effect in advance through, say, reducing carbon dioxide emissions would involve higher relative costs in the present but would avoid some of the costs incurred by forced adaptation and residual impacts in the future. Discounting the costs and benefits of different options to allow for time differences does not offer a useful guide in the case of climate change given the long time periods and the uncertainties involved.



TABLE 1

## ECONOMIC IMPACTS OF CLIMATE CHANGE

	<u>Adaptation Costs</u>	<u>Economic and Environmental Losses</u>
Sea Level Rise	Additional sea defence expenditure in UK and overseas (especially Netherlands, USA, and LDCs). Adaptation of Water Authorities' and industries' effluent outfalls.	Flooding (eg in East Anglia, Netherlands, Bangladesh). Environmental impacts of sea defences. Loss of wetlands. Loss of beaches.
Agriculture	Increased pest control. Adjustment of crops and agricultural practices.	Loss of cropland. Adjustment of outputs, prices and terms of trade. Losses suffered by certain LDCs. Environmental impacts of increased pests and their control.
Water Supply	Extra provision of reservoirs. Extra water pollution control expenditures. Increased charges for water supply and effluents.	Deterioration of river water quality due to reduced river flows.
Buildings	Increased air conditioning. Additional renovation costs to adapt building stock. Extra costs of new materials and techniques.	Higher office temperatures in summer. Deterioration in state of building with new climate conditions.
Forestry	Change to different tree types. Forestry management practices, especially pest controls.	Economic losses to existing forest plantations due to change in climate and increased pests.  Loss of old trees now in unsuitable areas (eg Californian Redwoods). Environmental impacts of increased pests and their control
Recreation	Extra costs for sewage treatment and clean up of beaches.	Pressure on beaches. Congestion in tourist areas (eg roads, water).
Nature Conservation		Extinction of Species. Loss of Biodiversity.

NB. No conclusions should be drawn from this table about the relative importance of the impacts listed.

CFCs AND THE OZONE LAYER

Background

1. The ozone layer is that part of the stratosphere where ozone is most concentrated. Ozone absorbs ultra violet radiation and prevents too much reaching the earth where it has the potential to affect the environment and human health. CFCs and halons have the capacity to destroy ozone. In the stratosphere they are decomposed by sun light to free chlorine or bromine which convert ozone into molecular oxygen. The hole in the ozone layer over the Antarctic is now attributed to the accumulation of CFCs, which are also implicated in ozone depletion over other parts of the globe.

2. Unlike the other major environmental concerns discussed in Annexes 1 and 3, viz climate change and global warming, and deforestation, desertification and the loss of genetic diversity, a well developed and internationally agreed policy on the ozone layer is already in place in the form of the Montreal Protocol. This was signed in September 1987 and entered into force on 1 January 1989. The Protocol enforces a reduction in the production and consumption of the most important CFCs and a freeze on the production and consumption of the major halons. Nearly forty countries, which together account for more than 80% of the global consumption of the regulated CFCs and halons have now ratified the Protocol. Consumption which is not covered by the Protocol is mainly in the newly industrialised countries and other developing countries.

Economic Review of the Montreal Protocol

3. The Protocol provides a mechanism to review the efficiency of the control measures and adjust them accordingly, although the Parties to the Protocol have already made a political commitment to eliminate the production and use of CFCs by the end of the century. Article 6 of the Protocol specifically directs Parties to assess the control measures provided in its Article 2 on the basis of available scientific, environmental, technical and economic information.

4. The terms of reference for the Economic Assessment Panel were set during the science review meeting and the technical workshop convened by UNEP in the Hague in October 1988. The scope of the work was to determine, on the

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basis of available information, the economic costs and benefits of the Protocol measures. This information would then serve to guide the revision of the Protocol foreseen for June 1990. The first Conference of the Parties to the Protocol convened in Helsinki in May 1989 confirmed the establishment and orientation of the Panel. The Panel itself has now met three times: 7 March in Brussels, 21-22 April in Washington DC and 29-30 May in Tokyo.

5. It was intended that a main task of the Economic Assessment Panel should be to draw on the expertise of the Environmental Effects and Technology Review Panels to quantify, as far as possible, the value of the benefits of reductions in ozone depletion and the costs of substitutes and alternatives for CFCs and halons on a global basis. This ambition has been considerably scaled down and the final panel report will concentrate rather on outlining the approach an individual country might take to making these calculations on a national basis. The report will include chapters on CFC and halon consumption, methodology, environmental effects, costs of substitution and alternatives, and technology transfer.

6. Much of the Panel's work is now nearing completion. Early indications are that the report will conclude that the monetary value of the benefits from reducing the use of CFCs/halons will be orders of magnitude greater than the costs of achieving those reductions. The evidence is mounting that the benefits from avoiding ozone depletion would be very large indeed in terms of human life and health and also for plants and animals ecosystems. Several national studies have also concluded that substantial reductions of CFC and halon use are feasible and most of these have concluded that the benefits would be much higher than the costs.

7. The development of new options for replacing CFCs and halons is evolving very rapidly. The report of the Panel is therefore likely to conclude that a static cost analysis based on current knowledge would be likely to over estimate the costs and under estimate the reduction in use achievable in the transition to CFC-free technologies.

8. Global diffusion of CFC replacement technology (including recovery and recycling) is in the interest of both developed and developing countries. Some CFC replacement technologies will be adopted in the course of economic growth, but development assistance will be required in other cases. Also means are needed to prevent the transfer of discarded CFC producing and using technologies to developing countries.

## DEFORESTATION

Background

1. Estimates suggest that the tropical forests in the 1980s have been contracting in area by about 12m hectares per year; representing an annual rate of depletion of about 0.6% per annum. Tropical forests are estimated to contain at least 50% of all the earth's species of plants and animals and hundreds of these are being lost every year. In the developing countries deforestation threatens the sustained availability of wood for economic and subsistence purposes. It is the major contributor to soil erosion and desertification with their adverse effects on agricultural production and the hydrological balance. It is causing irreversible destruction to plant and animal genetic resources. It also contributes to the greenhouse effect; the burning of wood and forest and oxidation of wood by other means (eg decomposition) could contribute as much as one-third of CO2 emitted by fossil fuel burning world wide.

2. The main cause of deforestation in developing countries is the poverty of the people who live in and around forest lands, for whom the forest is a major resource for exploitation to meet basic needs. Forests are cut down primarily to meet the demand for land for food and cash crop production. A population of over 2 billion people live in the tropical forest zone. Population is growing at about 2½% per annum. Forests represent the major reservoir of land still available to expand the area under cultivation to meet food production needs. FAO have estimated that 150 million hectares of forest will be cleared in 1988-2000 for this purpose.

3. Over 2 billion people in the developing countries also depend on fuelwood for cooking. As alternative cheap sources of energy for cooking are limited, the demand for fuelwood will continue to grow over the medium term. As the easy availability of fuelwood declines, increasing use is made of crop residues and animal manure for cooking which tends to reduce further the productivity of food production and intensify pressure for area expansion. Fuelwood is estimated to meet 63% of total energy needs in Africa and 16-17% in Asia and Latin America.

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4. Fire occurring naturally or deliberately is another major cause of deforestation. Animal owners often burn forest areas to improve grass production after the onset of the rains.
5. Commercial logging is also a cause of deforestation but off-take for this purpose is a small proportion of the annual increase in the growing stock of forest wood so that there is scope for its expansion as an income and foreign exchange earner provided forests are managed properly (ie protected and replanted).
6. Arresting deforestation in developing countries is a matter essentially of ensuring that the forest stock, and hence soils, moisture and nutrients, are conserved so that agricultural output and standards of living can be maintained in the long run. Priority attaches to conservation, protection and improved management. It will be a major challenge to restrain further reductions in the forest stock let alone increase the forest areas.
7. There are two obvious areas of "market failure" in relation to forestry which justify government intervention:
  - (i) First, forest products are often in effect free to the user and regarded as a common property resource. Poor people scavenging firewood from the forest act in their own self interest. The fact that the resource is free, common and its use unregulated, will result in the forest being depleted faster than is economically justifiable.
  - (ii) Second, even were trees priced to reflect their true economic value, and were privately owned, trees could still be over-exploited. This is because prices based on production costs would not reflect the "external" benefits that accrue from trees to the rest of the community (and indeed the world) through prevention of soil erosion and absorption of CO2.
8. Combining an economic and a scientific approach to forestry leads to a valuation of the "wider" costs and benefits of investment to the community as a whole and future generations. By and large the move towards more liberalised market allocation systems in developing countries (supported by IMF/IBRD and donors including the UK) should lead to more efficient husbandry of resources including natural resources. This "structural adjustment" movement seems to be proving helpful to economic recovery. In some respects

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It will also help with the sustainable management of natural resources like forests. Incentive systems for more intensive cultivation and higher yields from agricultural land by itself will limit encroachment on forested land. Better and wider access to credit, improved technology and inputs will help similarly. Clarification of land rights and security of tenure will also encourage improvement of land. The stimulus to development and more non-agricultural job opportunities may also reduce pressures on forests for the poor especially.

9. At the same time these economic measures to encourage fuller use of existing land may also encourage extension of land margins and loss of forest and it is a difficult challenge to devise a package of policy reforms which provide a stimulus to economic recovery/growth as well as conservation of the national resource stock and hence economic sustainability.

10. To influence climate change, by making a sizeable impact on fossil fuel generated CO<sub>2</sub>, would require an impossibly large programme of worldwide afforestation. Afforestation (and more particularly conservation, protection and improved management) has a role to play in combatting climate change but economic considerations suggest only as a relatively minor element in overall policies to reduce greenhouse gas concentrations.