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OECD Environmental Outlook to 2030

Chapter 13

Cost of Policy Inaction

This chapter provides information on the "costs of policy inaction", i.e. *the costs associated with the negative environmental impacts of the existing policy framework. It highlights three key environmental challenges: health impacts of water and air pollution; fisheries management; and climate change. Estimates of aggregate "costs of inaction" can help to identify important environmental policy problems, but they are not sufficient on their own to determine policy priorities. Non-linear impacts, including the existence of ecological thresholds and irreversible changes, can have significant effects on the total costs of inaction.*

KEY MESSAGES

The costs of policy inaction in a number of environmental areas are significant and are already affecting economies in a manner which shows up in market prices and national accounts both directly and indirectly. For example:

- The costs of inaction on *water pollution* are especially high in developing countries, where the health impacts of inadequate water supply and sanitation are particularly acute.
- The costs of inaction associated with *air pollution* are as much as a few percentages of GDP in the US, the EU, and China. Many of these costs are not reflected in market prices or national accounts (*e.g.* "pain and suffering" through poor health).
- While the costs of *unsustainable natural resource management* first affect those who previously exploited the (now-depleted) resources, others may also bear significant costs. For example, large sums of public finance have been used to support unemployed fishers and to facilitate sectoral adjustment as fish stocks have declined.
- The estimated costs of inaction associated with *climate change* vary widely, according to coverage of issues, modelling and valuation approaches. Assuming that emissions remain unmitigated, estimated costs range from less than 1% of global output, to more than 10%. Existing estimates are still partial, however, often excluding, for example, costs associated with increases in extreme weather events due to climate change.

Environmental policy action in the OECD and elsewhere has begun to limit environment costs of inaction, making these costs generally lower than they would otherwise have been.

Key policy and analytical issues

- Assess both the costs of inaction and the costs of the associated interventions to determine policy priorities. Estimates of aggregate "costs of inaction" can help to identify important environmental policy problems, but they are not sufficient on their own.
- Remember that non-linear impacts, including the existence of ecological thresholds and irreversible changes, can have significant effects on the total costs of inaction.
- Consider the use of declining (but not zero) discount rates to address uncertainties about both long-term environmental impacts and economic development.

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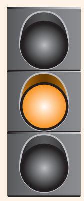
Introduction

This chapter summarises issues related to estimating the "costs of policy inaction", with particular focus on three key environmental challenges: health impacts of water and air pollution; fisheries management; and climate change.

"Costs of inaction" are understood here to mean the costs associated with the negative environmental impacts that result from the existing policy framework. In general, OECD countries have well-developed policy frameworks in place to address significant environmental impacts. Therefore "inaction" often already incorporates significant levels of policy intervention, as in the areas of air and water pollution. But there are still "residual" impacts from existing policies, and these can generate significant costs. There are also areas in which the policy regime is less well-developed. For instance, in many cases, inaction from past years may have left a significant legacy (*e.g.* contaminated sites, accumulated stock of greenhouse gases, unregulated groundwater extraction). And there are likely to be new challenges emerging in the future.



Environmental policy frameworks in the OECD and elsewhere have begun to limit environmental costs of inaction, making these costs generally lower than they would otherwise have been.

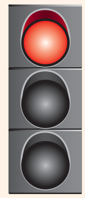
This chapter does not include a discussion of the costs of implementing the existing policy framework, nor of strengthening this framework. However, it is clear that for all environmental concerns, there is a point at which the economic costs of reducing adverse environmental impacts will exceed the benefits. There are some areas for which this may already be the case, particularly if the policies used to address the environmental concern in question are badly-designed. Efficient environmental policy depends upon carefully balancing the marginal benefits and costs of that policy, as well as choosing the most efficient policy instrument.

From the perspective of a policy-maker considering introducing new environmental policies, the most useful approach is to assess the *marginal* social costs and benefits associated with an incremental change in environmental quality, relative to the current policy situation (*i.e.* the Baseline). This approach can provide information that can be directly used in decisions about the allocation of scarce resources. However, estimates of the *total* costs of inaction have significant value in terms of highlighting the economic impacts of not addressing pressing environmental problems. It is these latter (total) costs that are the main focus of this chapter.

The total costs of environmental policy inaction involve several different types of costs (Figure 13.1). These include public finance expenditures (*e.g.* health service costs, restoring contaminated sites); direct financial costs borne by households and firms (*e.g.* increased insurance costs, reduced productivity in resource-based sectors); indirect costs, such as those which arise through markets affected by environmental factors (*e.g.* employment markets, real estate markets); and social welfare costs, which are not reflected in market prices or national accounts at all – including some non-use values of environmental damage (*e.g.* ecosystem degradation).

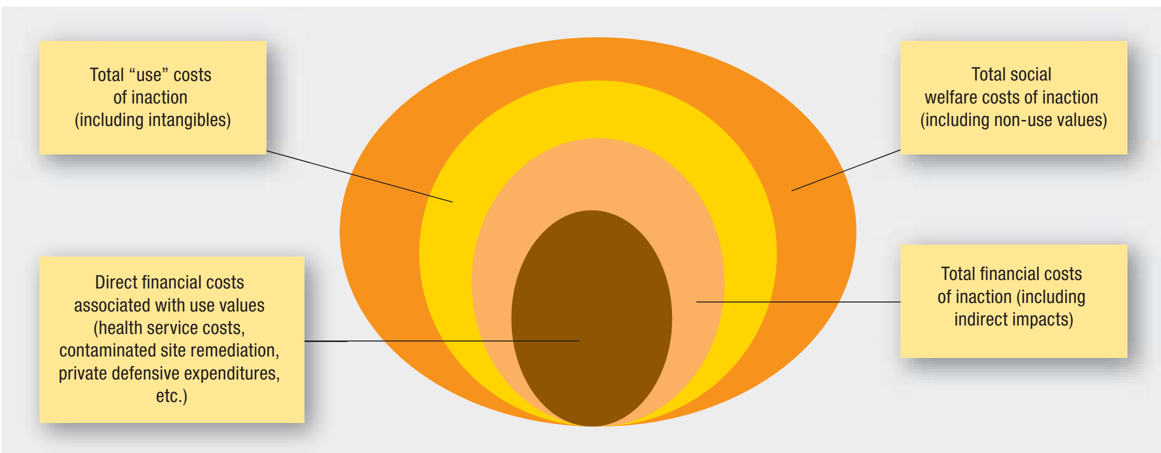
Several different units (or metrics) can be used to describe the costs of inaction, but the broadest distinction that can be made is between "physical" (ecological, health, etc.) metrics and "monetary" metrics (*e.g.* willingness to pay). However, even this distinction is somewhat artificial, since assessing the former is always a precursor to assessing the latter.

Inaction on a particular environmental concern is likely to lead to a varied set of impacts. For instance, unconstrained climate change will eventually lead to aggregate productivity losses in agriculture and food security problems, water stress, sea-level rise and risks to coastal settlements and summer tourism, loss of human life and sickness due to extreme heat events, loss of biodiversity and other ecosystem services. An impact assessment will give some indication of the nature and size of these impacts, expressed in different units, *e.g.* reduced agricultural yields in m^3; millions of people at risk of food or water shortages; biodiversity loss in terms of number of species threatened; lost tourism days; etc. A key challenge will therefore be to estimate the physical linkages between human actions and environmental change.



The costs of policy inaction in a number of environmental areas are significant and are already affecting OECD economies in a manner which shows up in market prices and national accounts, both directly and indirectly.

Figure 13.1. **Defining the "costs of inaction" of environmental policy**



Even if these relationships are known with precision, the non-commensurability of the units involved will mean that they cannot easily be aggregated. Taking the additional step to try to value these impacts in monetary terms therefore allows comparisons across types of environmental impact (*i.e.* loss of biodiversity and human health impacts) using a common metric, and also provides a basis for later comparing the benefits of inaction (*i.e.* avoided investment and other costs) with the costs of inaction.[1]

Actually taking this "valuation step" requires care, since many environmental impacts do not have a readily identifiable market value. Two approaches can be used to place a

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value on environmental assets at this stage: revealed preferences and stated preferences. In the case of revealed preferences, efforts are made to derive the value of environmental assets from behaviour in existing markets for "associated" goods and services. For instance, the cost of polluted air may be reflected indirectly in real estate markets. Efforts to value environmental assets through stated preference techniques posit a hypothetical market, for which respondents are requested to value changes in environmental conditions directly (Pearce *et al.,* 2006).

Issues in valuation (key assumptions and uncertainties)

Dealing with the very long run adds an additional level of complexity to estimating the "cost of inaction". Carbon dioxide emitted today has an atmospheric lifetime of over 200 years; air pollutants to which people are exposed today can generate adverse health impacts in 50-60 years; over-exploited fish stocks can take decades to recover (if ever). Costs today also have a higher value than those borne in the future, both because of "pure time preference" (preference for immediate over postponed consumption) and "declining utility of income" (with growing per capita consumption). The further into the future a cost occurs, the lower the weight that will tend to be attached to it. Indeed, the estimated present value of the costs of inaction can vary by orders of magnitude with small changes in the discount rate that is applied.[2] Some people even find the practice of discounting morally unacceptable, because it seems to suggest that future costs are less important than present ones, and is therefore unfair to future generations. Temporal considerations such as these lie at the heart of concerns about climate change, as well as the fisheries management problem, and the choice of a particular discount rate will determine to a great extent the estimated (present) value of the (future) damages.

Environmental pressures can also embody complicated non-linear impacts, including thresholds and irreversible changes. Three issues seem to be especially important in this regard:

- *Cumulative effects:* Some environmental impacts will become significantly greater as a result of cumulative environmental pressures over time. Many health-related impacts exhibit such an effect, such as bio-accumulation of hazardous substances in the food chain.
- *Thresholds:* Impacts may increase sharply once a particular level (threshold) of environmental pressure is exceeded. In the area of climate change, thermohaline circulation is one example; in effect, there may be a "tipping point" after which an inversion might arise, with significant implications for the total costs of inaction.[3]
- *Irreversible changes:* While some environmental impacts are potentially "reversible" (allowing for the restoration of environmental conditions to their prior state), there are many areas in which this is not the case (once degraded, environmental values are lost permanently). Species loss associated with unsustainable fisheries management is one example.

In the presence of such non-linear effects, the costs of preventing environmental degradation in the first place (mitigation) will be less than the costs of addressing the impacts of the environmental problem once it has occurred (restoration). For many types of impacts – and particularly for those involving irreversible changes – it is not possible to restore the environment to its previous state.

Uncertainty can also complicate efforts to value the cost of inaction. In some cases the probabilities of different outcomes may be known. Different weights can then be attached to these outcomes, depending upon the probability of their arising. However, some forms of uncertainty are more fundamental than this, so it may not even be possible to assign credible probabilities to different possible environmental outcomes. For instance, there is considerable uncertainty about the likelihood of certain catastrophes arising as a result of climate change, and the available information is insufficient to posit probabilities for them. In cases where probabilities can *not* be reasonably attached to different outcomes, sensitivity analysis will be appropriate, in which different values are assumed for key parameters.

Another important factor concerns the treatment of the distributional impacts of environmental degradation. Different environmental impacts can affect individual countries (and individuals within individual countries) very differently. In some cases, one group of individuals may benefit, while others will bear costs. There are good ethical and political reasons (*i.e.* social aversion to inequality) to weight impacts relatively more heavily if they particularly affect poorer households. These issues are particularly relevant for climate change, where equity weighting will have a significant impact on estimated costs. However, social concerns may also relate to specific communities above and beyond the distributional implications in terms of income levels. In the area of fisheries management, specific concerns of this kind are also common (*i.e.* employment in fishing communities).

Finally, valuing the costs of environmental policy inaction will depend on how households, firms and farmers, among others, are likely to respond in the face of changing environmental conditions. This "adaptation" can take many forms, and can arise spontaneously (or endogenously). For example, with changing temperatures and precipitation due to climate change, farmers may change their choice of inputs, crops and tilling practices. With rising sea levels and more frequent extreme weather events, there are likely to be investments made in protective infrastructure and changing spatial patterns of development. In the case of local air pollutants or contaminated sites, choices related to residential location will be affected. With groundwater depletion, alternative sources of water (and alternative means of livelihood) will be explored. Assuming that households, firms and farmers are completely "myopic" and do not adjust in any way to changing environmental conditions is, of course, unrealistic, and will likely result in a significant overestimate of the "costs of inaction".

Selected examples of the costs of inaction

Drawing on OECD (2008a and b), this section highlights the costs of inaction in three areas of environmental policy: *i)* health impacts from air and water pollution; *ii)* fisheries management; and *iii)* climate change. A few examples from other areas are noted at the end of the section.

Air pollution, water pollution and the health "costs of inaction"

The costs of inaction in the area of air and water pollution include a wide variety of "use" (*e.g.* the effects of ambient ozone on agricultural productivity) and "non-use" values (*e.g.* the existence value of affected species habitats). These costs can be further distinguished between costs which are generally reflected in existing "market" prices for different goods and services (*e.g.* lost employee productivity, medical costs, increased raw water treatment costs) and those which are not (*e.g.* health costs in terms of "pain and suffering").

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Table 13.1. **Selected types of costs related to air and water pollution**

Air pollution	Water pollution
Material damages (including cultural heritage)	Increased drinking water treatment
Reduced agricultural yields	Reduced commercial fish stocks
Polluted freshwater sources	Reduced recreational opportunities
Reduced visibility	Loss of biodiversity
Loss of biodiversity	Adverse health impacts
Adverse health impacts	

Table 13.1 illustrates the diversity of impacts that are involved. While all impacts from policy inaction in the area of water and air pollution are potentially difficult to value, the most difficult are probably those relating to ecosystems (*e.g.* airsheds, water courses) which are not directly related to some downstream economic activity. Valuation of some of the costs of inaction associated with human health (*i.e.* mortality) can also be very controversial.[4]

Pearce *et al.* (2006) suggested that the health-related costs are typically more than 80% of the total costs of air pollution (and sometimes much more). They also found that reduced health impacts were at least one-third (possibly extending to nearly 100%) of the total social benefits of pollution control. However, only a sub-set of the non-health costs are usually included in studies in which the health costs exceed 90%. For instance, in a study by Dziegielewska and Mendelsohn (2005), it was found that estimated ecosystem and cultural heritage costs comprise more than 13% of total damage; these costs were not even included in many of the other studies that were reviewed.

Many intangible health costs of environmental degradation are difficult to value, and may not be reflected in any market. For instance, the "personal pain and suffering" associated with being ill will not be reflected in financial expenditures.[5] Where intangible costs are significant – and the empirical evidence suggests that they frequently are – it is particularly important to rely on stated preference techniques (OECD, 2008a and b).

In a study of acute cardio-respiratory cases in Canada, Stieb *et al.* (2002) estimated that, for some impacts (*e.g.* emergency department visits, asthma symptom days, etc.), "pain and suffering" represented 40% or more of the total health costs of particulate matter. In a French study, Rabl (2004) found that, for other types of impacts attributable in part to pollution levels (*e.g.* cancer), the proportion of costs represented by "pain and suffering" may even exceed 90%.

Health impacts of water pollution[6]

Table 13.2 summarises the main health effects of selected water pollutants. The principal sources include municipal wastewater collection and treatment systems, runoff from agricultural practices, and effluent from manufacturing facilities (see Chapter 10 on freshwater). Particular industrial sectors in which the potential contribution to water pollution is significant include the chemicals sector, the food and beverage sector, and the pulp and paper sector. Mining and the mineral processing sectors can also have significant implications for water quality, as can direct household discharge of hazardous substances into drains.

The policy framework for regulating industrial point sources of water pollution is well-developed in most OECD countries, although some pollutants such as heavy metals and chlorinated solvents remain a concern. Increasing attention is being paid to "non-point"

Table 13.2. **Health effects associated with selected water pollutants**

	Disease/pollutant	Health impacts
Bacterial	Amoebic dysentery	Abdominal pain, diarrhoea, dysentery
	Campbylobacteriosis	Acute diarrhoea
	Cholera	Sudden diarrhoea, vomiting. Can be fatal if untreated
	Cryptosporidiosis	Stomach cramps, nausea, dehydration, headaches. Can be fatal for vulnerable populations
Chemical	Lead	Impairs development of nervous system in children; adverse effects on gestational age and foetal weight; blood pressure
	Arsenic	Carcinogenic (skin and internal cancers)
	Nitrates and nitrites	Methaemoglobinaemia (blue baby syndrome)
	Mercury	Mercury and cyclodienes are known to induce higher incidences of kidney damage, some irreversible
	Persistent organic pollutants	These chemicals can accumulate in fish and cause serious damage to human health. Where pesticides are used on a large scale, groundwater gets contaminated and this leads to the chemical contamination of drinking water.

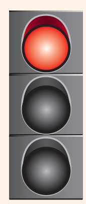
Source: EEA/WHO-Europe, 2002.

sources such as agricultural runoff, which are more difficult to regulate. In addition to efforts to reduce run-off of organic pollutants from fertilisers and manure, organophosphates and carbonates from pesticides are a concern.

The percentage of the population connected to sewerage systems has increased in OECD countries in recent decades (see Chapter 10 on freshwater). However, there are still deficiencies in collection and treatment systems in some countries. Total investment in the water sector for the 30 OECD countries – which already exceeds USD 150 billion per year (over 0.5% of GDP) – is likely to increase further in the years ahead (OECD, 2001).

The studies reviewed in OECD (2008a&b) suggest that national measures to reduce agricultural runoff and storm water management – including introducing targeted measures to reduce a variety of different pollutants (*i.e.* arsenic, nitrates, etc.) – could yield health benefits in excess of USD100 million in large OECD economies. Many of these estimates are *lower-bound* estimates, since they are obtained from cost-of-illness studies that do not account for "pain and suffering". In some cases, the non-financial opportunity costs for caregivers (and others) are not included either.

In a study of the Chesapeake Bay, Poor *et al.* (2007) found that a one mg/litre increase (approximately 8%) in total suspended solids resulted in a fall in coastal property prices of USD 1 086 (approximately 0.5%). For dissolved inorganic nitrogen, a one mg/litre change (300%) resulted in a USD 17 642 fall (approximately 9%). Gibbs *et al.* (2002) found that a one metre decrease in underwater visibility in New England led to a decrease in property values of 6%.



The costs of inaction with respect to water pollution are especially high in developing countries.

In non-OECD countries, the costs of inaction with respect to unsafe water supply and sanitation are particularly acute. At the global level, about 1.1 billion people still do not have access to a safe water supply; 2.6 billion people do not have access to adequate sanitation facilities (WHO/UNICEF, 2006). The associated health impacts are alarming: 1.7 million deaths per year, of which 90% are children under 5 years of age (see also Chapter 12 on health and environment). Indeed, unsafe WSH is the world's biggest child killer after malnutrition (Prüss-Üstün *et al.* 2004). In addition to the direct health impacts, the resources (time and money) devoted to obtaining safe drinking water can have appreciable negative impacts on employment opportunities and schooling.

Health impacts of air pollution[7]

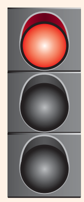
The main health effects associated with selected air pollutants are outlined in Table 13.3. Although the epidemiological evidence related to air pollution is uncertain, particulate matter (PM) appears to be the most health-damaging air pollutant – with well-recognised effects in terms of both morbidity and mortality (see also Chapter 8 on air pollution and 12 on health and environment).

Table 13.3. **Health effects associated with selected air pollutants**

Pollutant	Short-term effects	Long-term effects
PM	• Increase in mortality • Increase in hospital admissions • Exacerbation of symptoms and increased use of therapy in asthma • Cardiovascular effects • Lung inflammatory reactions	• Increase in lower respiratory symptoms • Reduction in lung function in children and adults • Increase in chronic obstructive pulmonary disease • Increase in cardiopulmonary mortality and lung cancer • Diabetes effects • Increased risk for myocardial infarction • Endothelial and vascular dysfunction • Development of atherosclerosis
O_3	• Increase in mortality • Increase in hospital admissions • Effects on pulmonary function • Lung inflammatory reactions • Respiratory symptoms • Cardiovascular system effects	• Reduced lung function • Development of atherosclerosis • Development of asthma • Reduction in life expectancy
NO_2	• Effects on pulmonary structure and function (asthmatics) • Increase in allergic inflammatory reactions • Increase in hospital admissions • Increase in mortality	• Reduction in lung function • Increased probability of respiratory symptoms • Reproductive effects

Source: Adapted from WHO, 2004; 2006.

At the aggregate level, the health costs associated with air pollution can be considerable. Muller and Mendelsohn (2007) have estimated that the total damages associated with emissions of air pollution from 10 000 major sources in the US are between USD 71 billion and 277 billion (0.7-2.8% of GDP). For China, which has a much less well-developed environmental policy regime, the relative costs are correspondingly higher. The World Bank (2007) estimated that the health impacts associated with air pollution in China were about 3.8% of GDP, with much of the impact occurring in urban areas (water pollution costs may also represent between 0.3 and 1.9% of rural GDP, depending on the estimated value of statistical life that is applied).



The costs of inaction associated with air pollution may be as high as a few percentage points of GDP. Most of these costs are not reflected in market prices or national accounts (e.g. "pain and suffering").

AEA Technology Environment (2005) has estimated that 3.7 million life years are lost annually in the EU25 countries due to PM. This is equivalent to 348 000 estimated premature deaths; 21 000 deaths were also estimated to occur earlier than normal due to ozone episodes (O_3). The total health damages associated with prevailing EU legislation for O_3 and PM in 2000 for these same countries was estimated to be between EUR 276 and EUR 790 billion, with the mortality impacts of PM being responsible for over two-thirds of these costs. This is equivalent to 3% to 10% of GDP for the EU25 region. According to the OECD Baseline, the worldwide number of premature deaths from PM is projected to be over 3 million in 2030 (see Chapter 12 on health and environment). Samakovlis *et al.* (2004) have estimated that an increase of 1 $\mu g/m^3$ in NO_2 emissions in Sweden resulted in a 3.2% increase in respiratory-related restricted activity days – approximately 685 637 additional restricted activity days. Hansen and Selte (2000) found that the effect of reducing PM_{10} concentrations in Oslo from 24.5 $\mu g/m^3$ to 12.3 $\mu g/m^3$ would reduce the sick-leave ratio by 7%.

Several studies report on the negative effects of O_3 pollution on agricultural yields. In Europe, for example, it has been estimated that the costs of not having introduced the Gothenburg Protocol[8] in terms of lost agricultural output would have been EUR 462 million/year (Holland *et al.* 2002).

Incidence of health costs

Given that health costs can be a significant proportion of the total costs of inaction on air and water pollution, environmental policy in this area can be understood as a form of "upstream prevention". The costs of inaction associated with not undertaking *ex ante* prevention are reflected in the health costs that are borne *ex post*. However, the *incidence* of the costs associated with these health impacts varies (Table 13.4).

Table 13.4. **Types and incidence of health costs from air and water pollution**

Cost	Examples	Incidence
Pain and suffering	Direct welfare loss	Individual sufferer
Restricted activity	Inability to undertake certain physical activities	Individual sufferer, dependents
Lost productivity	Sick leave, less efficiency	Individual sufferer, employer, insurance (public and/or private)
Preventive behaviour	Residential location, bottled water, lead-free paint	Individual sufferer
Caregiver resources	Compassionate leave, time and effort	Family/friends, employer
Medical service costs	Admission costs, operating costs	Individual sufferer, health insurance, public health service costs
Medicines	Prescription costs	Individual sufferer, health insurance, public health service costs

While the costs of "pain and suffering" are borne directly by exposed individuals, the financial costs may be diffused more widely. Indeed, one study of the costs of respiratory problems associated with air pollution (Chestnut *et al.*, 2005) found that only a small proportion of the financial and opportunity costs are borne directly by the individual sufferer.

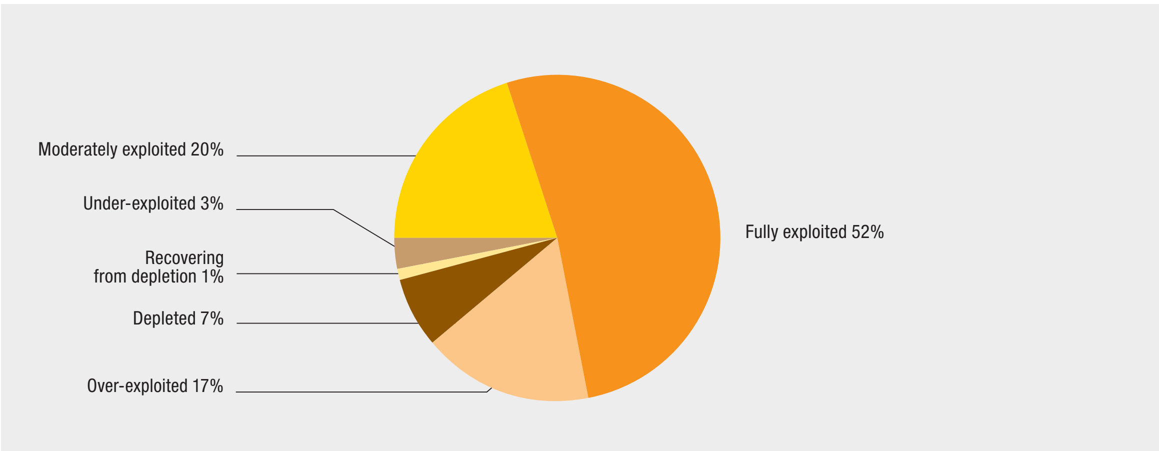
While this example provides a general indication of the breakdown of the "costs of illness" by type of cost and bearer, it is clear that institutional factors are also important. For example, a study by the (Canadian) Ontario Medical Association (2005) estimated that the healthcare costs associated with $PM_{2.5}$ and ozone in Ontario were CAD 507 million per annum. However, the incidence of these costs will depend upon how public health services are financed. Other institutional factors (*e.g.* labour market policy) can also affect the incidence of health-related costs of inaction.

Fisheries

The fisheries sector is an important source of employment (see Chapter 15 on fisheries and aquaculture) – about 40 million fishers and fish farmers depend on fisheries worldwide (FAO, 2005). An overwhelming majority of these people (about 95%) are located in developing countries (FAO, 1999). In many of these countries, fish is an essential part of the diet, providing 22% and 19% of animal proteins consumed in Asia and Africa, respectively (FAO, 2005). The recreational opportunities associated with fishery resources also contribute to the livelihoods of coastal or island communities. The impacts of fisheries on aquatic ecosystems are also being increasingly recognised. For all of these reasons, it is important that fishery resources be managed sustainably.

FAO (2007) has reported that exploitation of the world marine fishery resources intensified rapidly during the 1970s and 1980s. The proportion of over-exploited and depleted stocks rose from 10% in 1974 to 25% in 2005, although this trend has moderated in the last 10-15 years, even if increased rates of exploitation have been reported for some fish stocks and specific areas. Excess fishing pressure exerted on these stocks in the past leaves no possibilities in the short- or medium-term for further expansion, with an increased risk of further declines or even commercial extinction (Figure 13.2).

Figure 13.2. **Status of world fish stocks (2005)**



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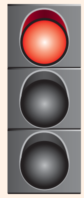
Source: Data from FAO, 2007.

Policy "inaction" in the context of fisheries management can be best described as unsustainable resource management (*i.e.* where the stock is being exploited at a rate which is greater than that which can be supported). In practice, few (if any) fisheries are currently unregulated. Regulation of fisheries typically involves some constraints via gear restrictions; spatial and/or temporal restrictions on fishing; and volume restrictions on fish harvest and fishing effort. If the combination of regulatory measures in place is not sufficient to ensure sustainable resource management, the economic consequences can be considerable.

Fisheries management takes place against a backdrop of imperfect information and imperfect control. The size of the stock, its growth rates, and its relationship with other stocks are not known with precision. Even if this was not the case, regulation of the sector would still be imperfect, particularly in areas not controlled by any one government (*e.g.* high-seas fisheries). In the face of imperfect information and control, precaution should be exercised – if thresholds are breached, a given stock can be fished into commercial extinction, with the permanent loss of all of the benefits indicated earlier. Therefore, the fisheries sector is also an example of where environmental pressures can have potentially "irreversible" consequences.

There are many different types of costs arising from unsustainable fisheries management. These include direct economic consequences, such as lost receipts for fishers and vessel owners from falling catches. There are also indirect consequences, such as lost earnings for workers and foregone profits of fish-processing and related industries. Then there is the additional loss of "use values", including those costs which can be difficult to value due to their non-market characteristics, such as reduced recreational opportunities. And finally, there are costs associated with damage to marine ecosystems.



While the costs of unsustainable natural resource management fall mainly on those who previously exploited the resource, others may also bear significant costs.

The costs of unsustainable fisheries management can be considerable:

- Bjorndal and Brasao (2005) have estimated that net present value (NPV) associated with retaining the existing ineffective fishery management regime (*i.e.* total allowable catch and restrictions on gear selection) for East Atlantic Bluefin tuna is only one-third of what would be achieved from an optimal regime. This is estimated to result in a total loss of USD 2 billion.
- Based on a study of 13 "overfished" fish stocks in US waters, Sumaila and Suatoni (2006) compared the lost direct use values (commercial fishery yields and recreational fishing) associated with continued excessive fishing with a case in which the stock "rebuilding" plans developed by Regional Fishery Management Councils were adopted. They found that the lost NPV of continuing the existing excessive fishing management regime was USD 373 million (USD 193.7 million, instead of USD 566.7 million).

The incidence of costs is also an important policy consideration for fisheries managers. Those who exploit a resource are often those who bear the highest cost from unsustainable management. However, others may also bear some of the costs, including taxpayers. In response to the collapse of the cod stock in Canada, for example, substantial public funds were spent on income support (including fishers' unemployment benefits) and government assistance programmes (expenditures towards restructuring, sectoral adjustment, and regional economic development). An estimated CAD 3.5 billion was spent on these programmes (OECD, 2006b).

Climate change

The total economic damage costs associated with climate change are likely to be significant. The projected consequences include:

i) The *market impacts* associated with the agriculture, forestry and energy sectors.

ii) The market and *non-market impacts* associated with human health, *e.g.* diarrhoea and heat stress, and on marine and terrestrial *ecosystems*.

iii) The impacts associated with extreme weather events (rather than with mean climate change), such as more frequent flooding and more intense hurricanes.

Climate change might also lead to a variety of social impacts, such as political instability or migration of people from one location to another. Finally, in the very long-run, climate change might lead to non-linear or catastrophic events, such as the shutting down of the thermohaline circulation in the North Atlantic, sudden and rapid release of methane emissions, or deglaciation of Antarctic or Greenland ice sheets.

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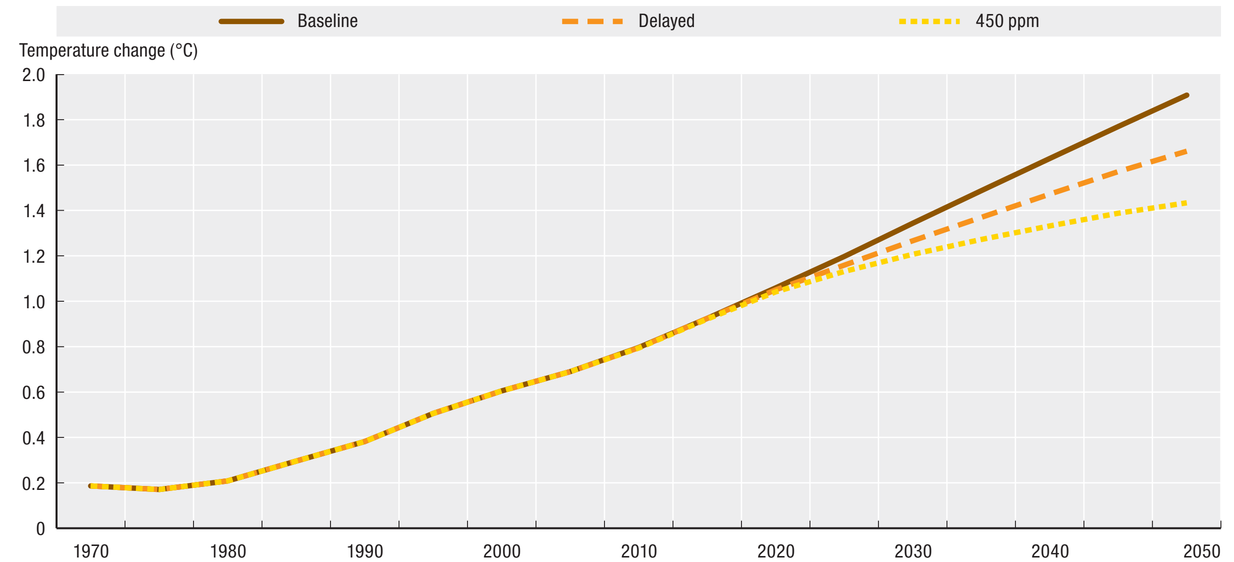
The *OECD Environmental Outlook* Baseline estimates that the expected "costs of inaction" or of delayed action for climate change are significant, at least in terms of physical environmental change. Delayed policy action is accompanied by a significantly faster rate of warming in 2030, of more than 0.22°C/decade, compared to 0.16°C/decade under the 450 ppm stabilisation policy (Figure 13.3; and Chapter 7 on climate change). By 2050, the difference between the 450 ppm stabilisation scenario compared to the Baseline ("no additional policy") projection is about 0.6°C.[9] Extrapolating *Outlook* projections to the end of the century suggests that the difference in the increase in the global mean temperature by 2080-2090 under the two scenarios is likely to be roughly 1-3°C (see Chapter 7 on climate change). The latest Intergovernmental Panel on Climate Change (IPCC) report (2007: WG1 and WG2) suggests greater risks than previously for temperature increases between 1 and 3°C (above pre-industrial levels).

Figure 13.3. **Global mean temperature change under the Baseline, an aggressive mitigation scenario, and delayed action, 1970-2050**

Global mean temperature change (2050 compared to preindustrial)



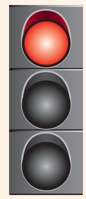
StatLink http://dx.doi.org/10.1787/261365884052

Source: *OECD Environmental Outlook* Baseline and policy simulations.

Estimates of the total costs of inaction on climate change are relatively few, due to the significant modelling requirements associated with generating these estimates. In recent work using the PAGE2002 Model, Stern (2007) estimated the costs of inaction in terms of reductions in "per capita consumption equivalents".[10] Taking into account all potential impacts (market, non-market, extreme weather events, and catastrophic events), the discounted value of the costs of inaction with respect to climate change were estimated by Stern (2007) to be 14.4% in terms of per capita consumption equivalents, relative to the "no additional policy" baseline scenario.

Kemfert and Schumacher (2005) estimated damage costs associated with a reference scenario in which no new climate policies are introduced. The total damage costs in 2100 represented 23% of global world output. The damages associated with "delayed action" were also assessed. In this latter case, no measures are undertaken until 2030, at which point measures are introduced to ensure that the increase in temperature is no larger than 2°C. In this case, the damages in 2100 are equal to approximately 15% of world GDP.

Since the early 1990s, Nordhaus has produced a series of estimates based on the Dynamic Integrated Model of the Climate and Economy (DICE), the most recent of which are contained in Nordhaus (2007). His baseline scenario is one in which "no policies are taken to slow or reverse greenhouse warming", consistent with the definition of "inaction" that is applied here. The discounted present value of damages for selected runs from the DICE model are USD 22.65 trillion. As a percentage of the discounted value of total future income, this is less than 1%. With a 50-year delay assumed in the implementation of "optimal" policies, the damages estimated by Nordhaus fall by approximately 20% relative to the "no policy" scenario.



Assuming that emissions remain unmitigated over time, estimated costs associated with climate change range from less than 1% to more than 10% of global output.

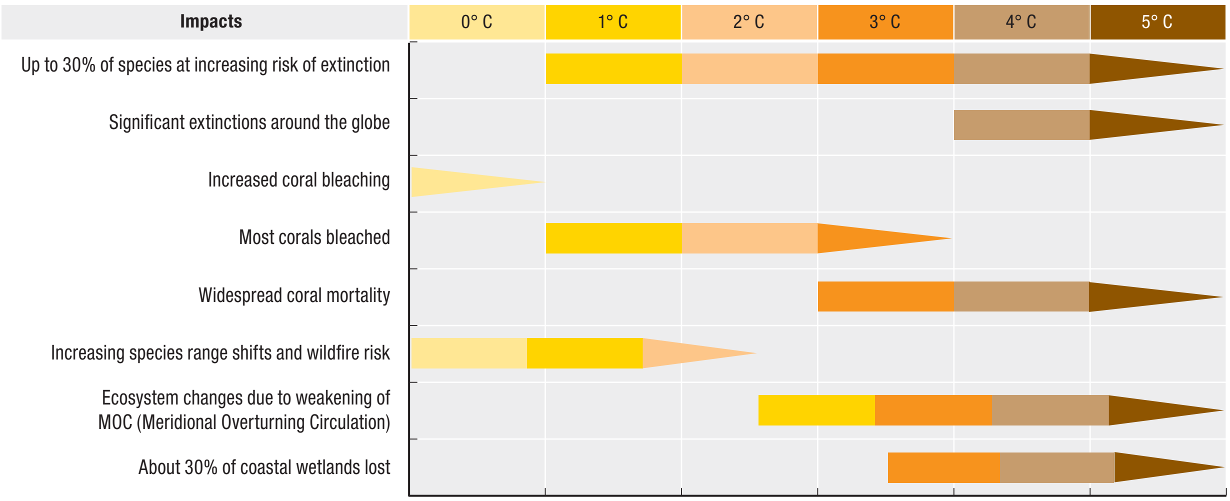
Climate change may affect aggregate levels of investment and savings, which affect the entire economy. Fankhauser and Tol (2005) undertook simulations which took into account the prospect of future damages on capital accumulation and savings rates. They found that these "indirect" costs can even exceed the "direct" costs of climate change, with the difference becoming greater over time. In the face of rigidities in capital and labour markets, these costs are likely to be greater still, particularly if the change in environmental quality is sudden. Using a model which allows for market rigidities in the adjustment to an extreme weather event "shock", Hallegatte *et al.* (2006) found that the overall impacts were much greater than if a smooth adjustment was assumed (as is the case in many models). Ultimately, with sufficient frequency and intensity of extreme weather events, an economy may therefore find itself in "perpetual reconstruction", with the economic impacts again being amplified over time.

Generally, estimates of aggregate damages and of social costs of carbon are thought to be underestimated, and to be growing over time (IPCC WG2, 2007). This recognises that studies in the literature generally omit extreme events and non-market impacts – as well as potentially high-consequence, low-probability events such as the deglaciation of Greenland or West Antarctic ice sheet, which could raise sea levels by over several meters in the long-term (IPCC WG2, 2007; Tol, 2005). On the other hand, many studies fail to consider potentially positive amenity *benefits* of climate change (*i.e.* warmer climates in northern Europe) or the offsetting impacts of higher levels of economic development over time, both of which are expected to increase adaptation capacity to climate change (Tol, 2005). However, the additional negative effects are expected to outweigh the positive ones, leading to the conclusion that the current literature is biased downward.

Because ecosystem impacts are often excluded from economic estimates of the costs of climate change inaction, it is useful to consider these explicitly (using both physical and economic metrics). Even with very low temperature increases (in the order of those already being experienced), there is evidence of coral bleaching and shifts in species habitat. In addition, there is high confidence that the extent and diversity of polar and tundra ecosystems is already in decline, and pests and disease have been spreading to higher latitudes and altitudes. Arnell *et al.* (2002) have reported that the "vegetation dieback" under the IPCC "unmitigated" scenario (IS92a) could amount to 1.5-2.7 million km^2 in 2050, rising to 6.2-8.0 million km^2 in 2080.

Figure 13.4 provides an overview of some of the areas for which there is reasonable confidence of impacts associated with different temperature increases. Globally, it is estimated that "net ecosystem productivity" would peak with a warming of 2°C. Beyond that point, terrestrial vegetation is "likely to become a net source of carbon".[11] It has been estimated that up to 43% of species in 25 biodiversity "hotspots" would be at risk from a warming of about 3-4°C (IPCC WG2, 2007).

Figure 13.4. **Temperature increases and likely impacts on marine and terrestrial ecosystems**



Source: Derived from IPCC WG2 (2007).

The damages to different ecosystems will depend to a great extent on their capacity to adapt to changing climatic conditions, and on the rate at which the climate is changing. For instance, grasslands and deserts can adapt quickly, while forests will adapt more slowly (particularly at higher latitudes) – not more rapidly than 0.05°C per decade (Arnell, 2006). Assuming a temperature increase of 2°C, Leemans and Eickhout (2004) estimated that over 15% of the total area of ecosystems would be affected,[12] with 40% of this area being able to adapt. However, almost 20% of nature reserves will be affected, with less than 40% being able to adapt. Warming, of course, is not the only climate change-related determinant of changes in ecosystems. Changing precipitation will also have important implications for ecosystem health and biodiversity, especially in Central Asia, the Mediterranean, Africa and Oceania. A small change in precipitation in desert ecosystems can also have devastating implications for local species.

Based on several previous studies which have valued willingness-to-pay (WTP) for species, ecosystem and landscape preservation, Tol (2002) estimated the costs of ecosystem damages of a 1°C increase in temperature in different regions, indicating wide variation (from USD 17 billion in OECD North America to roughly USD 100 million in Africa, or South and South East Asia). However, these estimates are extremely crude – due to uncertainties about impacts and their valuation. For example, Hitz and Smith (2004) point out that the evidence is not clear whether particular ecosystem impacts of increased warming will be linear or exponential. Similarly, "wllingness to pay" values are frequently transferred across regions using methods which are (at best) approximate.

Cost incidence is also an important dimension of climate change damages. The extent to which households are compensated for losses depends in part upon the "insurance density" of the response, and this varies widely across and within countries. For example, the data suggest that the ratio of insured losses to overall losses for natural disasters was about 38% in the US, *versus* about 27% in Europe between 1980 and 2005 (OECD, 2006a). However, these figures vary by incident. While the "insurance density" in the US is thought to be about 25-50% (OECD, 2006a), in the case of Hurricane Andrew, the relevant figure was approximately 65%. For Katrina, it was 27-33% (OECD, 2006a). The extent of insurance coverage can affect the rate at which reconstruction is undertaken, and thus the adjustment costs.

Partly because markets and capacities to adapt to climate change vary widely across countries, climate change damage costs are projected to be unevenly distributed across world regions, with the highest costs likely to be occurring in developing country regions. For example, Tol (2002) reviewed estimates of the effects on agriculture of a 2.5°C increase in global mean temperature above 1990 levels. For many of the studies reviewed, European and North American OECD regions are seen to experience net aggregate benefits, but in the developing regions of Africa, and South and South-East Asia, negative impacts are almost always found. In addition to ecological factors, higher losses occur in developing countries because they are more vulnerable to climate change due to lack of institutional and economic resources to deal with these impacts. This raises questions about equity in the assessment of global response strategies – an issue which remains prominent in international policy discussions.

Other issues

This section briefly outlines a few of the costs of inaction likely to be associated with other environmental problems than those discussed above.

Groundwater depletion (or pollution) can have significant impacts on agricultural yields – due to reduced irrigation possibilities (see Chapter 10 on freshwater). Indeed, in some cases, groundwater depletion may even render existing agricultural land unviable. It has been estimated, for example, that between 1982 and 1997, 1.435 million acres of irrigated cropland in Texas were brought out of cultivation, due to ground water depletion (USDA, 2007). Costs associated with the depletion of groundwater are also likely to be reflected in the availability and costs of drinking water. According to one estimate almost half of the world's population relies on groundwater for drinking water (Shah *et al.*, 2007). In many large cities falling water tables are resulting in sharply increased costs of drinking water, even if these are not always passed on to consumers.

In the case of *natural disasters*, some of the most visible costs of inaction relate to the need to reconstruct damaged physical infrastructure. Although data on reconstruction costs are not readily available, figures from Swiss Re and the Insurance Information Institute suggest that during the 1970s and 1980s, annual insured losses from natural disasters were in the USD 3-4 billion range (Kunreuther and Michel-Kerjan, 2007).[13] Since the 1980s, the scale of insured losses from major natural disasters has exhibited a steep upward trend. The World Bank (2006) has estimated that, for the poorest countries, the cost of natural disasters represents more than 13% of GDP. While only some of this cost can be

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attributed to environmental factors, which can in turn be influenced directly by public policy (*e.g.* flood control, GHG mitigation, etc.), "inaction" concerning natural disasters is clearly resulting in significant costs. The World Bank and the US Geological Survey have estimated that the worldwide economic losses from natural disasters in the 1990s could have been reduced by USD 280 billion, if USD 40 billion had been invested in disaster preparedness, mitigation and prevention strategies (World Bank, 2004).

The link between environmental policy inaction and industrial hazards is more apparent and better understood. The "costs of inaction" in this area can take a variety of forms. Even the "first-order" restoration and clean-up costs associated with *industrial hazards and accidents* can be significant. Restoration costs associated with oil spills are revealing. In the case of *Erika*, these direct costs were estimated to be EUR 100 million (Bonnieux and Rainelli, 2003); for the *Prestige*, they were valued at over EUR 500 million (Loureiro *et al.*, 2006; Garza-Gil *et al.*, 2006). For the *Exxon Valdez*, clean-up costs alone were over USD 2 billion (Carson *et al.*, 1992). Of course, this ignores all of the other impacts of oil spills, such as effects on ecosystems, the fisheries sector, and tourism – which are likely to be considerable. In a similar vein, the costs associated with the remediation of contaminated sites can also be high, representing a significant negative "legacy" of past inaction.

Concluding remarks

There are several issues that complicate the valuation of the "costs of inaction", including:

- Incomplete information and significant uncertainty associated with the likelihood and magnitude of different environmental impacts.
- The existence of ecological thresholds and irreversibilities which can lead to sudden and significant environmental impacts.
- The long-run nature of many impacts arising out of environmental degradation and resource depletion.
- The degree of substitutability which exists between environmental resources and other factors of production, and the implications this has for economic sustainability.
- The importance of the distribution of environmental impacts, and thus, the links between environmental impacts and social concerns for equity.
- The nature of responses of households, firms and governments to changing environmental conditions.

Given the uncertainties involved, and the fundamentally tendentious nature of the problem of estimating the costs of inaction, it would be foolhardy to attempt to "cost" environmental policy inaction in some aggregate sense. However, it is clear that there are many environmental problems for which the costs of not taking policy action are significant, and are already directly affecting OECD economies in a variety of ways. Some of these costs are reflected, for example, in public sector budgets, – *e.g.* public expenditures on health services, unemployment benefits and adjustment programmes for out-of-work fishers, remediation costs for contaminated sites, etc.

However, other elements of the costs of inaction are less apparent (and more difficult to quantify), such as the costs associated with the loss of marine and terrestrial biodiversity; and the "pain and suffering" associated with ill-health. Some components of the costs of inaction may also be reflected in existing markets, even though they are not readily perceived as costs of environmental policy inaction *per se*. Examples include the effects of contaminated sites on adjacent property prices, or the effects of air pollution on agricultural yields.

Focusing on the costs of inaction without taking into account key non-market and intangible issues (such as the "existence value" of biodiversity) can result in a gross underestimate of reality. Nonetheless, in some cases, the assessment of the more tangible market impacts alone may be sufficient to warrant additional policy interventions (*i.e.* above and beyond those policies already in place). Since these "more direct" costs are often easier to estimate with confidence, this is important to bear in mind.

OECD countries have made significant strides in addressing many of the environmental concerns discussed in this chapter. The term "inaction" must therefore be interpreted in this context. Even if the full costs of inaction are deemed to be significant, identifying those areas in which new environmental policies should be undertaken would still require a careful balancing of the marginal costs of inaction with the marginal costs of further reducing the associated impacts. Although an assessment of some of the elements of one side of this equation is instructive, this important additional step would also need to be taken before arriving at sound policy decisions.

The point of incidence of the costs of environmental policy inaction has direct implications for incentives to avoid future negative environmental legacies, and thus for the design of policy. Inaction is a reflection of the non-internalisation of environmental externalities. It is important that price and regulatory signals which reflect the costs of inaction be transmitted to those who are in a position to reduce such impacts, since *ex ante* prevention is often much less costly than *ex post* remediation or adaptation. In many cases (climate change, high-seas fisheries, etc.), this will imply the need for significant international co-ordination.

Notes

1. This chapter does *not* review estimates of the costs of action (*i.e.* the costs of environmental policy interventions). See Morgenstern *et al.* (2001) for one particularly useful example from this vast literature.
2. In the face of uncertainty about both future interest rates and future economic conditions, the appropriate discount rate to apply will vary over the life of the impact. Where such uncertainty exists, a declining rate should be applied through time (see Weitzman, 2001). See Hepburn (2007) for a discussion of the implications for estimating the costs of policy inaction.
3. According to the International Panel on Climate Change (IPCC) the probability of this happening this century is "very unlikely", but slowing of the current is "very likely" (IPCC WG2, 2007).
4. See Pearce *et al.* (2006) for a review of approaches to valuing human morbidity and mortality, and a summary of estimates from the literature of key assumptions (*e.g.* value of a statistical life).
5. Except, perhaps in terms of *ex ante* "defensive" expenditures. One example is time and energy spent collecting drinking water from an uncontaminated source, rather than from a more polluted source nearby. The purchase of bottled water to avoid lead contamination would be an example of private defensive expenditures. However, some "defensive" expenditures may actually overestimate the health costs of inaction, if other non-health benefits are also obtained (*e.g.* better taste).
6. This section draws heavily on Gagnon (2007a and b).
7. This section draws heavily on Scapecchi (2007).
8. The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. The protocol sets emission ceilings to 2010 for four pollutants: sulphur, NOx, VOCs and ammonia.

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Under the negotiated solution, parties whose emissions have a more severe impact and whose emissions are relatively less costly to reduce have an obligation to achieve the biggest reductions. Compared to 1990 levels, Europe's sulphur emissions should be cut by at least 63%, its NO_x emissions by 41%, its VOC emissions by 40% and its ammonia emissions by 17%.

9. These uncertainty ranges are presented for key *Baseline* estimates and are based on a scaling approach, using the MAGICC model and IMAGE result – see Chapter 7, Climate change, Table 7.4c.

10. The "metric" used in Stern (2007) has caused some confusion, but is an elegant way to express a complex issue. Assuming future growth rates in the absence of any economic impacts from climate change, Stern first calculated the consumption path associated with that growth rate. Next, he considered climate change impacts, which in his model translated into lower future growth rates, and thus a correspondingly lower future consumption path. The "cost of inaction" was thus the difference between these two consumption trajectories (see Sterner and Persson (2007) for additional clarification).

11. IPCC WG2 (2007: Chapter 19).

12. This is based on an indicator derived from the net change in extent of a particular ecosystem, expansion into other areas, and disappearance from existing areas.

13. The extent to which this reflects market losses depends in part upon the "insurance density", and this varies widely across (and within) countries.

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OECD Environmental Outlook to 2030

Introduction: Context and Methodology

Purpose of the report

The purpose of the *OECD Environmental Outlook* is to help government policy-makers to identify the key environmental challenges they face, and to understand the economic and environmental implications of the policies that could be used to address those challenges.

The *Outlook* provides a baseline projection of environmental change to 2030 (referred to as "the Baseline"), based on projected developments in the underlying economic and social factors that drive these changes. The projections are based on a robust general equilibrium economic modelling framework, linked to a comprehensive environmental modelling framework (see below, and Annex B, for more details). Simulations were also run of specific policies and policy packages that could be used to address the main environmental challenges identified, and their economic costs and environmental benefits compared with the Baseline.

This is the second *Environmental Outlook* produced by the OECD. The first *OECD Environmental Outlook* was released in 2001, and provided the analytical basis on which ministers adopted an *OECD Environmental Strategy for the First Decade of the 21st Century*. This second *Outlook:*

- extends the projected baseline used in the first *Outlook* from 2020 to 2030, and even 2050 for some important areas;
- is based on a stronger and more robust modelling framework;
- focuses on the policies that can be used to tackle the main challenges;
- expands the country focus to reflect developments in both OECD and non-OECD regions and their interactions.

Many of the priority issues and sectors identified in this *Outlook* are the same as those highlighted as needing most urgent policy action in the first *OECD Environmental Outlook* (2001) and in the *OECD Environmental Strategy for the First Decade of the 21st Century*. These include the priority issues of climate change, biodiversity loss and water scarcity, and the key sectors exerting pressure on the environment (agriculture, energy and transport). Added to these is a new priority issue: the need to address the health impacts of the build-up of chemicals in the environment. The 2001 *Outlook* indicated the environmental challenges expected in the next couple of decades; this *Outlook* not only deepens and extends this analysis, it also focuses on the policy responses for addressing these challenges. It finds that the solutions are affordable and available if ambitious policy action is implemented today, and if countries work together in partnership to ensure comprehensive action, avoid competitiveness concerns and share the responsibility and costs of action fairly and equitably. This latest *Outlook* analyses the policies that can be used to achieve the *OECD Environmental Strategy*. It will provide the main analytical material to support discussions on further implementation of the *OECD Environmental Strategy* at the OECD Meeting of Environment Ministers planned for early 2008.

Policy context

Why develop an environmental outlook? Many of the economic or social choices that are being made today – for example, investments in transport infrastructure and building construction, fishing fleets, purchase of solar heating panels – will have a direct and lasting affect on the environment in the future. For many of these, the full environmental impacts will not be felt until long after the decisions have been taken. These factors make policy decisions difficult: the costs of policy action to prevent these impacts will hit societies today, but the benefits in terms of improved environmental quality or damage avoided may only be realised in the future. For example, the greenhouse gases released today continue to build up in the atmosphere and will change the future climate, with serious impacts for the environment, the economy and social welfare.

But politicians tend to reflect the short-term interests of the voting public, not the long-term needs of future generations. They also tend to focus on the immediate costs and benefits to their own populations of a given policy approach, rather than on the global impacts. But many of the main environmental challenges countries face in the early 21st century are global or transboundary in nature, including global climate change, biodiversity loss, management of shared water resources and seas, transboundary air pollution, trade in endangered species, desertification, deforestation, etc. Building public understanding and acceptance of the policies that are needed to address these challenges is essential for policy reform.

These political challenges are exacerbated by uncertainty about the future. Often the exact environmental impacts of social and economic developments are poorly understood or disputed. In some cases, scientific uncertainty about environmental or health impacts is a main cause of policy inaction, while in others it is used as a justification for precautionary action. Scientific understanding and consensus about environmental change has been developing rapidly in a number of areas in recent years, for example through the 2005 Millennium Ecosystem Assessment and the 2007 IPCC Fourth Assessment Report on the Science of Climate Change. Despite the improvements in the scientific understanding of such issues, a gap remains in the development and implementation of effective environmental policies based on this scientific understanding.

This *Environmental Outlook* examines the medium to long-term environmental impacts of current economic and social trends, and compares these against the costs of specific policies that could be implemented today to tackle some of the main environmental challenges. The purpose is to provide more rigorous analysis of the costs and benefits of environmental policies to help policy-makers take better, more informed policy decisions now.

Many environmental problems are complex and inter-connected. For example, species loss is often the result of multiple pressures – including hunting, fishing or plant harvesting, loss of habitat through land use change or habitat fragmentation, impacts of pollutants – and thus a mix of policy instruments is needed to tackle the various causes of this loss. These policy packages need to be carefully designed in order to achieve the desired environmental benefits at the lowest economic cost. This *Outlook* examines the policy packages that could be used to tackle some of the key environmental challenges, and the framework conditions needed to ensure their success.

The transboundary or global nature of many of the most pressing environmental challenges identified in this *Outlook* require countries to increasingly work together in partnership to address them. The ways in which OECD environment ministries can work together in partnership with other ministries, stakeholder partners and other countries are explored in this *Outlook*.

A special focus on the emerging economies in the *Outlook*

This *Outlook* identifies the main emerging economies as the most significant partners for OECD countries to work with in the coming decades to tackle global or shared environmental problems. This is because these countries are responsible for an increasingly large share of the global economy and trade, and thus have an increasing capacity to address these challenges, in part because their economies are so dynamic. Moreover, the pressures that they exert on the environment are also growing rapidly.

In some chapters, where data are available and relevant, the BRIICS countries (Brazil, Russia, India, Indonesia, China and South Africa) are highlighted for attention as a country grouping. In other chapters, the smaller country grouping of BRIC (Brazil, Russia, India and China) is examined, or even further disaggregated to each of these four countries individually. The BRIC grouping is used for most of the modelling projections and simulations in the *Outlook*.

Modelling methodology and sources of information

The analysis presented in this *Environmental Outlook* was supported by model-based quantification. On the economic side, the modelling tool used is a new version of the OECD/World Bank JOBS/Linkages model, operated by a team in the OECD Environment Directorate and called ENV-Linkages. It is a global general equilibrium model containing 26 sectors and 34 world regions and provides economic projections for multiple time periods. It was used to project changes in sector outputs and inputs of each country or region examined to develop the economic baseline to 2030. This was extended to 2050 to examine the impacts of policy simulations in specific areas, such as biodiversity loss and climate change impacts. The economic baseline was developed with expert inputs from, and in co-operation with, other relevant parts of the OECD, such as the Economics Department, the International Energy Agency and the Directorate for Food, Agriculture and Fisheries.

The Integrated Model to Assess the Global Environment (IMAGE) of the Netherlands Environmental Assessment Agency (MNP) was further developed and adjusted to link it to the ENV-Linkages baseline in order to provide the detailed environmental baseline. IMAGE is a dynamic integrated assessment framework to model global change, with the objective of supporting decision-making by quantifying the relative importance of major processes and interactions in the society-biosphere-climate system. The IMAGE suite of models used for the *Outlook* comprises models that also appear in the literature as models in their own right, such as FAIR (specialised to examine burden sharing issues), TIMER (to examine energy), and GLOBIO3 (to examine biodiversity). Moreover, for the *Outlook* the IMAGE suite included the LEITAP model of LEI at Wageningen and the WaterGap model of the Center for Environmental Systems Research at Kassel University. IMAGE and associated models provided the projections of impacts on important environmental endpoints to 2030, such as climate, biodiversity, water stress, nutrient loading of surface water, and air quality. Annex B provides a more detailed description of the modelling framework and main assumptions used for the *Outlook* report.

The Baseline Reference Scenario presents a projection of historical and current trends into the future. This Baseline indicates what the world would be like to 2030 if currently existing policies were maintained, but *no new policies* were introduced to protect the environment. It is an extension of current trends and developments into the future, and as such it does not reflect major new or different developments in either the drivers of environmental change or environmental pressures. A number of major changes are possible in the future, however, that would significantly alter these projections. A few of these were examined as "variations" to the Baseline, and their impacts are described in Chapter 6 to show how these changes might affect the projections presented here.

Because the Baseline reflects no new policies, or in other words it is "policy neutral", it is a reference scenario against which simulations of new policies can be introduced and compared. Simulations of specific policy actions to address key environmental challenges were run in the modelling framework. The differences between the Baseline projections and these policy simulations were analysed to shed light on their economic and environmental impacts.

The simulations undertaken for the *Environmental Outlook* exercise are illustrative rather than prescriptive. They indicate the type and magnitude of the responses that might be expected from the policies examined, rather than representing recommendations to undertake the simulated policy actions. As relevant, some of the policy simulation results are reflected in more than one chapter. The table below summarises the policy simulation analyses and lists the different chapters containing the results.

Sensitivity analysis was undertaken to test the robustness of key assumptions in ENV-Linkages, and some of the results of this analysis are presented in Annex B. This, in conjunction with the Baseline variations described in Chapter 6, provides a clearer picture for the reader of the robustness of the assumptions in the Baseline.

Throughout the *Outlook*, the analysis from the modelling exercise is complemented by extensive data and environmental policy analysis developed at the OECD. Where evidence is available, specific country examples are used to illustrate the potential effects of the policies discussed. Many of the chapters in this *Outlook* have been reviewed by the relevant Committees and Expert Groups of the OECD, and their input has strengthened the analysis.

The *Outlook* is released at about the same time as a number of other forward-looking environmental analyses, such as UNEP's Fourth Global Environment Outlook (GEO-4); the IPCC Fourth Assessment Report (AR-4); the International Assessment of Agricultural Science and Technology for Development supported by the World Bank, FAO and UNEP; and the CGIAR Comprehensive Assessment of Water Use in Agriculture. Through regular meetings and contacts, efforts have been made by the organisations working on these reports to ensure co-ordination and complementarity in the studies, and to avoid overlap. The *OECD Environmental Outlook* differs from most of the others in its emphasis on a single baseline reference scenario against which specific policy simulations are compared for the purpose of policy analysis. Most of the others explore a range of possible "scenarios", which provide a useful communication tool to illustrate the range of possible futures available, but are less amenable to the analysis of specific policy options. The *OECD Environmental Outlook* also looks at developments across the full range of environmental challenges, based strongly on projected developments in the economic and social drivers of environmental change, while many of the other forward-looking analyses focus on a single environmental challenge.

Table I.1. **Mapping of the *OECD Environmental Outlook* policy simulations by chapter**

Simulation title	Simulation description	Chapters in which the results are reflected	Models used
Baseline	The "no new policies" Baseline used throughout the *OECD Environmental Outlook*.	All chapters	ENV-Linkages; IMAGE suite
Globalisation variation	Assumes that past trends towards increasing globalisation continue, including increasing trade margins (increasing demand by lowering prices in importing countries) and reductions in invisible costs (*i.e.* the difference between the price at which an exporter sells a good and the price that an importer pays).	4. Globalisation 6. Key variations to the standard expectation	ENV-Linkages; IMAGE suite
High and low growth scenarios	Variation 1: High economic growth – examines impacts if recent high growth in some countries (*e.g.* China) continues, by extrapolating from trends from the last 5 years of growth rather than the last 20 years. Variation 2: Low productivity growth – assumes productivity growth rates in countries converge towards an annual rate of 1.25% over the long-term, rather than 1.75% as in the Baseline. Variation 3: High productivity growth – assumes productivity growth rates in countries converge towards an annual rate of 2.25% over the long-term.	6. Key variations to the standard expectation	ENV-Linkages
Greenhouse gas taxes	Implementation in participating countries of a tax of USD 25 on CO_2eq, increasing by 2.4% per annum. OECD 2008: only OECD countries impose the tax, starting in 2008. Delayed 2020: all countries apply the tax, but starting only in 2020. Phased 2030: OECD countries implement the tax from 2008; BRIC countries from 2020, and then the rest of the world (ROW) from 2030 onwards. All 2008: in a more aggressive effort to mitigate global GHG emissions, all countries implement the USD 25 tax from 2008.	7. Climate change 13. Cost of policy inaction (Delayed 2020) 17. Energy 20. Environmental policy packages	ENV-Linkages; IMAGE suite
Climate change stabilisation simulation (450 ppm)	Optimised scenario to reach a pathway to stabilise atmospheric concentrations of GHG at 450 ppm CO_2eq over the longer term and limit global mean temperature change to roughly 2 °C. A variation on this case was developed to explore burden-sharing, using a cap and trade approach to implementation.	7. Climate change 13. Cost of policy inaction 17. Energy 20. Environmental policy packages	ENV-Linkages; IMAGE suite
Agriculture support and tariff reform	Gradual reduction in agricultural tariffs in all countries to 50% of current levels by 2030. Gradual reduction in production-linked support to agricultural production in OECD countries to 50% of current levels by 2030.	9. Biodiversity 14. Agriculture	ENV-Linkages
Policies to support biofuels production and use	Demand for biofuels growing in line with the IEA *World Energy Outlook* (2006) scenario. DS: a scenario whereby growth in biofuel demand for transport is driven by exogenous changes, keeping total fuel for transport close to the Baseline. OilS: a high crude oil price scenario to determine the profitability of biofuel in the face of increasing costs of producing traditional fossil-based fuels. SubS: a subsidy scenario in which producer prices of biofuels are subsidised by 50%.	14. Agriculture	ENV-Linkages
Fisheries	Global fisheries cap and trade system, representing a 25% reduction in open fisheries catch, with trading allowed within six geographical regions.	15. Fisheries and aquaculture	ENV-Linkages
Steel industry CO_2 tax	Implementation of a carbon tax of 25 USD per tonne CO_2, applied respectively to OECD steel industry only, all OECD sectors, and all sectors worldwide.	19. Selected industries – steel and cement	ENV-Linkages
Policy mix	Three variations of policy packages were modelled, depending on the participating regions: OECD countries only OECD + BRIC Global The policy packages included: • reduction of production-linked support and tariffs in agriculture to 50% of current levels by 2030. • tax on GHG emissions of USD 25 tax CO_2eq, increasing by 2.4% per annum (phased with OECD starting in 2012, BRIC in 2020, ROW in 2030). • moving towards, although not reaching, Maximum Feasible Reduction in air pollution emissions, phased over a long time period depending on GDP/capita. • assuming that the gap to connecting all urban dwellers with sewerage will be closed by 50% by 2030, and installing, or upgrading to the next level, sewage treatment in all participating regions by 2030.	8. Air pollution 10. Freshwater 12. Health and environment 20. Environmental policy packages	ENV-Linkages; IMAGE suite

Structure of the report

The *OECD Environmental Outlook* is divided into two main parts:

i) *The World to 2030 – the Consequences of Policy Inaction:* describes the Baseline, *i.e.* the projected state of the world to 2030 in terms of the key drivers of environmental change and the developing environmental challenges, as well as analysing some possible variations to the Baseline.

ii) *Policy Responses:* focuses on the policy responses at both the sectoral level and in terms of implementing a more comprehensive and coherent policy package.

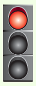
The first part describes the key elements of the Baseline to 2030, including the main drivers of environmental change (consumption and production patterns, technological innovation, population dynamics and demographic change, economic development, globalisation, and urbanisation) and the key environmental challenges (climate change, air pollution, biodiversity, freshwater, waste and material flows, health and environment). For each of these, the key recent trends and projections to 2030 are presented, as well as some of the policy approaches that are being used to address the environmental challenges. Chapter 6 describes some key variations to the Baseline – for example, how the Baseline would differ if key economic drivers (such as economic growth or global trade) were changing faster than projected in the Baseline. The chapter also explores other sources of uncertainty in the *Outlook* projections. Finally, this first part of the report examines the consequences and costs of policy inaction – essentially the environmental, health and economic impacts embodied in the "no new policies" Baseline scenario.

The second part of the *Outlook* report examines the possible policy responses to address the key environmental challenges, and assesses the economic and environmental impact of these responses. The key sectors whose activities affect the environment are examined, with a brief summary of the trends and outlook for their impacts, followed by an assessment of the policy options that could be applied in that sector to reduce negative environmental impacts. This section assesses the environmental benefits of specific policy options and their potential costs to the sector involved and/or economy-wide (and disaggregated by region where appropriate). This analysis can be used by environment ministries in discussing specific policy options for tackling environmental challenges with their colleagues in other ministries, such as finance, agriculture, energy or transport. The sectors examined include those that were prioritised in the *OECD Environmental Strategy* – agriculture, energy and transport – and also other sectors which strongly affect natural resource use or pollution, such as fisheries, chemicals and selected industries (steel, cement, pulp and paper, tourism and mining).

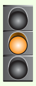
In addition to analysing sector-specific policies, this part of the *Outlook* also examines the effects of a package of policies (the EO policy package) to tackle the main environmental challenges. The analysis of this EO policy package highlights the potential synergies between policies (*i.e.* where the benefits of combining two or more policies may be greater than the simple sum of their benefits as separate policies), or potential conflicts where policies may undermine each other. Chapter 21 outlines the key framework conditions needed to ensure the successful identification and implementation of appropriate environmental policies at the national level, in particular institutional capacity and policy implementation concerns. Chapter 22, on global environmental co-operation, highlights the issues for which OECD countries will need to work together in partnership with other countries in order to reduce overall costs of policy implementation and maximise benefits. It also assesses the costs of inaction.

Traffic lights in the *OECD Environmental Outlook*

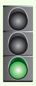
As with the 2001 *Outlook*, this report uses traffic light symbols to indicate the magnitude and direction of pressures on the environment and environmental conditions. Traffic lights are used to highlight the key trends and projections in the summary table in the Executive Summary, in the Key Messages boxes at the start of each chapter and throughout the chapters. The traffic lights were determined by the experts drafting the chapters, and then refined or confirmed by the expert groups reviewing the report. They represent the following ratings:



Red lights are used to indicate environmental issues or pressures on the environment that require urgent attention, either because recent trends have been negative and are expected to continue to be so in the future without new policies, or because the trends have been stable recently but are expected to worsen.



Yellow lights are given to those pressures or environmental conditions whose impact is uncertain, changing (*e.g.* from a positive or stable trend toward a potentially negative projection), or for which there is a particular opportunity for a more positive outlook with the right policies.



Green lights signal pressures that are stable at an acceptable level or decreasing, or environmental conditions for which the outlook to 2030 is positive.

While the traffic light scheme is simple, thus supporting clear communication, it comes at the cost of sensitivity to the often complex pressures affecting the environmental issues examined in this *Outlook*.

While each of the individual chapters discusses the regional developments for the drivers or environmental impacts analysed, Annex A also provides an easily accessible "summary" of the economic, social and environmental developments in the Baseline for each region. Annex B provides a more detailed analysis of the modelling framework used in the development of the *OECD Environmental Outlook*. A number of background working papers, which provide further information on specific issues addressed in the *Outlook*, were developed to complement the report (see: *www.oecd.org/environment/outlookto2030*).

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Acronyms and Abbreviations

BRIC	Brazil, Russia, India and China
BRIICS	Brazil, Russia, India, Indonesia, China and South Africa
CBD	Convention on Biological Diversity
CCS	Carbon capture and storage
CDM	Clean Development Mechanism
CFC	Chlorofluorocarbon
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalents
CSD	Commission on Sustainable Development
DAC	OECD Development Assistance Committee
EJ	Exajoules
EU15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom
EU25	Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom
EUR	Euro (currency of European Union)
FAO	Food and Agriculture Organization of the United Nations
GBP	Pound sterling
GDP	Gross domestic product
GHG	Greenhouse gas
GJ	Gigajoules
GNI	Gross national income
Gt	Giga tonnes
GW	Gigawatt
HFC	Hydrofluorocarbon
IEA	International Energy Agency
IMAGE	Integrated Model to Assess the Global Environment
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land use, land use change and forestry
MAD	Mutual Acceptance of Data
MDGs	Millennium Development Goals
MEA	Multilateral environmental agreement
MNP	Netherlands Environmental Assessment Agency
MSA	Mean species abundance

Mt	Million tonnes
MWh	Megawatt-hour
NO_2	Nitrogen dioxide
N_2O	Nitrous oxide
NO_x	Nitrogen oxides
ODA	Official development assistance
ppb	Parts per billion
ppm	Parts per million
PFC	Perfluorocarbon
PM	Particulate matter
$PM_{2.5}$	Particulate matter, particles of 2.5 micrometres (µm) or less
PM_{10}	Particulate matter, particles of 10 micrometres (µm) or less
ppmv	Parts per million by volume
ROW	Rest of world
RTA	Regional trade agreement
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
SF_6	Sulphur hexafluoride
TWh	Terawatt hour
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
VOC	Volatile organic compound
WHO	World Health Organization
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization

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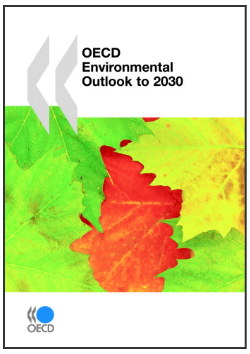

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