Chapter 8: Decoupling Economic Growth from Environmental Pressures.

Introduction

"We do so much to prepare our children for the future, but are we doing enough to prepare the future for our children?" --Larry Chalfan

Chapter 7 has addressed the topic of decoupling economic growth from greenhouse gas emissions. Chapter 7 showed that urgent decoupling of greenhouse gas emissions from economic growth was needed to avoid dangerous climate change, that this was technically possible and economically affordable if we act now. Chapter 7 also showed that the costs of inaction significantly out-weighed the costs of action. Climate change is particularly high on the political agenda now, but achieving sustainable development requires decoupling economic growth from all environmental pressures, such as irreversible biodiversity loss, restoring ecosystem resilience, ensuring clean water and adequate sanitation for all, and rapidly reducing pollution through end of pipe and green eco-efficiency and resource productivity improvements. The UN[1], UNEP[2], OECD[3], the World Bank[4] and numerous scientific bodies have warned that humanity faces a number of serious environmental challenges in addition to climate change which require urgent action. The most urgent environmental challenges (see Table 8.1) are of a complex global nature, and their impacts often only reveal themselves when it is too late, once ecosystems have already passed ecological thresholds and are rapidly losing their resilience..

[1] UN Millennium Ecosystem Assessment, (2005) *Ecosystems and Human Well-being: Biodiversity Synthesis*. World Resources Institute, Washington, DC

[2] UNEP (2007) *Global Environment Outlook: Environment for development (GEO-4) report*. UNEP. Available At http://www.unep.org/geo/geo4 Accessed 23.03.08

[3] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[4] World Bank (2003) '*World Bank Development Report 2003: Sustainable Development in a Dynamic World'*, Oxford University Press, Oxford

Climate change		• Declining GHG emissions per unit of GDP	• Global GHG emissions • Increasing evidence of an already changing climate
Biodiversity and renewable natural resources	• Forested area in OECD countries	• Forest management • Protected areas	• Ecosystem quality • Species loss • Invasive alien species • Tropical forests • Illegal logging • Ecosystem fragmentation
Water	• Point-source water pollution in OECD countries (industry, municipalities)	• Surface water quality and wastewater treatment	• Water scarcity • Groundmater quality • Agricultural water use + pollution
Air quality	• OECD country SO_2 and NO_x emissions	• PM and ground-level ozone • Road transport emissions	• Urban air quality
Waste and hazardous chemicals	• Waste management in OECD countries • OECD country emissions of CFCs	• Municipal waste generation • Developing country emissions of CFCs	• Hazardous waste management and transportation • Waste management in developing countries • Chemicals in the environment and in products

Table 8.1 Environmental Protection Priority Areas (Red=Urgent, Yellow= Priority, Green=Well Managed)

(Source: OECD, 2008[5])

Thus a transition to environmental sustainability will involve a range of complex tasks from reversing biodiversity loss to restoring the environment, to better managing common natural resources such as water, to reducing environmental pressures, such as air and water pollution, through better pollution control and resource productivity improvements.

The first part of Chapter 8 looks at how to decouple economic growth from loss of biodiversity and natural resources. Then the following parts of Chapter 8 look at how to further decouple economic growth from a range of environmental pressures – air and water pollution, waste and material flows - through pollution prevention and resource productivity. The UN[6], UNEP[7], OECD[8] and World Bank[9] have all argued that greater efforts are required now whilst costs of action are relatively small to avoid greater long term costs of inaction. Without new (or more stringent) policies to better address environmental health issues, the adverse health effects of the most harmful environmental pollutants (e.g. air and water pollution) are likely to increase in many developing countries in the future.

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[5] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[6] UN Millennium Ecosystem Assessment, (2005) *Ecosystems and Human Well-being: Biodiversity Synthesis*. World Resources Institute, Washington, DC

[7] UNEP (2007) *Global Environment Outlook: Environment for development (GEO-4) report*. UNEP. Available At http://www.unep.org/geo/geo4 Accessed 23.03.08

[8] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[9] World Bank (2003) '*World Bank Development Report 2003: Sustainable Development in a Dynamic World'*, Oxford University Press, Oxford

- Health impacts of air pollution are projected, based on current trends. to increase worldwide, with the number of premature deaths linked to ground-level ozone quadrupling and those linked to particulate matter more than doubling.

- A range of expert institutions now warn that water scarcity and water stress could increase from 1 billion to affect over 3 billion people by 2030 if there is not further action.[10] In 2004, 17% of the world's population did not have reasonable access to a non-contaminated water supply and 41% lacked access to basic sanitation and sewerage treatment. This is forecast by the OECD to deteriorate with population growth. By 2030, more than 5 billion people (67% of the world population) are expected to be without a connection to public sewerage if no further action is taken over the coming decades. A 2007 scorecard showed the 2015 sanitation goal of halving the numbers of people without access to clean water was likely to be missed by 600 million people worldwide on current trends.

- Already levels of unsafe water sanitation and hygiene are causing 3% of all deaths and 4.4% of all disability-adjusted life years (DALYs) around the world.[11] Virtually all of these deaths and DALYs occur in developing countries; with 9 out of 10 of those dying are children. Indeed, unsafe water is the world's biggest child killer.

- Chemical production volumes in fast growing and developing countries are rapidly increasing. There is a lack of data and information of the risks from the release of chemicals in these regions. Chemical substances can cause problems if either the chemical is toxic or hazardous or if they bio-accumulate to become hazardous. Also there are risks of combinations of chemicals causing serious damage to human health and the environment. The greatest environmental impacts will be felt by developing countries, which are less equipped to manage and adapt. But the economic and social costs of policy inaction or delaying action in these areas are significant. Given the globalisation of food and seafood production and given that chemical pollution can effect groundwater, water tables and rivers that cross national borders, poor chemical management and chemical pollution in one country can negatively effect people and the environment around the world.

- Whilst, OECD countries have improved recycling rates and waste management practices, globally still much needs to be done. According to UNEP, in Indonesia, Malaysia, Myanmar,

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[10] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[11] EEA (European Environmental Agency) (2003) *Europe's Environment: the Third Assessment, Environmental Assessment Report*, No. 10, European Environment Agency, Copenhagen. World Bank (2003), "Water, Sanitation and Hygiene", At a Glance Series, November 2003, available at:
http://siteresources.worldbank.org/INTPHAAG/Resources/AAGWatSan11-03.pdf

Philippines, Singapore, Thailand and Vietnam, 50-80% of municipal waste is simply dumped.[12] Only 5-30% of municipal waste in these countries is correctly landfilled and composted. In Brazil, studies show that approximately 60% of all municipal solid waste is disposed of inappropriately.[13] In China, 48% of municipal waste is not treated.[14] In India, up to 40% of the municipal waste across urban areas remains uncollected.[15] This can create significant health risks and costs.

Therefore, there is a window of opportunity now to introduce greater investment coupled with robust and ambitious policy changes to tackle the key environmental problems and promote sustainable development. Lack of action now will only increase costs of action to future generations.

Therefore, these environmental challenges will require greater investment especially by OECD countries to undertake the necessary urgent action to avoid irreversible decline of ecological resilience globally. These environmental risks require concerted policy action, and co-operation among countries, and between different ministries within countries. But given how daunting most environmental problems are today, many decision makers assume that the costs of action will be too great and hence doubt that it will be possible to make a significant difference with the funding they have.

The Stern Review has been very effective in shifting the debate on climate change because the Stern Review investigated both the costs of inaction as well as the costs of action on climate change. The Stern Review showed that since costs of inaction on climate change over the coming decades were significantly greater than the costs of action greater investment in climate change mitigation and adaptation is economically efficient. The Stern Review showed that wise investment in decoupling economic growth from greenhouse gas emissions will lead to higher economic growth over the longer term. The Stern Review showed that action on climate change is the pro-growth strategy for the 21st century.

So, this chapter will examine the risks and costs of inaction on environmental sustainability and compare these to the cost benefits of greater investment in early action. This chapter will investigate whether or not investing significantly more in environmental sustainability is economically efficient (the costs of inaction significantly outweigh the costs of action).

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[12] United Nations Environment Programme (2004) *State of Waste Management in South East Asia,* United Nations Environment Programme UNEP/IETC, Paris, www.unep.or.jp/Ietc/Publications/spc/State_of_waste_Management/index.asp .

[13] Leslie, K. L. Utter (eds.) (2006) *Recycling and Solid Waste in Latin America: Trends and Policies 2006*, Raymond Communications, Inc., College Park, Maryland.

[14] OECD (2007) *Environmental Performance Review of China*. OECD, Paris.

[15] Joardar, S.D. (2000), *Urban Residential Solid Waste Management in India: Issues related to Institutional Arrangements*, Public Works Management and Policy, Vol. 4, No. 4:319-330.

In the previous chapter, Chapter 7, a key result was that global investments of even a trillion dollars to address climate change would not harm global economic growth significantly in the short term if such investments were spent wisely and phased in over a couple of decades. Chapter 7 showed that, since the global economy is already worth over US$30 Trillion and will continue to grow at least two to three per cent per annum over the 21st century, investments by the global economy of even as much as a trillion dollars over a number of decades would have negligible negative effect on short term economy growth. And since the economic costs of inaction on climate change are, according to the Stern Review, significantly greater than the costs of action, investment on climate change mitigation and adaptation is justified.

Here in Chapter 8, I argue that a similar argument applies to investments in environmental protection to reduce the loss of biodiversity, water and air pollution, and the build up of chemicals and waste in the environment. This chapter will investigate what are

- the costs and benefits of action on each of these environmental pressures compared to the costs and risks of inaction and feature
- model examples from around the world where economic growth has been decoupled from these environmental pressures and where environmental degradation is being halted and reversed.

Protecting and restoring the environment will cost money, but the longer the world community delays serious action, the higher the costs will grow for future generations. The Chair of UNEP's 4th Global Environment Outlook has stated in late 2007 that:

> "The systematic destruction of the Earth's natural and nature-based resources has reached a point where the economic viability of economies is being challenged—and where the bill we hand on to our children may prove impossible to pay,"[16]

Since there is a cost to restoring natural resources and ecosystems, it is important that investment in restoring natural systems and resources is done as economically efficiently as possible. Also it will make the transition to environmental sustainability more cost effective if there is simultaneously also investment in pollution control and resource productivity improvements to reduce environmental pressures. To protect the environment investment is needed both to restore the resilience of natural systems plus reduce environmental pressures rapidly and pollution through a wide range of strategies from end of pipe to more resource productive eco-efficient solutions.

This chapter seeks to bring together and overviews some of the more cost effective strategies for environmental protection. Part 8.1-8.4 looks at the costs of inaction versus the costs of action to

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[16] See Media Release for UNEP (2007) *Global Environment Outlook: Environment for development (GEO-4) report*. UNEP. Available At http://www.unep.org/geo/geo4/media/media_briefs/Media_Briefs_GEO-4%20Global.pdf Accessed 23.03.08

restore natural systems and resources and reduce pollution. It is important to put the investment costs needed to achieve sustainable development into context against the costs of inaction. Parts 8.1-8.4 show that the costs of inaction are significant. But clearly there will be investment costs to restore nature's ecosystems and replacing polluting and inefficient systems with those that will enable the achievement of environmental sustainability. Hence it behoves us all to work to find more cost effective ways to reduce environmental pressures.

Parts 8.2-8.5 look at cost effective strategies to reduce and prevent air, water, waste and chemical pollution. Reducing pollution reduces health costs and boosts labour productivity and the economy. Parts 8.2-8.5 also investigates ways that pollution can be reduce cleverly through strategies which simultaneously also achieve resource productivity gains. Whenever resource productivity gains can be made this both reduces environmental pressures whilst also ensuring a good rate of return on the investment made by individuals, business or government. This chapter shows that using wise approaches it is possible to invest in solutions which both reduce pollution (air, water, waste, chemical) whilst simultaneously improving resource productivity. Taking this approach helps to increase the economic efficiency of such investments since they will provide both significant health and operational cost savings over the longer term.

Finally, the topics for this chapter have not been chosen randomly. The types of environmental pressures discussed in this chapter align with those chosen by the OECD Environment Directorate in their work over the last decade on decoupling economic growth from environmental pressures. As discussed in Chapter 5, the OECD has created a set of specific decoupling indicators. Thus by using the OECD framework, within which to have this discussion about the costs of inaction versus action, this chapter seeks to compliment and value add to the OECD's work. It is beyond the scope of this thesis to provide a detailed overview of the best policy frameworks needed to achieve decoupling on all of these environmental pressures. Hence the chapter instead references relevant OECD and other literature on the policy front. Since this chapter seeks to cover a wide range of environmental pressures this chapter is more a summary and synthesis compared to Chapter 7.

8.1 Decoupling Economic Growth from Loss of Biodiversity and Renewable Natural Resources

8.1.1 Estimating Costs of Inaction

The OECD Environmental Outlook to 2030 outlines in detail a range of issues regarding the vexed topic of estimating the costs of inaction on environment protection. Discussing this vexed field in detail is beyond the scope of this thesis but a few comments need to be made to inform the following discussion on the costs of inaction versus action.

First, it is important to note that when assessing the costs of inaction on environmental sustainability, the total costs of environmental policy inaction always involves several different types of costs. As the OECD Environmental Outlook to 2030 stated:

> "These include public finance expenditures (e.g. health service costs, restoring contaminated sites, restoring degraded habitat); 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)."[17]

Creating a total aggregate cost of policy inaction on biodiversity and natural resources according to the OECD is not possible given the different nature and units of these different types of costs. Such a topic requires discussions of issues of valuing non-market goods and externalities, detailed discussion of which is beyond the scope of this thesis.[18]

In the OECD Environmental Outlook to 2030 a key point is made concerning the costs of inaction on environmental protection versus the costs of action. The OECD Environmental Outlook to 2030 report states that:

> "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.
>
> ● Thresholds: Impacts may increase sharply once a particular level (threshold) of environmental pressure is exceeded.
>
> ● 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

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[17] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[18] OECD (2002) *Handbook of Biodiversity Valuation: A Guide for Policymakers*, OECD, Paris.

> of impacts – and particularly for those involving irreversible changes – it is not possible to restore the environment to its previous state."[19]

Because of these threshold effects, in most cases the economic costs of destroying ecosystem services becomes apparent only when the ecosystem services cross these thresholds and start to break down.

8.1.2 Costs from Deforestation

The Worldwatch Institute cites the following examples.[20]

- Bangladesh suffered its most extensive flood of the century in the summer of 1998. Two-thirds of this low-lying nation at the mouth of the Ganges and Brahmaputra rivers was inundated for months, 30 million were left temporarily homeless. Ten thousand miles of roads were heavily damaged, and the rice harvest was reduced by two million tons. Damage estimates exceed US$3.4 billion. Logging upriver in the Himalayas of north India and Nepal exacerbated the disaster, as did the fact that the region's rivers and floodplains have been filled with silt and constricted by development. Climate change and rising sea levels are projected to make Bangladesh even more vulnerable to flooding in the future.

- In China's Yangtze basin in 1998, heavy rainfall plus upstream deforestation triggered flooding that killed 3,700 people, dislocated 223 million and inundated 60 million acres of cropland. That US$30 billion disaster forced a logging moratorium and a US$12 billion crash program of reforestation. The damage was caused not just by heavy rain but also by deforestation and extremely dense settlement on the floodplain. The Yangtze catchment had lost over 85 percent of its forest cover.

More countries are beginning to recognize the economic, social and environmental costs associated with deforestation. China, New Zealand, the Philippines, Sri Lanka, Thailand, and Vietnam all have total or partial bans on deforestation.[21] Most brought in these bans after similar experiences to Bangladesh and China. But simply stopping logging is often not enough to ensure environmental sustainability. Restoration of forests will also be required. South Korea offers one of the best examples of reforestation. When the Korean War ended, half a century ago, the mountainous country was largely deforested. Since around 1960 the South Korean government has invested in a major national reforestation effort utilizing village cooperatives involving overall hundreds of thousands of people to

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[19] OECD (2008) *OECD Environmental Outlook to 2030. OECD.* Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[20] Bright, C. (2000) *State of the World Report, Anticipating Environmental Surprise*, Worldwatch Institute, Washington, DC, Ch 2, pp22-38.

[21] Durst, P. *et al.,* (2001) *Forests Out of Bounds: Impacts and Effectiveness of Logging Bans in Natural Forests in Asia-Pacific*. FAO, Asia-Pacific Forestry Commission, Bangkok.

dig trenches and create terraces for supporting trees on barren mountains. Se-Kyung Chong, researcher at the Korea Forest Research Institute, writes

> "The result was a seemingly miraculous rebirth of forests from barren land. Today forests cover 65 percent of the country, an area of roughly six million hectares. While driving across South Korea in November 2000, it was gratifying for me to see the luxuriant stands of trees on mountains that a generation ago were bare. We can reforest the earth!"[22]

South Korea has also shown that there is great but unrealised potential to reduce the demand for forest timber. It has achieved paper recycling rates of 77per cent, the highest in the world. Deforestation reduces the environment's resilience to shocks enabling storms to cause greater havoc. Deforestation leads to greater rainfall runoff and the associated flooding and soil erosion. Worldwide, areas with a high level of erosion risk from water are projected to increase from 20 million km2 in 2000 to nearly 30 million in 2030 (Figure 8.2[23]). The increase will occur in all regions. This will make more regions more vulnerable to natural disasters.

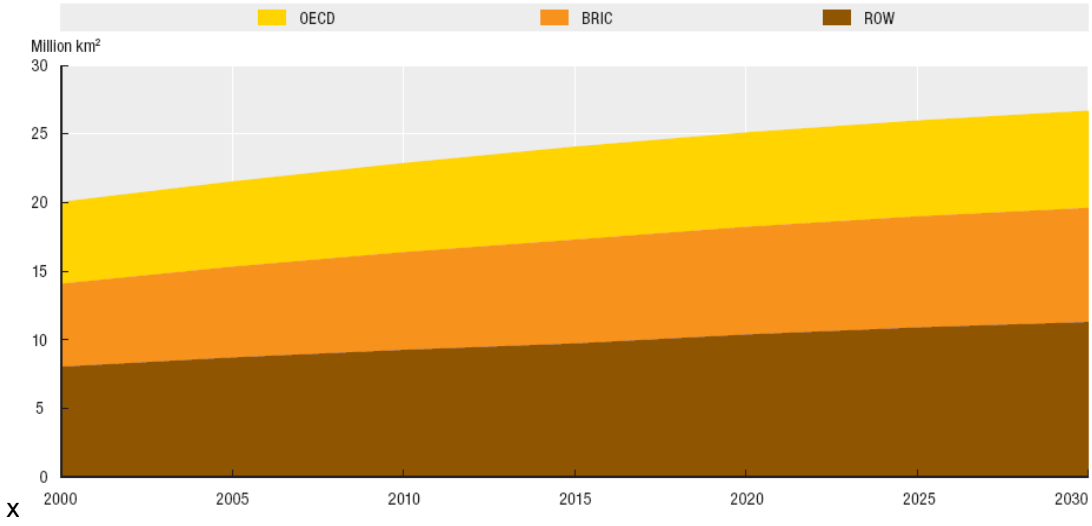

Figure 8.1 Land area under high soil erosion risk by surface water runoff, 2000-2030.

(Source, OECD, 2008[24])

8.1.3 Costs from Natural Disasters

The IUCN[25] has found that often supposedly natural disasters are increasingly man made because nature's natural resilience to shocks has been removed.[26] The World Bank[27] has estimated that, for the

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[22] Chong, S.K. (2005) *Anmyeon-do Recreation Forest: A Millennium of Management*, in Durst, P et al., (2005) In Search of Excellence: Exemplary Forest Management in Asia and the Pacific, Asia-Pacific Forestry Commission. FAO Regional Office for Asia and the Pacific. Bangkok, pp. 251–59.

[23] In Figure 8.2 BRIC refers to Brazil, Russia, India and China and ROE refers to rest of world.

[24] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

poorest countries, the cost of natural disasters represents more than 13% of GDP. While only some of this cost can be attributed to environmental factors, that which can in turn be influenced directly by public policy (e.g. flood control, GHG mitigation, preventing deforestation, soil erosion and mudslides 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 US$280 billion, if US$40 billion had been invested in disaster preparedness, mitigation and prevention strategies.[28] .

With 50 per cent of the world's population now living in cities, it is easy to forget that the economy, indeed our existence, is wholly dependent on the earth's biodiversity, natural systems and resources. Those that pose the question of whether the economy can afford to make the necessary investments to achieve environmental sustainability ignore the fact that the economy is dependent on the goods supplied by the earth's natural ecosystems whether it be clean water or seafood, and also dependent on the services it supplies. As the Earth Charter states

> "The Earth has provided the conditions essential to life's evolution. The resilience of the community of life and the well-being of humanity depend upon preserving a healthy biosphere with all its ecological systems, a rich variety of plants and animals, fertile soils, pure waters, and clean air."[29]

If the environmental support systems of our civilization continue to decline, so will civilization itself until it reaches the point of collapse. This has been shown by Joseph Trainter,[30] Clive Ponting,[31] Charles Redman,[32] Fagan[33] and more recently popularised by Jarod Diamond's book *Collapse.*[34] Environmental factors have been shown to be significant factors in the decline and collapse of over ten of the most advanced ancient civilisations.[35]

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[25] Masundire, H., Rizvi, A. and Rietbergen, S. (2006) *Ecosystems, Livelihoods and Disasters: An Integrated Approach to Disaster Risk Management*, IUCN, See http://www.icsu-asia-pacific.org/resource_centre/Ecosystems%20Livelihoods%20Disasters.pdf

[26] In Asia, the 2004 tsunami would have been less disastrous if the mangroves, serving as a natural barrier, had not been destroyed for tourism and shrimp farming; in the Northern Pakistan earth quake of 2005, local people claim that intact forest cover prevented landslides which caused extensive damage elsewhere.

[27] World Bank (2006) *Hazards of Nature, Risks to Development*, World Bank, Washington DC

[28] World Bank (2004), *Natural Disasters: Counting the Cost*, feature story on March 2, 2004, World Bank,Washington DC

[29] See UN Earth Charter at http://www.earthcharter.org/ Accessed 26.03.2008

[30] Tainter, J. (1988) *The Collapse of Complex Societies.* Cambridge:Cambridge University Press, 1988.

[31] Ponting, C. (1991) *A Green History of the World*: The Environment and the Collapse of Great Civilisations. New York: Penguin, 1991.

[32] Redman, C. (1999) *Human Impact on Ancient Environment*. Tuscon:University of Arizona Press, 1999.

[33] Fagan, B. (1999) *Floods, Famines, and Emperors: El Nino and the Fate of Civilisations*. New York:Basic Books, 1999. Fagan, B. (2001) *The Little Ice Age,* New York, Basic Books. 2001. Fagan, B. (2004) *The Long Summer:How Climate Changed Civilisation*. New York: Basic Books, 2004.

[34] Diamond, J (2006) *Collapse:How Societies Choose to Fail or Succeed*. Random House.

[35] Ibid

8.1.4 Ecosystem Services Which Are Not Substitutable

The costs of biodiversity and natural resource loss through continued policy inaction will be significant in both measurable economic loss and difficult-to-measure non-marketed terms. Getting a precise total figure for that loss is not possible, but there is good reason to suspect that it is large. As mentioned previously in Chapter 5, sub section 5.4, experts in ecology and economics at least have tried to put a figure on it and estimated that the worth of the world's ecosystem services was US$43 billion.[36] They also showed that most of these ecosystem services are not substitutable by technology. The Millennium Ecosystem Assessment and the UNEP's 4th Global Environment Outlook have shown that such ecosystem services are now threatened by multiple environmental pressures, all of which cause biodiversity loss.

8.1.5 Market Failure and Environmental Degradation.

As chapter 1 and 3 explained, the 2005 Millennium Ecosystem Assessment (MEA) estimates that two-thirds of all of the world's ecosystems have already reached or are close to reaching such irreversible tipping points. According to the MEA,[37]

> "the main sources of biodiversity loss are land use changes (usually associated directly or indirectly with increasing populations, e.g. conversion to agriculture); unsustainable use and exploitation of natural resources (especially fisheries and forestry); invasive alien species; global climate change; and pollution (e.g. nutrient loading)."

As the OECD states:

> "While these are the immediate sources of the loss of biodiversity, the underlying problem is that biodiversity is usually not fully accounted for by consumers in the market place[38] – there is often no distinction between biodiversity-friendly goods and those that damage biodiversity. Without government intervention, the market place has difficulty making that distinction. That so few policies have been enacted to mitigate biodiversity loss is an indicator of the strength of the underlying market failure, especially since there is considerable evidence for direct and indirect values of biodiversity that are not reflected in the market." [39]

Good examples of environmental degradation caused by market failure are pointed out in Table 8.2. These examples of environmental degradation have serious social costs such as from the collapse of fisheries upon which many vulnerable and poor people depend.

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[36] Robert Costanza *et al*., (1997) *The Value of the World's Ecosystem Services and Natural Capital,* Nature, 15 May 1997,

[37] Millennium Ecosystem Assessment (2005), *Ecosystems and Human Well-Being*, Island Press, Washington DC.

[38] OECD (2004), *Handbook of Market Creation for Biodiversity: Issues in Implementation*, OECD, Paris.

[39] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

Table 8.2: Signs of EcoSystems Under Stress and Collapsing

Fisheries	Fisheries are collapsing throughout the world. In the Atlantic, stocks of bluefin tuna have fallen 94% as a result of heavy fishing. If fishing was stopped it would take many years for that species to recover. In the Caspian Sea the harvest of sturgeon, the source of the most prized caviar, fell from a peak of 27,700 tons in 1977 to 461 tons in 2000.A 2003 study by a Canadian-German research team (published in Nature) has concluded that , in the last 50 years, 90 percent of the large fish in the oceans had disappeared.[40]
Deforestation and loss of biodiversity of Forests	Haiti, a country of 9.6 million people, was once largely covered with forests, but growing firewood demand and land clearing for farming have left forests standing on scarcely 4 percent of its land. First the trees go, then the soil.[41] Environmentalists warn that current rates of deforestation mean that Madagascar could soon become a landscape of scrub growth and sand.[42] Malawi, in East Africa (population 14 million people)" has lost close to a quarter of its forest cover since the early 1970s – up to 1 million hectares. Trees have been cut down to be used to produce charcoal and cure tobacco creating a a chain of events similar to those that occurred in Haiti.[43]
Losing Soil	Topsoil loss is occurring faster than the formation of a new soil on about a third of land used for growing crops with a resulting loss of productivity..[44] Soil erosion has accelerated over the last century and can be seen in the dust bowls that have formed..Examples can be seen in northwest China, and in the Sahelian region of Africa. Each was the result of overgrazing, deforestation, and agricultural expansion onto marginal land, followed by retrenchment as the soil began to disappear.[45] Mountainous countries with steeply sloping land, like Ethiopia, lose topsoil each year to rain. It has been losing about 2 billion tons of topsoil each year in this way.[46] Surface water run-off generally can seriously impair the capacity of soils to produce food.. It has been projected that worldwide,the area of land with a high level of erosion risk from water willincrease between 2000 and 2030 from 20 million ito nearly 30 million km2[47]

[40] Myers, R. Worm,B. (2003) "Rapid Worldwide Depletion of Predatory Fish Communities," Nature, vol. 432 (15 May 2003), pp. 280–83; Charles Crosby, "'Blue Frontier' is Decimated," Dalhousie News, 11 June 2003.

[41] U.N. Population Division, (2007) World Population Prospects: The 2006 Revision Population Database, at esa.un.org/unpp updated 2007;.

[42] Ibid.

[43] Ibid.

[44] Durst, P.B. et al., (2001) Forests Out of Bounds: Impacts and Effectiveness of Logging Bans in Natural Forests in Asia-Pacific (Bangkok: FAO, Asia-Pacific Forestry Commission.

[45] Youlin, Y. Squires, V. Qi, L. eds., (2002) Global Alarm: Dust and Sandstorms from the World's Drylands Secretariat of the U.N. Convention to Combat Desertification, Bangkok, pp. 15–28.

[46] UNEP (2002) Africa Environment Outlook: Past, Present, and Future Perspectives (Nairobi: 2002), at www.unep.org/dewa/Africa

[47] OECD (2008) OECD Environmental Outlook to 2030. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

From Grassland to Desert	Ten per cent of the earth's land surface is fertile enough for crops, but forty per cent is rangeland, which is land that is too steep, dry, or simply not fertile enough for crop farming. Rangeland supports more than 50 per cent of the world's 3.3 billion cattle, sheep, and goats.[48]. An estimated 200 million people worldwide depend on rangelands to graze their cattle, sheep, and goats in countries in Africa Middle East, Central Asia, Mongolia, and northwest China. Most rangelands are held in common and suffer from overgrazing due to the tragedy of the commons effect.[49] China is a good example of this. In China, responsibility for farming has shifted from state-organized production teams to farm families. This has led to a rapid increase in numbers of sheep and goats being farmed. As Lester Brown writes "While the United States has only 9 million sheep and goats, China has 366 million. Concentrated in China's western and northern provinces, sheep and goats are destroying the land's protective vegetation. The wind then does the rest, removing the soil and converting productive rangeland into desert."[50]
Advancing Deserts	In Africa and parts of Asia the spread of desertification is a serious threat to 100s of millions of people and the environment. In the north of Africa the Sahara is advancing.[51] Nigeria is losing 351,000 hectares of rangeland and cropland to desertification each year. China's desertification is also a serious problem. A leading Chinese scholar on the issue, Wang Tao, writes on the exponentially rising levels of desertification in his country. He writes that "From 1950 to 1975 an average of 1,560 square kilometres of land turned to desert each year. Between 1975 and 1987, this climbed to 2,100 square kilometres a year. From then until the century's end, it jumped to 3,600 square kilometres of land going to desert annually."[52]
Disappearing Plants and Animals	The UNEP GEO 4 stated "Current biodiversity changes are the fastest in human history. Species are becoming extinct a hundred times faster than the rate shown in the fossil record."[53] The IUCN's latest findings on the percentage of birds, mammals, and fish that are vulnerable or in immediate danger of extinction is as follows: 12 percent of the world's nearly 10,000 bird species; 20 percent of the world's 5,416 mammal species; and 39 percent of the fish species analysed[54].

[48] Land area estimate from Wood, S. Sebastian, K. Scherr, S.J. (2003) Pilot Analysis of Global Ecosystems: Agroecosystems (Washington, DC: International Food Policy Research Institute and WRI, 2000), p. 3; livestock counts from FAO, The State of Food and Agriculture 1995 (Rome: 1995), p. 175..

[49] Number of pastoralists from FAO, The State of Food Insecurity in the World 2003 (Rome 2003), p.15;

[50] FAO (1995) The State of Food and Agriculture. Rome.p. 175.

[51] U.N. Population Division, (2007) World Population Prospects: The 2006 Revision Population Database, at esa.un.org/unpp, updated 2007.

[52] Tao, W. *et al* (2004) A Study on Spatial-temporal Changes of Sandy Desertified Land During Last 5 Decades in North China. Acta Geographica Sinica, vol. 59 (2004), pp. 203–12.

[53] See Media Release for UNEP (2007) *Global Environment Outlook: Environment for development (GEO-4) report*. UNEP. Available At http://www.unep.org/geo/geo4/media/media_briefs/Media_Briefs_GEO-4%20Global.pdf Accessed 23.03.08

[54] Species Survival Commission (2007) *IUCN Red List of Threatened Species*, Available at www.iucnredlist.org, updated 12 September 2007.

(Source, Brown. L[55], 2008)

8.1.6 Case Study: Global Fisheries

The state of global fisheries illustrates this phenomenon well. Fisheries management is limited by imperfect information and imperfect control. It is impossible to know precisely the size of the stock, its growth, and its relationship with other stocks. In addition to imperfect information, regulation is imperfect, especially for the high seas fisheries which are not controlled by any one government. There are now many examples of stocks being fished to commercial extinction. In 2007, the Food and Agricultural Organisation (FAO) has reported that the proportion of over-exploited and depleted stocks rose from 10% in 1974 to 25% in 2005.[56]

Unsustainable fishing practices in many parts of the world mean that there is no potential in the short or medium-term for further expansion of the fisheries sector. As shown in Chapters 3 and 5, the fisheries sector is one where environmental pressures can lead to irreversible collapse of the whole fishery. Thus the long term costs of unsustainable fishing practices are significantly greater than costs of action to ensure that future generations can also realise the economic, social and environmental benefits of sustainable fishing. The OECD has listed some of the 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."[57]

The costs of unsustainable fisheries management can be considerable: the OECD[58] highlight this through reference to a number of studies including one study of thirteen overfished fish stocks in US waters by Sumaila and Suatoni.[59] In this study they compared the lost direct income from reduced commercial fishery yields and reduced recreational fishing associated with continued excessive fishing with a case in which the stock "rebuilding" plans developed by Regional Fishery Management

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[55] This table has been constructed based on studies and literature from Brown, L (2008) Plan B. Mobilising to Save Civilisation. The Earth Policy Institute Available At http://www.earth-policy.org/Books/PB3/Contents.htm Accessed 17.02.2008 Accessed 23.03.08

[56] FAO (2007) *The State of World Fisheries and Aquaculture 2006*, FAO, Rome. (Accessed on 11 May 2007 at www.fao.org/sof/sofia.)

[57] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[58] Ibid.

[59] Sumaila, U.R. Suatoni, L. (2006) *Economic Benefits of Rebuilding US Ocean Fish Populations*, Fisheries Centre Working Paper No. 2006-04, The University of British Columbia, Vancouver.

Councils were adopted. They found that the lost income of continuing the existing excessive fishing management regime was US$373 million (US$193.7 million, instead of US$566.7 million).

In addition to lost income from reduced population levels of fish, there are other costs from continuing unsustainable commercial and recreational fishing practice. When a fishery collapses, such as the Atlantic cod fishery discussed in Chapter 3 and 5, some of the costs may also be borne by others such as the taxpayers. In Canada, following the collapse of the cod fishery n estimated CA$3.5 billion was spent on structural adjustment programmes [60] which included income support (including unemployment benefitsfor the fishermen) and government assistance programmes (directed, among other things restructuring and regional economic development). If nations do not head the warnings from the UN, UNEP and the OECD concerning currently unsustainable fishery practices the long-term costs globally to future generations will be significant. The fisheries sector employs about 40 million fishers and fish farmers, most living in developing countries,[61] who depend on fisheries worldwide.[62] 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.[63] Fishery resources also contribute to the livelihoods of coastal or island communities. Fish is also recommended as a healthy part of any diet due to the presence of eicosapentaenoic acid (EPA) which have significant health benefits. On September 8, 2004, the U.S. Food and Drug Administration gave "qualified health claim" status to EPAs and docosahexaenoic acid (DHA) ω−3 fatty acids, stating that "supportive but not conclusive research shows that consumption of EPA and DHA ω−3 fatty acids may reduce the risk of coronary heart disease."[64] People with certain circulatory problems, such as varicose veins, benefit from fish oil. Fish oil stimulates blood circulation, increases the breakdown of fibrin, a compound involved in clot and scar formation, and additionally has been shown to reduce blood pressure.[65] There is strong scientific evidence, that ω−3 fatty acids significantly reduce blood triglyceride levels[66] and regular intake reduces the risk of secondary and primary heart attack.[67]

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[60] OECD (2006) *Subsidy Reform and Sustainable Development: Economic, Environmental and Social Aspects*, OECD, Paris.

[61] FAO (1999) *The State of World Fisheries and Aquaculture 1998*, FAO, Rome

[62] FAO (2005) *Increasing the Contribution of Small-scale Fisheries to Poverty Alleviation and Food Security, FAO Technical Guidelines for Responsible Fisheries*, No. 10, FAO, Rome.

[63] Ibid.

[64] United States Food and Drug Administration (2004) *FDA announces qualified health claims for omega-3 fatty acids*. Press release. Retrieved on 2006-07-10.

[65] Morris, M.C.; Sacks, F.; Rosner, B. (1993) *Does fish oil lower blood pressure? A meta-analysis of controlled trials.* Circulation 88 (2): 523–533. American Heart Association. PMID 8339414.

[66] Harris, W.S. (1997). *n−3 fatty acids and serum lipoproteins: human studies*. American Journal of Clinical Nutrition 65 (5 Supplement): 1645S–1654S. The American Society for Nutrition. PMID 9129504.

Sanders, T.A.B.; Oakley, F.R.; Miller, G.J.; Mitropoulos, K.A.; Crook, D.; Oliver, M.F. (1997). *Influence of n−6 versus n−3 polyunsaturated fatty acids in diets low in saturated fatty acids on plasma lipoproteins and hemostatic factors.* Arteriosclerosis, Thrombosis, and Vascular Biology 17 (12): 3449–3460. American Heart Association. PMID 9437192.

For all of these reasons, it is important that fishery resources be managed sustainably. A precautionary approach needs to be taken because the information is not perfect and if sustainability thresholds for particular stock are breached, they can be fished into extinction and the benefits associated with fishing lost.

8.1.7 Costs of Inaction on Invasive Species

Another statistic which helps highlight the costs of inaction on biodiversity loss is the economic cost of alien invasive species. They degrade water catchment areas and freshwater ecosystems, thereby decreasing water supply. They reduce the yields of crops and their control adds to costs. Alien plants introduced by tourists into national parks degrade protected ecosystems and increase management costs. Pests and pathogens of crops, trees and livestock can destroy plants , or reduce yields and add to costs because of the need to increase pest control. Commercially important fisheries have been degraded by bacteria and viruses and harmful aquatic organisms introduced by the discharging of ballast water, Significant social and economic consequences flow from the killing or disabling of people as a result of the spread of disease organisms. Biologist Edward Wilson has claimed that the introduction of alien species is second only to habitat loss as the leading cause of extinctions worldwide.

The cost of invasive species to the U.S. economy is estimated to exceed US$138 billion per year over the next 50 years.[68] About 50,000 species have been introduced to the United States directly or indirectly by humans. The economic cost of invasive alien species on the Canada economy is estimated to be between CA$13 and CA$35 billion. Invasive alien species damage to the agricultural and forestry industries results in an estimated CA$7.5 billion of lost revenue annually in Canada alone.[69]

Rapid economic growth and giant infrastructure projects have allowed invasive species to spread throughout China and inflict more than US$14.5 billion of damage to the nation's economy annually according to a study published in Bioscience. Over the past three decades the number of invasive

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Roche, H.M.; Gibney, M.J. (1996). *Postprandial triacylglycerolaemia: the effect of low-fat dietary treatment with and without fish oil supplementation*. European Journal of Clinical Nutrition 50 (9): 617–624. Nature Publishing Group. PMID 8880041

[67] Bucher, H.C.; Hengstler, P.; Schindler, C.; Meier, G. (2002). *n−3 polyunsaturated fatty acids in coronary heart disease: a meta-analysis of randomized controlled trials*. The American Journal of Medicine 112 (4): 298–304. Elsevier. PMID 11893369.

Burr, M.L.; Sweetham, P.M.; Fehily, A.M. (1994). *Diet and reinfarction*. European Heart Journal 15 (8): 1152–1153. Oxford University Press. PMID 7988613.

Willett, W.C.; Stampfer, M.J.; Manson, J.E.; Colditz, G.A.; Speizer, F.E.; Rosner, B.A.; Sampson, L.A.; Hennekens, C.H. (1993). *Intake of trans fatty acids and risk of coronary heart disease among women*. The Lancet 341 (8845): 581–585. Elsevier. doi:10.1016/0140-6736(93)90350-P. PMID 8094827

[68] Pimentel,D. Lach, L. Zuniga, R. Morrison, D. (1999) Environmental and Economic Costs Associated with Non-Indigenous Species in the United States.

[69] See Canadian Government Environment Department at http://www.ec.gc.ca/eee-ias/default.asp?lang=En&n=02101A38-1#ws2A6F42D7

species in the country has more than tripled while the number of international ports of entry to China has doubled and the total length of express highways has expanded by a factor of 40.[70]

Whilst it should be acknowledged that there is considerable uncertainty in estimating the total economic costs of invasions, these estimates of the economic impacts on particular sectors indicate the seriousness of the problem. Most countries are now affected negatively by invasive alien species. For example, New Zealand it has been recently invaded by the varroa mite. The mite is a serious pest in honeybee hives. Its overall economic cost is expected to be NZ$267-602 million and will force beekeepers to change their management of their hives. Beekeepers attribute the invasion to the failure to follow border rules and argue that with earlier detection, the problem could have been avoided. It appears unlikely that the mite can be eradicated and it is estimated that the mitigation program required will cost NZ$1.3 million in its first stage.

The economic cost of the invasives include both the direct costs of their management and their indirect environmental consequences and non-market impacts. For example, invasives may disturb the hydrological cycle by causing changes in ecological services such as flood control, water supply, waste assimilation, recycling of nutrients, conservation and regeneration of soils, pollination of crops, and seed dispersal. Such services have both current use value and future value. The Cape Floral Kingdomin South Africa experienced decreased water supplies for nearby communities, increaseds fire hazards, and threats to native biodiversity as a result of the establishment of invasive tree species requiring manual and chemical control which required government annualexpenditures of $40 million per year.

While most evidence of economic cost of invasive alien species has come from the developed world, there are strong indications that similar or greater losses are being experienced in the developing world.

It is costing developing countries more than US$100 million annually to try to deal with Water hyacinth and other alien water weeds affecting water use. Direct threats to food security are imposed by alien insect invaders like the white cassava mealybug and larger grain borer in Africa. The restoration of degraded land, the regeneration of forests and the improved use of water for irrigation and fisheries has been constrained by invasive weeds.

To conclude, whilst it is hard to put a price on the costs of inaction, it is clear from the scientific and economic evidence currently available that it is considerable. UN[71], UNEP[72] and the OECD[73] all argue

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[70] Mack, R *et al* (2008) *China's Booming Economy is Sparking and Accelerating Biological Invasions*. BioScience vol. 58, pages 317-324.

[71] UN Millennium Ecosystem Assessment, (2005) *Ecosystems and Human Well-being: Biodiversity Synthesis.* World Resources Institute, Washington, DC

[72] UNEP (2007) *Global Environment Outlook: Environment for development (GEO-4) report*. UNEP. Available At http://www.unep.org/geo/geo4 Accessed 23.03.08

that significant and urgent investment is needed now to restore biodiversity, habitat and natural resources because over 60 per cent of the world's ecosystems are severely degraded. To date governments have failed to invest sufficiently in biodiversity and natural resources: these issues tend to be low on the list of voter concerns. To build greater political will for investment in this area it is vital then that the economic case be presented for greater investment in biodiversity and natural resources.

8.1.8 Estimates of Economic Benefits of Investing in Biodiversity and Natural Resources

There are direct and indirect sources of biodiversity value, the latter including the existence value of biodiversity, sources of agricultural production innovation and protection against major pathogens.

Eco-tourism based on charismatic mega-fauna and bio-diverse ecosystems such as the Great Barrier Reef are harder to estimate in total, but again clearly run to hundreds of billions of dollars internationally. The International Eco-Tourism Society estimates the global eco-tourism market will be worth US$473.6 billion by 2015.[74]

The pharmacological value of biodiversity is in the multi-billion dollar range; a successful product can be worth US$5 to US$10 billion per year in revenues net of production costs, with a present value over its life of perhaps US$50 to US$100 billion. Indeed, finding just a small number of additional blockbuster drugs from the remaining biodiversity would justify significant conservation for bio-prospecting.[75]

Eco-tourism and charismatic mega-fauna are harder to estimate in total, but again clearly run to hundreds of billions of dollars internationally.

The services provided by biodiversity through watersheds globally run into the tens of billions. New York City alone saved hundreds of millions of dollars by maintaining its source watershed rather than building a water purification plant.[76] As discussed in Chapters 1 and chapter 6, the UN set a millennium goal of halving the proportion of people with no access to sanitation - even simple latrines rather than sewers - by 2015. Currently 40 per cent of humanity or 2.6 billion people now do not have regular access to clean water. About 90 per cent of the sewage and 70 per cent of the industrial waste in developing countries are being discharged untreated into water courses. The ability of marshes and wetlands to play an integral part in filtering waste water is often overlooked. Novel schemes currently looking to utilise ecosystem services to purify water include a plan to build an artificial wetland at a

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[73] OECD (2008) *OECD Environmental Outlook to 2030. OECD*. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[74] See International Eco-Tourism Society Factsheet at http://www.kti.szie.hu/OMAT/letoltes/ecotourism_fact_sheet_-_global.pdf

[75] OECD (2002) *Handbook of Biodiversity Valuation: A Guide for Policymakers*, OECD, Paris

[76] Heal, G. (2000) *Nature and the Marketplace: Capturing the Value of Ecosystem Services*, Island Press, Washington, DC

jail in Mombasa in Kenya, to process sewage from 4,000 inmates that now flows untreated into a creek, or ponds in South Africa where algae purify waste and are then used as fertiliser. This is but one way healthy ecosystems positively impact on human health. UN Millennium Ecosystem Assessment demonstrated that there are significant human health benefits from restoring and maintaining healthy ecosystems likely again to be worth at least tens of billions of dollars per annum.[77]

As discussed in Chapter 7, the Stern Review recommends not just slowing down but stopping completely further deforestation as a cost effective way to mitigate climate change. The Stern Review puts the opportunity cost of stopping deforestation in 8 countries responsible for 70% of emissions at US$5-10 billion per annum and the cost of ongoing management of the forests at US$12-93 million per annum. But the Stern Review did not investigate the cost benefits of also investing in restoration and reafforestation of the world's forests. There is potential in currently semi degraded land to sequester carbon further and help to restore the landscape and reduce soil erosion and thus further reduce costs to society from environmental degradation.

Lester Brown writes about an important study by Swedish energy firm, Vattenfall,[78] which has examined the large-scale potential for foresting wasteland to sequester carbon dioxide. This study shows that that there are 1.86 billion hectares of degraded land in the world which was once forestland, cropland, or grassland. This study finds that half of this has a decent chance of being reclaimed for an affordable price. As Lester Brown writes

> "Vattenfall estimates that the maximum technical potential of these 930 million hectares is to absorb roughly 21.6 billion tons of CO2 per year. If, as part of a global climate stabilization strategy, carbon sequestration were valued at $210 per ton of carbon, the company believes that 18 percent of this technical potential could be realized. If so, this would mean planting 171 million hectares of land to trees which would sequester 3.5 billion tons of CO2 per year, sequestering carbon at $210 per ton would be $200 billion. Spread over a decade, this would mean investing $20 billion a year to give climate stabilization a large and potentially decisive boost. A $210 per ton carbon price is higher than what is realistic to expect but the fact that the private sector is seriously considering this shows that there is potential for government working with the private sector to leverage private investment to solve this problem and thus reduce the amount of tax payer funding required to address climate change. Vattenhall recommend an independent body would be set up to administer, fund, and monitor the vast tree planting initiative."[79]

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[77] UN Millennium Ecosystem Assessment (2005) *Health, Ecosystems and Human Well-being*. World Resources Institute, Washington, DC

[78] Vattenfall, (2007) *Global Mapping of Greenhouse Gas Abatement Opportunities up to 2030*: Forestry Sector Deep-Dive. Stockholm. cit Brown, L (2008) Plan B. Mobilising to Save Civilisation. The Earth Policy Institute Available At http://www.earth-policy.org/Books/PB3/Contents.htm Accessed 17.02.2008 Accessed 23.03.08

[79] Ibid. .

Many cities are planting trees. In Tokyo, for example, trees and shrubs have been planted on the roofs of buildings to help reduce the urban heat island effect and cool the city.[80]

> A study of the economic and social values of planting trees on the streets and in the parks of five western U.S. cities including for instance Cheyenne, Wyoming, and Berkeley, California, found that the community benefits were greater than two dollars for every dollar spent. Mature trees in cities can reduce air temperatures by five to ten degrees Fahrenheit. In cities which have extremely cold winters trees can help reduce wind speed dramatically and thus reduce heating bills.[81]

There are agricultural practices that can increase the storage in the soil of carbon as organic matter.. They include practices that reduce soil erosion and raise cropland productivity such as shifting from conventional tillage to minimum-till and no-till, increased use of cover crops, the return of all livestock manure to the land, , more mixed crop-livestock farming, expansion of irrigated areas and the forestation of marginal farmlands.

The extent of potential carbon sequestration for many practices, such as those just cited, have been calculated by.Rattan Lal, a Senior Agronomist with the Carbon Management and Sequestration Center at Ohio State University. For example, 68 million to 338 million tons of carbon worldwide could be stored each year by expanding the use of cover crops to protect soil during the off-season. Taking the practices he cites, and using the low end of the range for calculating the likely benefit for each, his calculations show a potential for sequestering 400 million tons of carbon each year. Calculating the likely benefit on the basis of the more optimistic of the range for each practice, he arrives at a total of 1.2 billion tons of carbon stored per year. For calculating a carbon budget, it is assumed, that 600 million tons of carbon can be sequestered by adopting such carbon-sensitive practices.[82]

Another significant development which highlights the economic value of protecting the world's biodiversity is biomimicry, innovation inspired by nature.[83] CSIRO states that 'biomimetic engineering mimics natural systems, utilising molecular self-assembly as the key link between physics, chemistry and biology, creating novel advanced structures, materials, and devices'. The idea is that, during its 3.8 billion years of research and development, nature has evolved highly efficient non-toxic, benign systems and processes that can inform solutions to many of the waste, resource efficiency and management problems that humanity now grapples with today.

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[80] Chang-Ran Kim (2002) *Tokyo Turns to Rooftop Gardens to Beat the Heat*, Reuters, 7 August 2002; Washington, D.C., program from Casey Trees, at www.caseytrees.org, viewed 12 October 2007.

[81] Kathy Wolf, (1998) *Urban Forest Values: Economic Benefits of Trees in Cities*, fact sheet (Seattle, WA: Center for Urban Horticulture, November 1998); McPherson, G. *et al.,* (2005) *Municipal Forest Benefits and Costs in Five US Cities,* Journal of Forestry, December 2005, pp. 411–16. cit Brown, L (2008) *Plan B. Mobilising to Save Civilisation*. The Earth Policy Institute

[82] Brown, L.(2008) *Plan B. Mobilising to Save Civilisation*. The Earth Policy Institute

[83] Benyus, J. (1997) *Biomimicry: Innovations Inspired by Nature*, William Morrow, New York

Hence the biodiversity of nature itself offers humanity a guide on how human systems can be designed and built to be sustainable and effective. Biomimicry has already provided some timely, standout sustainable innovations in areas such as sustainable agriculture, energy efficiency, water filtration and purification, aerodynamics, green buildings, benign adhesives and glues. Janine Benyus's *Biomimicry: Innovation Inspired by Nature*[84] shows that innovators across many fields are learning from nature to innovate for sustainability.

8.1.9 Recognition of the Value of Biodiversity and Natural Resources is Growing

To conclude, the above discussion has shown that there are significant economic benefits from maintaining and preserving the world's biodiversity. As of March 2008, this is recognised formally by 190 countries which have ratified the UN Convention on Biological Diversity (CBD)[85] with the aim of conserving biodiversity as well as ensuring the sustainable use of its components. A range of other multilateral environmental agreements also help to protect biodiversity, for example the Convention on International Trade in Endangered Species (CITES), the Convention on Wetlands (Ramsar Convention), the World Heritage Convention, and the Convention on the Conservation of European Wildlife and Natural Habitats. These measures attempt to ensure a co-ordinated process for addressing biodiversity loss. Hence there is widespread recognition globally of the importance of biodiversity conservation.

There has been progress over the last 20 years. Figure 8.3 shows that there has been particularly rapid growth in protected areas in the last three to four decades. By 2003, just under 12% of the world's land area was devoted to protected areas.[86]

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[84] Ibid.

[85] See UN Convention on Biodiversity List of Parties at http://www.cbd.int/convention/parties/list.shtml

[86] Chape, S. et al. (2003), *United Nations List of Protected Areas,* IUCN, Gland, Switzerland and Cambridge, UK and UNEP-WCMC, Cambridge.

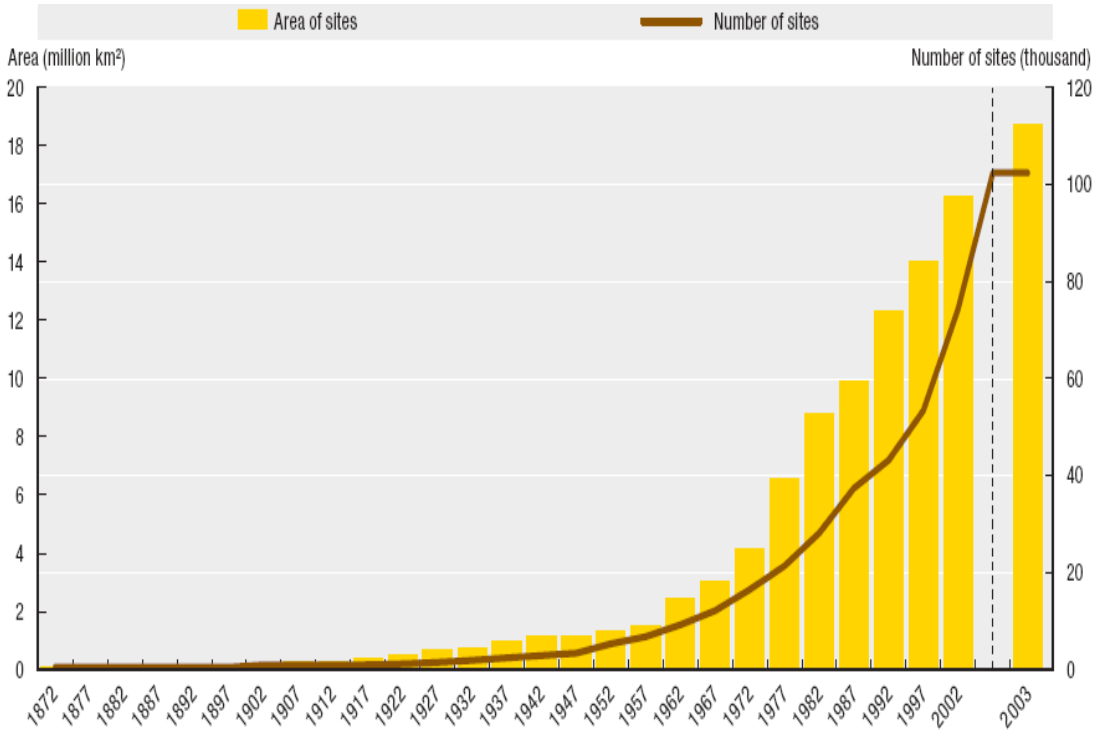

Figure 8.2 Cumulative change in protected areas worldwide, 1872-2003.

(Source. OECD, 2008[87])

There is also increasing recognition globally of the importance of biodiversity conservation and of restoring the Earth. There are numerous inspiring initiatives occurring globally driven by a range of concerns, from climate change to desert expansion, to soil conservation, to making cities more habitable. Inspired by Kenyan Nobel laureate Wangari Maathai, who had earlier organized women in Kenya and several nearby countries to plant 30 million trees, the worldwide Billion Tree Campaign launched in 2007, is a stand out example. The United Nations Environment Programme is administering the Billion Tree Campaign.[88] In October 2007, it reported that pledges had been made to plant 1.2 billion trees by the end of that year, 431 million of which had already been planted. Among the leading pledges were those of Mexico (250 million) and Ethiopia (60 million), Senegal (20 million) and Indonesia (80 million). The Ministry of Environment and Forestry of Turkey has confirmed that, this year, 150 million trees were planted as part of the Billion Tree Campaign.

There are numerous other re-afforestation initiatives occurring such as the Great Green Wall being planted in China, and the Saharan Green Wall of Africa, as well as a big push to expand tree plantations within a number of countries. As part of New Zealand's commitment to become net climate neutral, Prime Minister Helen Clark, announced an impressive set of initiatives which

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[87] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[88] See Billion Tree Campaign at http://www.unep.org/billiontreecampaign/ Accessed 25 March 2008

included expanding areas of forests by 250,000 hectares (617,000 acres) by 2020. This would require approximately 125 million trees (30 per New Zealander).[89]

8.1.10 A Costed Planetary Biodiversity and Ecosystem Restoration Plan

The international effort required to restore the earth will be enormous, far bigger, for example, than the Marshall Plan to help rebuild Europe and Japan after World War 11. And it must be undertaken at wartime speed if environmental deterioration is not to result in economic decline and civilization collapse, just as it did for earlier civilizations as Jarod Diamond has highlighted in his book *Collapse*.[90] To restore the earth at least the following steps will need to be taken

- Stop further deforestation and loss of remnant vegetation
- Re-afforestation
- Protect topsoil
- Restore rangelands and fisheries
- Protect biological diversity.
- Ensure north south wildlife corridors so that species, including vegetation, can migrate to adapt to climate change.

Although we lack detailed data in some cases, the following provides a rough estimate of how much it will cost to stop deforestation, reforest the earth, protect topsoil, restore rangelands and fisheries, stabilize water tables, and protect biological diversity. What follows is a summary of Brown's work plus other useful studies which estimate the costs of different aspects of a planetary ecosystem restoration plan.

Costs of Stopping Deforestation: As outlined above, the Stern Review has found that the opportunity cost of stopping deforestation in eight countries responsible for 70% of emissions at US$5-10 billion per annum and the cost of ongoing management of the forests at US$12-93 million per annum. As the Stern Review has highlighted this provides significant climate change mitigation benefits. This was covered in Chapter 7 in detail.

Costs of Stopping the Removal of Remnant Vegetation: In addition to stopping deforestation, the other most cost effective way to stop the loss of biodiversity is to stop private landholders from removing and clearing remnant habitat and vegetation. Preserving remnant vegetation usually helps to preserve and sustain farming land and rangeland productivity. But from the farmers perspective remnant vegetation reduces their potential acreage for cropping. There is a strong case for governments regulating and compensating existing farmers for preserving remnant vegetation as this is one of the most cost effective ways to reduce the loss of biodiversity and ensure there is a basis to build

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[89] Ministry for the Environment (2007) *New Zealand's Climate Change Solutions:An Overview* (Wellington, New Zealand: September 2007),

[90] Diamond, J (2006) *Collapse:How Societies Choose to Fail or Succeed*. Random House

connectivity between national parks and biodiversity protected areas across private landholdings. Currently many national governments, especially in the OECD, subsidize the farming sector significantly without requiring farmers to farm more sustainability. This is starting to change. Increasingly governments are looking at shifting at least some of the current farming subsidies to become subsidies for maintaining and enhancing ecosystem services on farming properties. Given the significant current government subsidies to the farming sector in OECD countries, OECD governments should be able to fund the preserving of remnant vegetation under existing subsidy arrangements by shifting the economic incentives to farmers in this way.

Costs of Further Re-Afforestration: Forested areas are already expanding in most OECD countries hence here we will focus on what is needed for developing countries. Lester Brown writes that:

> "Meeting the growing fuelwood demand in developing countries will require an estimated 55 million additional hectares of forested area. Conserving soils and restoring hydrological stability would require roughly another 100 million hectares located in thousands of watersheds in developing countries. Recognizing some overlap between these two, we will reduce the 155 million total to 150 million hectares. Beyond this, an additional 30 million hectares will be needed to produce lumber, paper, and other forest products."[91]

With the clean development mechanism, it is likely that at least a reasonable share of this tree planting will come from plantations. But also part of the planting will be done by locals and volunteers on the outskirts of villages, along field boundaries and roads, on small plots of marginal land, and on denuded hillsides.[92]

The World Bank has estimated that seedlings will cost US$40 per thousand. Assuming that the average planting rate will be roughly 2,000 per hectare, the seedlings cost per hectare will be US$80. The cost for planting trees (including seedlings and labor) has been estimated at US$1200 per hectare. If 150 million hectares are to be planted over the next ten years, this will require an average planting each year of 15 million hectares. At a cost of US$1200 per hectare, the annual cost will be of the order of US$18 billion.[93]

But planting trees achieves other objectives. It sequesters carbon, conserves soil, reduces flooding as well as supplying firewood. But because climate stabilization is essential, planting trees for carbon should be costed separately. The proposal of Vattenfall to reforest or afforest 171 million hectares of

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[91] Wolf, E. (1998) *Reclaiming the Future* in Lester R. Brown et al., State of the World 1988 (New York: W. W. Norton & Company, 1988), p. 174,

[92] Runsheng Yin et al. (2005) *China's Ecological Rehabilitation: The Unprecedented Efforts and Dramatic Impacts of Reforestation and Slope Protection in Western China*. China Environment Series 7 Online at: http://www.wilsoncenter.org/topics/pubs/feature22.pdf

[93] Wolf, E. (1998) *Reclaiming the Future* in Lester R. Brown et al., State of the World 1988 (New York: W. W. Norton & Company, 1988), p. 174,

wasteland over 10 years can be costed. Using a value of sequestered carbon of US$210 per ton, it would cost close to US$20 billion per year.

Costs of Soil Conservation: Conserving the earth's topsoil must involve at least the following two steps. The first step is to retire the highly erodible land that cannot sustain further farming— the estimated one tenth of the world's cropland that accounts for perhaps half of all excess erosion. In the United States, that has involved retiring 14 million hectares at a cost of US$125 per hectare totaling US$2 billion over a ten year period.[94] The second step involves using conservation practices on the remaining land to restore eroded and degraded land. This initiative includes providing an economic incentive to encourage farmers to adopt conservation practices such as contour farming, strip cropping, and, increasingly, minimum-till or no-till farming. It costs roughly US$1 billion per year in the USA.[95] Lester Brown writes that

> "In expanding these estimates to cover the world, it is assumed that roughly 10 percent of the world's cropland is highly erodible and should be planted to grass or trees before the topsoil is lost and it becomes barren land. In both the United States and China, the two leading food-producing countries, which account for a third of the world grain harvest, the official goal is to retire one tenth of all cropland. In Europe, it likely would be much less than 10 percent, but in Africa and the Andean countries it could be substantially higher than that. For the world as a whole, converting 10 percent of cropland that is highly erodible to grass or trees seems a reasonable goal. Since this costs roughly US$2 billion in the United States, which represents one eighth of the world cropland area, the total for the world would be roughly US$16 billion annually.[96] Assuming that the need for erosion control practices for the rest of the world is similar to that in the United States, we again multiply the U.S. expenditure by eight to get a total of US$8 billion for the world as a whole. The two components together—US$16 billion for retiring highly erodible land and US$8 billion for adopting conservation practices—give an annual total for the world of US$24 billion."[97]

Costs for Rangeland Protection and Restoration. This has been fully costed by The United Nations Plan of Action to Combat Desertification. This plan, which focuses on the world's dryland regions, containing nearly 90 percent of all rangeland, estimates that restoration of rangelands would cost approximately US$183 billion over 20-years. The key restoration measures include improved economic incentives to stop overstocking, revegetation with appropriate rest periods, when grazing would be banned and sustainable rangeland management.[98] This is a costly undertaking, but Lester

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[94] Ibid.
[95] Ibid.
[96] Ibid.
[97] Ibid.
[98] The United Nations Plan of Action to Combat Desertification at http://www.unccd.int/main.php Accessed 26 March 2008

Brown[99] argues that every dollar invested in rangeland restoration yields a return of US$2.50 in income from the increased productivity of the rangeland ecosystem.

The alternative to action would cause a loss not only of land productivity but of livelihood, and ultimately leads to both the loss of life and to millions of refugees. Though not quantified here, restoring this vulnerable land will also have carbon sequestration benefits.[100] An example of the good use of restoring vulnerable land is the planting of jatropha in Africa and Asia. Jatropha is a four-foot high perennial shrub. Not only does it cover wasteland and sequester carbon but its seeds can be used to make biodiesel..[101]

Costs of restoration of fisheries: The restoration of oceanic fisheries centers primarily on the establishment of a worldwide network of marine reserves, which would cover roughly 30 percent of the ocean. Costings by a UK team of experts have estimated expenditures around US$13 billion per year being required.[102]

Costs for Wildlife and Biodiversity Protection: For wildlife and biodiversity protection, the bill is somewhat higher. The World Parks Congress estimates that US$25 billion in additional annual support is required to establish and maintain an effective global system of protected areas.[103] Additional areas needed, including those encompassing the biologically diverse hotspots not yet included in designated parks, would cost between US$500 million-US$5 Billion a year over five years[104], yielding a total of US$30 billion per annum.[105] Professor Norman Myers argues that it would be possible to set up the remaining biodiversity hotspots for US$500 million a year over five years.[106] Globally, already US$10 billion is spent per annum on biodiversity so Professor Myers suggestion is not a great stretch financially.

Finally, with climate change, wildlife corridors north and south on the great continents of the world will be needed to ensure that species can migrate north and south as the planet warms. Former NSW Environment Minister Bob Debus showed that much progress can be made here for minimal extra cost

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[99] Brown, L. (2008) *Plan B. Mobilising to Save Civilisation.* The Earth Policy Institute

[100] Dregne, H.E. Chou, N.T. (1992) *Global Desertification Dimensions and Costs in Degradation and Restoration of Arid Lands.* UNEP.

[101] See Information about Jatropha at http://www.jatrophaworld.org/ Accessed 26 March 2008

[102] Balmford, A. *et al.* (2004) *The Worldwide Costs of Marine Protected Areas*, Proceedings of the National Academy of Sciences, vol. 101, no. 26. pp. 9694–97.

[103] See Message of the vth IUCN *World parks congress to the convention on biological diversity* at http://www.internationalwildlifelaw.org/WPCCBD.pdf Accessed 26 March 2008

[104] Myers ,N., Mittermeier RA, Mittermeier C.G, daFonseca G.A.B, Kent J. 2000. *Biodiversity hotspots for conservation priorities*. Nature 403: 853–858. Summary Available at http://files.globalmarshallplan.org/Myers%202003_Biodiversity%20hotspots_revisited_bioScience.pdf

[105] See World Parks Congress, Recommendations of the Vth IUCN World Parks Congress, op. cit. note 60; World Parks Congress (2007) The Durban Accord, Available at www.iucn.org/themes/wcpa , viewed 19 October 2007

[106] Myers N, Mittermeier RA, Mittermeier CG, daFonseca GAB, Kent J. (2000) *Biodiversity Hotspots for Conservation Priorities.* Nature 403: 853–858. Summary Available at http://files.globalmarshallplan.org/Myers%202003_Biodiversity%20hotspots_revisited_bioScience.pdf

if there is the necessary political will. In NSW two wildlife corridors are being created one up through central rural NSW and another up the great dividing range and east coast of NSW.[107] The NSW government is achieving this relatively cost effectively because they have undergone effective stakeholder engagement with the relevant national parks and state forest authorities and private landholders. Nevertheless, there will be costs to achieving greater connectivity for wilderness corridors across the world's great continents. Hence it would be wise to strategically align efforts and expenditure for re-afforestation, re-vegetation, reversing soil erosion, carbon sequestration and protection of biodiversity to simultaneously, where appropriate, also be building and maintaining these north south wildlife corridors on all the continents of the globe.

Altogether, stopping the further loss and rebuilding resilience of the world's ecosystems will require additional global expenditures approximately US$108 billion per annum in addition to what is currently spent. Currently OECD nations spend approximately US$400 billion per annum on environmental protection as a whole. Hence an increase of US$108 billion is feasible given increased public concern and public will for action on climate change and the environment. To put US$108 billion in perspective, it is worth reiterating what was discussed earlier in the chapter, namely that nature's ecosystem services contribute approximately US$43 trillion worth of free services[108] to the global economy. Thus spending US$108 billion per annum to ensure the sustainability of US$43 trillion worth of ecosystem services is very small price to pay to restore resilience to the earth's ecosystems. Also, given that the world economy currently is over US$30 trillion dollars per annum and growing exponentially, an extra expenditure of US$108 billion per annum would simply mean that the same level of economic growth and average wage rises would be achieved by just months later as would be achieved by January 1, 2020. Diverting one month of global military expenditure would also cover this bill, as would diverting approximately one-tenth1/10 of current annual government perverse subsidies to companies which harm the environment. According to a range of studies global perverse subsidies which harm the environment amount to between US$650 billion to US$2 trillion.[109] Thus such an additional investment especially by OECD nations and fast growing economies like China is affordable and justifiable to avoid irreversible loss of ecosystem resilience relative to other expenditures.

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[107] See Wilderness Society Congratulates NSW Government on Wildlife Corridor at http://www.wilderness.org.au/articles/wildlife_corridor

[108] Robert Costanza et al., (1997) *The Value of the World's Ecosystem Services and Natural Capital* Nature 15 May 1997

[109] Myers, N. Kent, J. (2001) *Perverse Subsidies: How Tax Dollars Can Undercut the Environment and the Economy*. Island Press.

Of course it is vitally important that effective policy and economic frameworks are used to ensure such investment in biodiversity and natural resources is as efficient as possible. A wide range of OECD[110] and other publications[111] have covered what policies, economic incentives and institutional arrangements[112] tend to be more effective than others. There have also been significant reviews of advances in adaptive governance to help address the tragedy of the commons.[113] Hence this thesis will not cover these important areas.

To conclude, this first part of Chapter 8 looked at how to decouple economic growth from loss of biodiversity and natural resources. But as stated in the opening to this chapter, this is just one aspect of what is required to achieve environmental sustainability. The OECD Environmental Outlook to 2030 highlights other urgent environmental pressures which need to be reduced, such as ensuring clean air and water and adequate sanitation for all, and rapidly reducing environmental degradation and pollution through end of pipe and resource productivity improvements. (See Table 8.1 at the start of the chapter) As chapter 5 showed, some OECD countries, like the Netherlands, have made significant progress at reducing pollution and other environmental pressures from which we can both take encouragement and valuable lessons. In many OECD countries, pollution from industrial sources, air and water pollution has been reduced, ozone depleting substances have largely been phased-out and the use of natural resources, water and energy has to some extent been decoupled from continuing economic growth (i.e. become more efficient per unit of GDP). Similarly volumes of waste produced have also been relatively decoupled from economic growth. In OECD counties in the mid-1990s, approximately 64% of municipal waste was sent to landfills, 18% for both incineration, and

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[110] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008 OECD (2002) *Handbook of Biodiversity Valuation: A Guide for Policymakers*, OECD, Paris.

OECD (2006) *Subsidy Reform and Sustainable Development: Economic, Environmental and Social Aspects*, OECD, Paris

[111] UNEP (2007) *Global Environment Outlook: Environment for development (GEO-4) report*. UNEP. Available At http://www.unep.org/geo/geo4 Accessed 23.03.08

[112] Dovers, S. Price, R. 2007. *The integration imperative in resource and environmental management*. In: Hanna, K. Slocombe, D.S. (eds). *Integrated resource and environmental management*. Oxford University Press.

Dovers, S. 2006. *Precautionary policy assessment for sustainability*. In: Fisher, E. et al. (eds). *Implementing the precautionary principle*. Edward Elgar.

Dovers, S. 2005. *Environment and sustainability policy*. Federation Press.

Connor, R., Dovers, S. 2004. *Institutional change for sustainable development.* Edward Elgar.

Dovers, S. and Wild River. S. (eds). 2003. *Managing Australia's environment*. Federation Press.

[113] Ostrom, E., Dietz, T., Dol_ak, N., Stern, P., Stonich, S. and Weber, E. (eds) (2002) *The Drama of the Commons, Committee on the Human Dimensions of Global Change,* Division of Behavioural and Social Sciences and Education, National Research Council, National Academy Press, Washington, DC. Ostrom, E., Burger, J., Field, C., Norgaard, R. and Policansky, D. (2003) *'Revisiting the Commons: Local Lessons, Global Challenges'*, Science, 9 April.Milton, J., Kiker, C. and Lee, D. (1997) '*Adaptive Ecosystem Management and the Florida Everglades: More than Trial-and-Error?'*, Journal of Agriculture and Applied Economics, vol 29, July, pp99-107. Gandy, M. (1997) *'The Making of a Regulatory Crisis, Restructuring New York's Water Supply'*, Transactions of the Institute of British Geographers , New Series vol 22, no 2, pp338-358. Ellsworth, J., Hildebrand, L. and Glover, E. (1997) *'Canada Atlantic Coastal Action Program: A Community Based Approach to Collective Governance*', Oceans and Coastal Management, vol 36, nos 1-3, pp121-142.

recycling.[114] In 2005, only 49% of municipal waste being disposed of in landfills, 30% being recycled and 21% being incinerated or otherwise treated.[115]

Despite these signs of progress, for the most part OECD countries have only achieved relative levels of decoupling. Local, regional and global environmental pressures are still often increasing and where they are being reduced, they are often not being reduced fast enough to avoid irreversible tipping points. The UN,[116] UNEP,[117] OECD[118] and World Bank[119] have all argued that greater efforts are required now whilst costs of action are relatively small to avoid greater long term costs of inaction. Without new (or more stringent) policies to better address environmental health issues, the adverse health effects of the most harmful environmental pollutants (e.g. air and water pollution) are likely to increase in many developing countries in the future. Hence we now explore the economic efficiency of decoupling of economic growth from these other environmental pressures by similarly integrating studies to date which explore the relative costs of inaction versus action.

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[114] OECD (2001) *OECD Environmental Outlook*, OECD, Paris.

[115] OECD (2008) *OECD Environmental Data Compendium*, OECD, Paris.

[116] UN Millennium Ecosystem Assessment, (2005) *Ecosystems and Human Well-being*: Biodiversity Synthesis. World Resources Institute, Washington, DC

[117] UNEP (2007) *Global Environment Outlook: Environment for development (GEO-4) report*. UNEP. Available At http://www.unep.org/geo/geo4 Accessed 23.03.08

[118] OECD (2008) *OECD Environmental Outlook to 2030. OECD*. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[119] World Bank (2003) *World Bank Development Report 2003: Sustainable Development in a Dynamic World*, Oxford University Press, Oxford

8.2 Decoupling Economic Growth from Air Pollution through Pollution Prevention and Resource Productivity

Air pollution is an important environmental pressure that needs to be decoupled from economic growth in large part because it causes significant adverse health effects. The World Health Organization states that more than 2 million people die prematurely each year from causes directly attributable to air pollution[120]; with 1.6 million of these deaths caused by indoor air pollution.[121] According to a WHO assessment[122] more than half of these deaths occur in developing countries. Also some air pollutants, such as sulphur and nitrogen oxides which cause acid rain, accelerate damage to materials, including historic buildings. Tropospheric[123] ozone[124] causes damage to rubber products due to its oxidizing effect. Acid rain and persistent organic pollutants contribute to the loss of resilience of ecosystems. Because of this, air pollution is a significant cost to economies.

8.2.1 Costs of Inaction

Different studies have reported economic losses of 2-4% of GDP of cities and countries because of air pollution.[125] Most of the economic costs are due to health costs. For instance the World Bank in 2007[126] estimated Chinese air pollution health costs at about 3.8% of GDP.

Air pollution costs economies in numerous ways, some of which may surprise. For instance, a European study found that tropospheric ozone causes measurable, regional-scale reductions on crop yields for 23 arable crops costing Europe US$5.72–12 billion/year[127] in lost production. There is also evidence of significant crop yield reductions in other countries, such as India, Pakistan and China[128]. China's economic losses due to acid rain damage to forestry and agriculture are estimated to be worth

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[120] World Health Organisation (2005) *Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide: Global update 2005*. Summary of risk assessment. WHO. Available at http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf Accessed 15 August 2008

[121] UNEP (2007) *Global Environment Outlook: Environment for development (GEO-4) report*. UNEP. Available At http://www.unep.org/geo/geo4 Accessed 23.03.08

[122] World Health Organisation (2005) *Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide: Global update 2005*. Summary of risk assessment. WHO. Available at http://whqlibdoc.who.int/hq/2006/WHO_SDE_PHE_OEH_06.02_eng.pdf Accessed 15 August 2008

[123] The troposphere is the lowest portion of Earth's atmosphere. The average depth of the troposphere is approximately 11 km

[124] Ozone, when it is in the stratospheric level of the atmosphere, carries out an important role in protecting the earth from harmful UV rays. However, when it is present near ground level in the troposheric level, (near ground level) of the atmosphere it is a significant air pollutant.

[125] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008.

[126] World Bank (2007) *Cost of Pollution in China: Economic Estimates of Physical Damages*, World Bank, Washington DC.

[127] Holland, M., Kinghorn, S., Emberson, L., Cinderby, S., Ashmore, M., Mills, G. and Harmens, H. (2006). *Development of a framework for probabilistic assessment of the economic losses caused by ozone damage to crops in Europe.* CEH project No. C02309NEW. Centre for Ecology and Hydrology, Natural Environment Research Council, Bangor, Wales

[128] Emberson, L., Ashmore, M. and Murray, F. (eds). (2003). *Air Pollution Impacts on Crops and Forests - a Global Assessment*. Imperial College Press, London

US$13.25 billion annually.[129] The World Bank in 1995 reported a study for 18 cities in Central and Eastern Europe, which found that 18,000 premature deaths a year could be prevented and $1.2 billion a year in working time lost to illness could be regained by achieving European Union pollution standards for dust and soot.[130] Air pollution also affects visibility and results in corrosion of buildings and heritage structures, such as Taj Mahal in India.[131] Air pollution can also harm the lucrative tourism sector. A survey of 150 tour guides in Hong Kong found that half of the tourist visitors had complained about the air pollution. The poll of tour guides also found that one in ten tourists suffered pollution-linked health problems while visiting Hong Kong.[132] In Kathmandu, 17% of tourists interviewed indicated that they would avoid visiting Nepal again because of poor air quality.[133]

There can be significant short and long term health effects of air pollution. Short term negative effects on health include higher rates of lung, cardio and respiratory problems leading to an increase in mortality rates and hospital admissions. In addition to these short term effects, long term effects can include reduction in lung function in children and adults, increase in lung cancer and myocardial infarction rates, the development of atherosclerosis and a reduction in life expectancy.

The costs of lack of further action on air, water and chemical pollution and waste include a wide variety of "use" (e.g. the effects of water pollution 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"). Table 8.3 illustrates the diversity of impacts that are involved from air and water pollution.

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[129] Clean Air Initiative for Asian Cities Centre (2007) *2007 Annual Report. Clean Air Initiative for Asian Cities Centre.* Clean Air Initiative for Asian Cities Centre. Available awww.cleanairnet.org/caiasia/annualreport Accessed 15 August 2008.

[130] See The World Bank: *Beyond Economic Growth – Meeting the Challenges of Global Development*. Online publication available at http://www.worldbank.org/depweb/beyond/global/chapter10.html Accessed 15 August 2008

[131] Ibid.

[132] Agence France-Presse (2006) *Hong Kong Pollution Leaves Tourists Choking*. Agence France-Presse . Hong Kong cit Terra Daily. Available at http://www.terradaily.com/reports/Hong_Kong_Pollution_Leaves_Tourists_Choking.html Accessed 15 August 2008

[133] Clean Air Initiative for Asian Cities Centre (2007) *2007 Annual Report. Clean Air Initiative for Asian Cities Centre.* Clean Air Initiative for Asian Cities Centre. Available awww.cleanairnet.org/caiasia/annualreport Accessed 15 August 2008.

Table 8.3 Costs Incurred from Air and Water Pollution (Source, OECD, 2008[134])

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	

While all impacts from policy inaction in the area of water, air and chemical pollution are potentially difficult to value, the most difficult are probably those relating to ecosystems (e.g. air-sheds, water courses) which are not directly related to some downstream economic activity. Valuation of some of the costs of inaction associated with human health is also not straightforward and tends to be estimated as a range of costs.

Many intangible health costs from air, water pollution and 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. In a study of acute cardio-respiratory cases in Canada, Stieb et al[135] 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[136] 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%. Pain and suffering costs are felt directly by individuals but the financial costs may be shared widely. One study of the costs of respiratory illness caused by air pollution[137] found that only a most of the financial and opportunity costs were borne widely. As well as the societal costs other health costs are borne by the government's health care system paid for by tax payers. This was shown by a study by the Ontario Medical Association[138] which estimated that the healthcare costs associated with PM2.5 and ozone in Ontario were CA$507 million per annum.

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[134] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[135] Stieb, D., *et al*. (2002), *Economic Evaluation of the Benefits of Reducing Acute Cardiorespiratory Morbidity associated with Air Pollution*, Environmental Health: A Global Access Science Source 2002, Vol. 1, p. 7.

[136] Rabl, A. (2004) *Valuation of Health End Points for Children and for Adults*, Working Paper, École des Mines, Paris.

[137] Chestnut, L.G., et al. (2005) *The Economic Value of Preventing Respiratory and Cardiovascular Hospitalizations,* Contemporary Economic Policy, Vol. 24, No. 1, pp. 127-143.

[138] Ontario Medical Association (2005) *The Illness Costs of Air Pollution*, OMA, Toronto. \

A study by Pearce *et al*[139] shows that the health-related costs are usually more than 80% of the total costs of air pollution. Pearce *et al* also found that reduced health impacts were at least one-third of the total social benefits of pollution control. 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".

Whilst, much of the attention has been on the impacts of outdoor air pollution, indoor air pollution is now being appreciated as a major issue. Poor indoor air quality in Australia's homes, offices, factories and buildings is costing Australia as much as AU$12 billion a year due to ill-health and lost production. In the UK poor indoor air costs the economy $30 billion a year, while in the US the cost is $170 billion.

Indoor air pollution is an even bigger problem in developing countries. More than two billion have no access to electricity and thus depend on crop waste or coal, dung or wood to meet their energy needs. As discussed in Chapter 6, this is a significant factor in deforestation globally. Cooking and heating with such solid fuels on open fires or stoves without chimneys or adequate ventilation leads to indoor air pollution. This indoor smoke contains a range of health-damaging pollutants including small soot or dust particles that are able to penetrate deep into the lungs. In many developing countries, indoor smoke is responsible for an estimated 3.7% of the overall disease burden. The multiple benefits of reducing outdoor and indoor air pollution are considered next.

8.2.2 Multiple Benefits of Reducing Air Pollution through Pollution Prevention and Resource Productivity

Where air pollution has been reduced, the economic benefits associated with reduced impacts have far outweighed the costs of action.[140] The USA EPA, for instance, conducted an extensive study[141] which found that the total benefits of Clean Air Act programs saved the US economy US$22 trillion from 1970-1990. In other words, if US air pollution trends in 1970 had continued to 1990, then the measurable economic, social, health and environmental costs to the US economy would have been an extra US$22 trillion. By comparison, the actual costs of achieving the pollution reductions observed over the 20 year period was US$523 billion, a small fraction of the estimated economic costs from inaction.

Significant advances have been achieved over the last few decades both in the scientific understanding of air pollution and technological innovations to reduce it. Through these advances, air quality has

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[139] Pearce, D. et al. (2006) *Cost-Benefit Analysis and the Environment*, OECD, Paris.

[140] UNEP (2007) *Global Environment Outlook: Environment for development (GEO-4) report*. UNEP. Available At http://www.unep.org/geo/geo4 Accessed 23.03.08.

[141] USEPA (1999). *The benefits and costs of the Clean Air Act 1990 to 2010. US Environmental Protection Agency*, Washington, DC Available at http://www.epa.gov/air/sect812/prospective1.html (last accessed 14 April 2007)

been improved dramatically in many cities, especially in the OECD, at much less cost than first anticipated. Investments to decouple economic growth from air pollution through pollution prevention, end of pipe approaches and fuel efficient transport technologies are economically efficient partly because the health costs associated with inaction on air pollution are significant.

In many parts of the world the problem of air pollution is due to transportation. A World Bank study in 2001 calculated that transport was responsible for potentially 80 percent of poor air quality or even higher. In Chapter 7 it was shown that one of the co-benefits of investments to greater fuel efficiency was that such investments would also significantly reduce air pollution. In Chapter 7 it was discussed how cities like Curitiba and Bogota are showing the way by investing in sustainable transport options which significantly reduces both automobile dependency and air pollution compared to cities of a similar size. Chapter 7 also discussed how a shift to greater fuel efficiency in cars to reduce greenhouse gas emissions will also result in significantly less air pollutants being produced per vehicle. Thus there are significant co-benefits for nations seeking to improve both transport fuel efficiency and reduce air pollution. Accounting for the co-benefits of reduced air pollution and reduced greenhouse gas emissions can have significant impacts on the cost effectiveness of climate and air pollution policy. As the OECD states:

> "The co-benefit relationship suggests that co-ordination of policy efforts in these areas could deliver important cost savings. For example, van Harmelen et al[142]. found that to comply with agreed or future policies to reduce regional air pollution in Europe, mitigation costs are implied, but these are reduced by 50-70% for SO2 and around 50% for NOx when combined with GHG policies. Similarly, in the shorter-term, van Vuuren et al[143] found that for the Kyoto Protocol, about half the costs of climate policy might be recovered from reduced air pollution control costs."

Clearly, aligning investments to decouple economic growth from both greenhouse gas emissions and air pollution simultaneously will increase the economic efficiency of such investments.

Investments to reduce air pollution are politically very popular. Urban air pollution is an environmental pressure which immediately effects people's health and sense of well being, Hence political will for action to decouple economic growth from air pollution is typically very high. This is illustrated through economic studies of the Kuznets curve and air pollution. As was discussed in Chapter 5, the Kuznets curve hypothesis does not apply to most environmental pressures but it does apply to urban air and water pollution where the population is directly and immediately affected. History shows that in most countries air quality reduces in the early stages of industrialization and

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[142] Van Minnen, J.G., Onigkeit, J., Alcamo, J (2002) *Long-term reductions in costs of controlling regional air pollution in Europe due to climate policy*. Environmental Science & Policy Volume 5, Issue 4, August 2002, Pages 349-365

[143] Van Vuuren, D. P., den Elzen, M. J. E. et al (2006) *Exploring the Ancillary Benefits of the Kyoto Protocol for Air Pollution in Europe, Energy Policy*, 34, pp. 444-60.

urbanization. Then overtime, when countries per capita GDP increases, priorities on air pollution shift, whereupon they implement laws to reduce air pollution. This is shown by a number of studies. Smoke, for example, tends to peak in the urban air when a country's per capita income reached approximately US$6000, after which this kind of air pollution tended to decrease. Lead pollution peaked and started to decrease when per capita income reached about US$1,900. Whilst OECD nations have eliminated lead from their petrol, in much of the developing world lead additives are still widely used, especially in Africa. Economists have calculated that making gasoline unleaded rarely costs more than 2 cents a litre, and countries can save 5 to 10 times as much as that through health cost savings. When the United States converted to unleaded gasoline, it saved more than $10 for every $1 it invested thanks to reduced health costs, savings on engine maintenance, and improved fuel efficiency. Thus eco-innovation which simultaneously reduces pollution (in this case lead) whilst at the same time improving engine fuel productivity, provides a double dividend from reduced health costs and fuel costs to the population. Such eco-innovation enables decoupling between economic growth to occur in such a way that in the long term improves productivity and economic prosperity.

Recognizing the high costs of the damage to human health caused by lead emissions and adopting appropriate national policy are matters of high urgency for many developing countries. Since OECD nations have had significant success at reducing air pollution cost effectively, there is much from this experience from which developing countries can learn. But it is also important to recognise that there are differences too.

Unlike American and European cities, Asian and developing country metropolitan areas owe a substantial portion of their pollution to two and three-wheel motorized vehicles. Motorcycles and "baby taxis" constitute the majority of vehicles in many Asian and developing countries. Many of these small vehicles employ two-stroke engines which emit 50 times the amount of air pollution compared modern automobiles.

Envirofit,[144] an independent, non-profit company established at Colorado State University in 2003, is now working to distribute affordable retrofit kits that will both reduce air pollutant emissions by 90 per cent whilst also improving fuel efficiency by 30-50 per cent of two-stroke engines.

> "Originally developed for snowmobiles, the direct injection technology of the kits has been now adapted so that the retrofit system eliminates the carburettor and fuel is instead introduced directly into the engine cylinder, thus conserving more unburned fuel."[145] Envirofit's retrofit engine kit costs about US$300. This may sound a lot for people in a developing economy, but governments are sponsoring micro financers to lend taxi drivers the money for their installation. At the moment, taxi drivers make

[144] ECOS (2007) Engine Retrofit Kit Helps Filipinos Breathe Easier. CSIRO ECOS: Towards A Sustainable Future Magazine. Available at http://www.publish.csiro.au/?act=view_file&file_id=EC139p4.pdf Accessed May 2008

[145] Ibid

> US$3–5 a day, but after their motorcycles are fitted with the kit, they can expect their income to increase by US$1–2 a day due to the engines' improved fuel efficiency. This provides the taxi driver with a 30 per cent pay rise which enables drivers to pay back their loans within a year. [146]

Since retrofitting two stroke engines results in a 30-50 per cent improvement in fuel efficiency projects to roll this out will qualify as projects under the Clean Development Mechanism. This should attract further funding from governments looking for genuine CDM projects to invest in.

8.2.3 Multiple Benefits of Reducing Indoor Air Pollution through Pollution Prevention and Resource Productivity

As stated above, at least two billion people worldwide burn wood, dung and crop residues indoors for home cooking and heating. According to the World Health Organization, this widespread use results in the premature deaths of an estimated 1.6 million people each year from breathing elevated levels of indoor smoke, resulting in Indoor air pollution as the fourth leading cause of death in poor developing countries. The Partnership for Clean Indoor Air (PCIA), which involves over 160 partners worldwide, is addressing the problem by funding projects in Asia, Africa, and Latin America to identify and demonstrate effective approaches for increasing the use of clean, reliable, affordable, efficient, and safe home cooking and heating practices that reduce people's exposure to indoor air pollution. PCIA for instance are promoting the design of more efficient wood burning cook-stoves heat cookers.[147] These more energy efficient wood cookstoves and solar cookers dramatically reduce indoor air pollution.

The World Health Organisations analysis on "The health benefits of interventions to reduce indoor air pollution from solid fuel use:[148] concludes that

> "From a public health point of view, there should be a continued emphasis on the promotion of improved stoves, as well as other locally appropriate means to reduce exposures within solid fuel-using households."

The World Health Organisation's analysis occurred before climate scientists discovered in early 2008 that black carbon, a form of particulate air pollution produced from biomass burning and cooking has a global warming effect in the atmosphere three to four times greater than prevailing estimates. Ramanathan and Carmichael[149] have found that soot and other forms of black carbon could be a

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[146] Ibid

[147] See Partnership for Clean Indoor Air at http://www.pciaonline.org/site/c.krLWJ7PIKqG/b.2684649/ Accessed 23.03.08

[148] See Partnership for Clean Indoor Air at http://www.pciaonline.org/site/c.krLWJ7PIKqG/b.2684649/ Accessed 23.03.08

[149] See Scripps Media Release at http://scrippsnews.ucsd.edu/Releases/?releaseID=891

significant contributor to global warming.[150] Between 25 and 35 percent of black carbon in the global atmosphere comes from China and India, emitted from the burning of wood and cow dung in household cooking and through the use of coal to heat homes. In their paper they write that

> "Black carbon in soot is an efficient absorbing agent of solar irradiation that is preferentially emitted in the tropics and can form atmospheric brown clouds in mixture with other aerosols. These factors combine to make black carbon emissions the second most important contribution to anthropogenic climate warming, after carbon dioxide emissions."[151]

Their report claims that

> "…. soot and other forms of black carbon could have as much as 60 percent of the current global warming effect of carbon dioxide, more than that of any greenhouse gas besides CO2."[152]

Black carbon particles only remain airborne for weeks at most compared to carbon dioxide, which remains in the atmosphere for more than a century.[153] Thus investments in more efficient wood and solar heaters and cookers would have a very rapid pay back in terms of greenhouse gas mitigation.

Indoor air pollution is not just a major health issue in developing countries. As stated earlier in section 8.2.6 in OECD countries poor indoor air quality is costing the economy US$10s of nillions per annum from ill health, absenteeism and lost productivity. In most OECD countries, people spend most of their time indoors either in offices at work or at home. For example, in Australia, people spend 90 per cent of their time indoors, seven per cent in cars and the remainder, only three per cent, outdoors. While indoors in a typical office or home, Australians could be inhaling a very damaging mixture of volatile organic compounds (VOCs) emitted by the building materials used, paint, carpets, furnishings and office equipment and other gaseous and particulate pollutants from other sources. The type and intensity of such pollutants will varydepending on the age of the building, the construction materials and the type of equipment used. Symptoms produced by indoor air pollution include, nausea, headaches sore throats and eye irritation and a feeling of general discomfort. As to illnesses, medical science has linked exposure to high levels of polluted air to illnesses including asthma and lung cancer.

Already in Australia and many OECD countries there are now many eco-friendly products on the market which are accredited as producing negligible indoor air pollution. In Australia there are online

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[150] Ramanathan, V. Carmichael, G. (2008) Global and regional climate changes due to black carbon. Nature Geoscience. April For futher information see Scripps Media Release at http://scrippsnews.ucsd.edu/Releases/?releaseID=891 Accessed 23.03.08

[151] Ibid.

[152] Ibid.

[153] See PhysOrg (2008) *Black carbon pollution emerges as major player in global warming.* Available at www.physorg.com/news125500721.htm

databases[154] which assess the indoor air pollution risks of products, materials, paints, glues and adhesives as part of a Life Cycle Analysis. This demonstrates that technical and relatively cost effective solutions already exist. Much more could be done though to require all new buildings to use these modern low emission indoor materials, paints, adhesives and glues. The studies referenced above suggest that such regulation would be economic efficiency given the significant health costs that would be avoided from a systematic approach to reducing indoor air pollution. Also reducing indoor air pollution is one of the reasons why higher labour productivity is reported in many green buildings.

To conclude, for many decades now it has been clearly demonstrated that the costs of inaction on air pollution significantly outweigh the costs of action by an order of magnitude.[155] Hence there is a strong imperative for governments to act to better regulate and provide the appropriate frameworks which encourage investment in technologies which decouple air pollution from economic growth. Providing a comprehensive overview of government policies and incentives to decouple air pollution from economic growth is beyond the scope of this thesis. Other publications have already provided such overview and the reader is referred to their publications in this area.[156]

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[154] See Ecospecifier at http://www.ecospecifier.org/

[155] Watkiss, P., Baggot, S., Bush, T., Cross, S., Goodwin, J., Holland, M., Hurley, F., Hunt, A., Jones, G., Kollamthodi, S., Murrells, T., Stedman, J. and Vincent, K. (2004). *An evaluation of air quality strategy*. Department for Environment, Food and Rural Affairs, London http://www.defra.gov.uk/environment/airquality/publications/ stratevaluation/index.htm (last accessed 17 April 2007)

[156] UNEP (2007) *Global Environment Outlook: Environment for development (GEO-4) report*. UNEP. Available At http://www.unep.org/geo/geo4 Accessed 23.03.08

WHO (2006). WHO *Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, Global update 2005: Summary of risk assessment*. World Health Organization, Geneva.

Cohen, A.J., Anderson, H.R., Ostro, B., Pandey, K.D., Krzyzanowski, M., Kunzli, N., Gutschmidt, K., Pope, A., Romieu, I., Samet, J.M. and Smith, K. (2005). *The global burden of disease due to outdoor air pollution*. In Journal of toxicology and environmental health Part A (68):1–7.

8.3 Decoupling Economic Growth from Water Pollution and Water Stress through Pollution Prevention and Resource Productivity

8.3.1 Costs of Inaction

In non-OECD countries, the costs of inaction with respect to unsafe water supply and sanitation are particularly acute. At the global level, water stress is a major issues with 1.1 billion people without access to a safe water supply and 2.6 billion people do not have access to adequate sanitation facilities.[157] The associated health impacts are alarming: 1.7 million deaths per year, of which 90% are children under 5 years of age. 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. Achieving the MDG of halving the population without access to water and sanitation by 2015 is expected to cost about US $10 billion per year. But this figure could be far outweighed by the costs of inaction if the MDG is not achieved, in terms of impacts on human health and economic productivity.

Even in OECD countries, the number of disease outbreaks and droughts reported in the last decade demonstrates that, despite substantial advances in recent years, access to safe drinking water and ensuring water availability are major challenges.[158] In Australia and Asia declining water availability and water stress are already significant issues and likely to become more acute due to climate change this century as outlined in Chapter 1 and in the introduction to this chapter. Whilst OECD water quality and safety is significantly better than the water quality in most developing countries outbreaks of disease have occurred in many OECD countries in the last couple of decades. In 1993, in Milwaukee, the largest city in the US state of Wisconsin, there was a major outbreak of gastro-intestinal illness. It was caused by a parasite commonly harboured by cattle, Cryptosporidium, . 400,000 residents were infected, and more than 60 people died. Cost estimates for this outbreak exceeded $54 million. The outbreak revealed the vulnerability of OECD urban water systems. The outbreak occurred in water that met traditional guidelines for indicators of microbial contamination. The Milwaukee outbreak also brought home the severe consequences of waterborne diseases in OECD countries. More recently, in the Spring of 2000, there was an outbreak of E. coli O157:H7 in Walkerton, Ontario (Canada) resulting in over 2,300 cases of infection and six deaths. There have been other outbreaks.

It is likely that a mixture of causes was involved including the ageing of water treatment infrastructure, inadequate treatment, the discharge of greater quantities of wastewater,and the increase

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[157] WHO/UNICEF (2006), *Joint Monitoring Programme for Water Supply and Sanitation*, (www.wssinfo.org/en/ welcome.html, accessed October 2006).

[158] CRC/IWA (2002) *Drinking Water and Infectious Diseases*: Establishing the Links

(or possibly the increasing recognition and detection), of organisms resistant to conventional disinfection. Contamination of water distribution systems can have a variety of causes and explanations includingcorrosion, construction and repairs of the distribution system, cross-connections, and back-siphonage. Contaminated groundwater can also be responsible for waterborne epidemics. This was probably the explanation for the 116 outbreaks of waterborne diseases in in Sweden from 1980 to 1999, which affected about 58,000 people. It is also the probable explanation for 41 outbreaks in the UK between 1991 and 2000, with more than 3,768 reported cases of illness. In most cases, the outbreaks were due to Campylobacter and Cryptosporidium. They are emerging pathogens. Many water supply systems have struggled to deal with them.

Table 8.4 Health Effects Associated with Selected Water Pollutants (Source, OECD, 2008[159])

	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.

These cases emphasise the urgency of reviewing the effectiveness and reliability of methods, management approaches, and technologies for guaranteeing the safety of drinking water. The World Health Organisation and OECD have produced a guidance document[160] as a basis for risk management decisions at every point in the system. It gives guidance on selecting and using various parameters and technologies to meet specific information needs and to support safe practice throughout the water system: catchment protection and assessment, assessment of source-water quality and of treatment efficiency, and monitoring of drinking water quality at the point of leaving the treatment facility and throughout the distribution system. It is in effect a total system approach for improved drinking water quality.

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[159] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

[160] IWA/OECD/WHO (2003) *Assessing Microbial Safety of Drinking Water: Improving Approaches and Methods*. WHO Available at http://www.who.int/water_sanitation_health/dwq/en/9241546301_intro.pdf

The aim is to control each treatment step so as to prevent contaminants from reaching the consumer. Consideration is also given to tolerable risk, water-quality targets, public health status, and education. Thus, risk management can no longer be confined to a single organisation or agency; national, regional and local governments, water authorities, water supply agencies, and public health authorities all play a role. This creates significant challenges for co-ordination as well as production of useful and compatible data since each of these stakeholders has specific responsibilities and information needs.

But systems are not enough, detection techniques also have to be improved. Emerging molecular methods[161] are likely to make a significant contribution by increasing the chances of detecting a pathogen from an implicated source of drinking water, particularly in the case of viruses with no readily available or rapid method of culture. These include the likes of rotaviruses, astroviruses, caliciviruses, and the hepatitis A virus.

Traditional methods for detecting viruses are based on tissue-culture techniques that can take several weeks. Thanks to rapid advances in biotechnological research of the last few years, a wide range of new genetic (nucleic-acid- based) and immunological tools are now available and some molecular techniques appear particularly promising. They can offer faster, more sensitive and specific ways of detecting micro-organisms. For example, genotyping, or molecular characterisation, is a powerful new tool for identifying the source of microbial contaminants and is already in routine use for detecting Cryptosporidium in some OECD countries. On the horizon are methods based on micro-arrays and biosensors. As ever, resources are needed to increase the usefulness and broad applicability of the new technologies in the pipeline.

8.3.2 Cost Benefits of Investing in Reducing Water Pollution

Investment to improve water quality by effectively removing water pollutants is economically efficient. The studies reviewed in OECD's forthcoming reports[162] will show that national measures to reduce agricultural runoff and storm water management – including introducing targeted measures to reduce a variety of different pollutants such as arsenic and nitrates could result in health benefits costed to be in excess of US$100 million for large OECD economies. Recreational water quality improvements through sewage treatment in France, Portugal, the US and the UK and drink water quality improvements in the US show that health benefits of drinking water quality and sewage treatment often outweigh the costs of policy implementation.[163] A 2006 US Environmental Protection Agency[164] study calculating the annual cost of the Long Term 2 Enhanced Surface Water Treatment

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[161] OECD (1997) *Biotechnology for Water Use and Conservation*, OECD, Paris

[162] OECD (2008*) Cost of Inaction: Technical Report*, OECD, Paris.
OECD (2008) *Costs of Environmental Policy Inaction: Summary for Policy-makers*, OECD, Paris.

[163] ibid

[164] US EPA (2006) *National Primary Drinking Water Regulations*: *Long Term 2 Enhanced Surface Water*

Rule to improve drinking water quality found that the policy cost between US$93 and 113 million to implement. However the US EPA also found that such investment was more than justified from an economic efficiency perspective since the annual health benefits range from US$177 million to 2.8 billion. Georgiou et al.[165] showed a similar cost benefit result for the UK's compliance with EU Bathing Water Directive.

8.3.3 Cost Effective Innovations in Water Supply and Treatment

Despite the significant cost benefits from reducing water pollution and ensuring water sanitation for all people, current levels of investment in the water sector are inadequate to achieve existing environmental and social sustainability goals. Successive reports by international groups on water issues have estimated that total global annual expenditure in the water sector would need to roughly double in order to achieve the Millennium Development Goal of halving by 2015 the proportion of people without sustainable access to safe water. The World Summit on Sustainable Development in Johannesburg, and the Fourth World Water Forum in Mexico focused global attention on deficits in water and sanitation services in developing countries and high capital needs of infrastructure development.

At the same time OECD countries, who have not faced major financial deficits in the water and environmental infrastructure sectors, now need to mobilise capital in the next one or two decades to replace ageing water infrastructure, identify and fix leaks, and to meet increasingly stringent environmental and health standards. A recent OECD report estimates that France and the UK will have to increase their spending on water as a proportion of GDP by about 20% just to maintain water services at their current levels, while Japan and Korea may have to increase their water expenditure by more than 40%. Hence water experts like Professor Stuart White from UTS are urging a fundamental rethink of how we deliver water services more cost effectively and socially and environmentally sustainably.

The real financial, environmental and social costs of supplying water services, as shown by the findings of the World Commission on Dams, have also provided impetus for a major rethink on how water services are provided and how water is managed. The ecological footprint and social impacts of humanity's water usage are very significant. Many rivers are in crisis, whether due to salinity, pollution or simply due to the lack of natural environmental flows as a consequence of dams. Kader Asmal, Chairperson of the 2000 World Commission on Dams wrote

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Treatment Rule; Final Rule, Federal Register, Vol. 71, No. 3, pp. 653-786.

[165] Georgiou, S, I.J. Bateman and I.H. Langford (2005) *Cost-benefit Analysis of Improved Bathing Water Quality in the United Kingdom as a Result of a Revision of the European Bathing Water Directive*, in R. Brouwer and D. Pearce (eds.), Cost-benefit Analysis and Water Resources Management, Edward Elgar, Cheltenham, UK.

> "On this blue planet, less than 2.5 per cent of our water is fresh, less than 33 per cent of fresh water is fluid, less than 1.7 percent of fluid water runs in streams. And we have been stopping even these. We dammed half our world's rivers at unprecedented rates of one per hour."[166]

Dams, inter basin transfers and water withdrawals for irrigation have fragmented 60 per cent of the world's rivers. By the end of the 20th century, there were over 45,000 dams in over 150 countries. Some of the key findings of the landmark report[167] from the World Commission on Dams (WCD), were:

- dams, especially shallow dams in the tropics, are significant greenhouse emitters due to rotting vegetation
- performance data in the WCD knowledge base confirms that large dam projects often incur substantial capital cost overruns -– for 250 projects examined. The average overrun was half again as much as the projected cost
- poor accounting in economic terms for the social and environmental costs and benefits of large dams implies that the true economic efficiency and profitability of these schemes remains largely unknown
- dams have been the biggest drain on aid budgets for the past 50 years, costing US$4 billion a year in the 1980
- so far, dam building has driven up to 80 million people from their homes
- one of the most disturbing findings is that few dams have ever been looked at to see if the benefits outweigh the costs
- a quarter of dams built to supply water deliver less than half the intended amount. – in a tenth of old reservoirs, the build-up of silt has more than halved the storage capacity
- by stopping the flow of silt downstream, dams reduce the fertility of flood plains and invariably cause erosion of coastal deltas
- dam construction is one of the major reasons for the extinction of freshwater fish and the vanishing of bird species from flood plains.

Hence water experts like Professor Stuart White from UTS are urging a fundamental rethink of how we deliver water services more cost effectively and socially and environmentally sustainably

> "(Today) Urban water utilities and government have an opportunity to reverse a legacy of over 100 years... Many of the problems facing urban water systems had their roots in history, and the solutions

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[166] World Commission on Dams (2000) *Dams and Development: A New Framework for Decision-making, The Report of the World Commission on Dams,* Earthscan, London.

[167] Ibid.

> required a fresh approach. The historical approach of the water industry was based on a simple premise. If demand rose, new dams and pipelines were built. If water ran out in one catchment, it was taken from the next. When water was piped into houses, offices and factories, it came out as sewage which needed expensive treatment and disposal. This "supply-side" thinking is pervasive – we see it still in the preference for desalination plants over real investment in demand management. This has led to an over-investment in the supply of water and to an under-investment in reducing demand. One of the water industry's best-kept secrets is this: it is cheaper, faster and less environmentally damaging to pay customers to save water rather than to supply it. This is the basis of "demand-side" thinking, which provides the biggest gains at the lowest cost. -There are huge cost and environmental advantages associated with reducing water demand through efficient appliances, low water using landscapes and reduced leakage. For example, while the US has had standards which regulate the efficiency of water-using equipment since 1994, federal and state environment ministers in Australia agreed only recently to introduce compulsory labelling. By itself this will be inadequate."[168]

In the last two decades, whole system cost analysis has shown that water efficiency delivers far more benefits than previously imagined. Research undertaken by Stuart White's group at UTS' Institute for Sustainable Futures indicates that in cities and towns facing water supply augmentation, investment in water efficiency can result in water savings of greater than 30% at a unit cost that is less than supply augmentation, yielding net present value economic benefits in excess of AUD$100m for some capital cities.[169]

Most OECD nations' water infrastructure assets total tens to hundreds of billions of dollars, at least half of which is for metropolitan water supply and sewerage. Demand management and water efficiency can significantly reduce the need for the construction of new dams, new treatment plants and reducing the maintenance of the pipes and associated infrastructure used to deliver and remove water, significant savings can be made.

The latest studies are showing that we can use water much more efficiently through water recycling, reuse and the redesign of urban water systems over the next 50 years (see Table 8.5).

Table 8.5 A sample of some of the cost effective options to improve water efficiencies.

Using less water whilst still providing the same or better service	
Retro-fit homes	Water efficient showerheads can save over half the water used by the traditional showerhead. One of the largest users of energy of the home is water heating, therefore such an investment in showerheads will typically pay itself back within months.

[168] See Professor Stuart White Media Release at http://www.uts.edu.au/new/releases/2003/June/04a.html Accessed July 2008

[169] Private Communication.

Buy front loading washing machines	In Australia, the Victorian Government has made it compulsory for all new clothes washing machines to be front loading rather than top loading (which are 40–75% less efficient). Front loading machines also work better because the chemicals are more concentrated and clothes last longer because they are not agitated.
Indoor taps/sinks	Cheap gadgets that reduce the flow by at least 30% can be attached to indoor taps to reduce the amount of water flowing into sinks.
AquaLoc	A new invention called AquaLoc replaces the traditional tap seat and washer and lasts for at least 15 years. Reductions in flow rates of up to 70% are possible, and in most situations water consumption costs are reduced by up to 45% when the recommended models are installed. Organizations that also bear the cost of wastewater can often add another 20–25% on this figure from savings on sewerage usage. By reducing water consumption, AquaLoc reduces the energy required for heating hot water, and power cost reductions can be up to 60% with significant savings in CO_2 emissions as a result. The main benefit of this, however, is reduced maintenance.
Science laboratories	Some laboratories still use respirators with tap water running for as long as is needed to create vacuums. Small desktop electric diaphragm pumps create better vacuums, thereby increasing lab workers productivity as much as fourfold whilst eliminating significant noise. These also pay themselves back through the water saved within two years.
Recycling/reusing water	
Recycling water used for industrial cooling	In the Dutch industry the majority of this water use concerns the use of surface water in once-through coolers. A so-called open recirculating cooling system forms an ideal compromise, in which the benefits of water-cooling are preserved and the environmental disadvantages are reduced. Inside these systems, cooling water is recirculated in a cooling tower. The evaporation of a small part of the circulating water carries the largest amount of the heat away. The water intake that is needed to refill this part is a factor of 50–70 lower than the water intake of a once-through system with the same cooling capacity. Worldwide, the advance of these systems led to a strong reduction of surface water for cooling purposes.
Water recycling decreases discharge to sensitive water bodies	Take, for example, the release of water from the San Jose/Santa Clara Water Pollution Control Plant into the south San Francisco Bay that threatened the area's natural salt water marsh. In response, a $140 million recycling project was completed in 1997. The South Bay Water Recycling Program now has the capacity to provide 21 million gallons per day of recycled water for use in irrigation and industry. By avoiding the release of this water, the conversion of salt water marsh to brackish marsh was prevented and the habitat for two endangered species was protected.
Embedding	Mawson Lakes, in Adelaide Australia is a 31/2-thousand home development for

water recycling into major housing development	approximately 10,000 people. Attached to it is Australia's largest fully self-contained recycled water scheme. All the water for re-use is collected on site, and up to 70% of the water used by residents is recycled. Every house is fitted with two sets of pipes and the recycled water is used for toilets and gardening. A key challenge for recycling is storage, because the bulk of water falls in winter while the demand is in the summer. Mawson Lakes will store the water underground with the help of CSIRO's urban water project team (see below).
Storing water for later use	
Storing stormwater in aquifers	Preliminary work by CSIRO's Urban Water Program shows that the Adelaide Hills could provide water for the city's needs all year round, with some to spare. 'The potential recovery from storm water alone would supply almost a third of Adelaide's current water needs', says Mr Andrew Speers, leader of CSIRO's Urban Water Program. In a normal year, Adelaide derives 40% of its water or 70 billion litres per year from the Murray river and 60% comes from the Adelaide Hills. Recycling just some of the city's wastewater and run-off could reduce Adelaide's dependence on the Murray to zero and reduce the use of water from the Adelaide Hills to less than half the current demand. This team won the inaugural Great Man-Made River International Water Prize award. Granted by UNESCO, the prize is for innovation in water resources management in arid and semi-arid areas. It rewards eight years of research, exploring the use of aquifers to store urban stormwater and reclaimed water to be reused in irrigation.
Commercial buildings	Australian Conservation Foundation's 60L Commercial Green Building in Melbourne, Australia uses 90% less water than standard commercial buildings through a variety of measures including: minimizing the demand for water by providing water efficient fixtures and fittings, including waterless urinals and low flush volume toilet pans; using collected rainwater to replace 100% of normal mains water consumption whenever possible; 100% on-site treatment and reuse of grey-water (basins and sinks) and black-water (sewage) streams to produce reclaimed water for flushing toilet pans and irrigating the roof garden and landscape features.
Harnessing new sources of water more cost effectively	
De-salination breakthrough	Those living in the world's arid regions could enjoy fresh water courtesy of a British architect, Charlie Paton, and his revolutionary seawater greenhouse. The pioneer building, which has won a series of awards, uses sunlight to turn salt water into fresh water for growing vegetables and for drinking water. The building operates at a fraction of the cost of traditional desalination plants, costing 21p to make 1000 litres of distilled water. At the heart of the design is a steel-framed greenhouse with 'evaporators' at each end made from corrugated cardboard. This creates a huge surface area, allowing fresh water to evaporate, leaving salts behind. These strengthen the cardboard, so that it will last indefinitely. The roof lets in light in the red and blue spectrums, which is needed for photosynthesis and infra-red and ultraviolet are used to heat air in a roof cavity to help to drive

	the evaporation processes. This first seawater greenhouse was built on Tenerife, partly with European Commission funds. A second is under development in Oman and there are plans for others.[170]
Savings to taxpayers	**Cheaper ways to purify water** A recent study showed that the provision of adequate clean water to New York City by forests in the Catskill Mountains was equivalent to a capital investment of US$6–8 billion and an annual operating cost of US$1–2 billion for a plant to carry out the same service. The City took the option of maintaining water quality via ecosystem services by purchasing some small parcels of land, applying some covenants on the use of fertilizers in the catchment, and making a one-off investment of approximately US$1 billion to upgrade a few local sewerage plants. Hence, by taking ecosystems into account, NYC saved US$10 billion.

Source: Hawken *et al*[171] (1999, ch 11) and Postel[172] (1999)

In Australia, CSIRO has run a five year Urban Water R&D and delivery programme working with the major European Urban Water Network on urban water issues. CSIRO's Australian Urban Water Program concluded that, 'Together with water conservation, water re-use and recycling provides a means of extending limited water resources. In some circumstances, there is potential to support three times as much activity as is possible under traditional water use practices where water is used once and then thrown away.'

Urban water systems were designed largely to meet the health concerns of over 100 years ago, and ensuring clean water sanitation has had a profoundly positive effect on the overall health of OECD nations. But now, in the 21st century, innovations in water recycling and water treatment are making it possible to re-design urban water systems anew. For instance, as CSIRO's Professor Mike Young stated: 'One of the really interesting ones is how we use sewage water. Recent work by CSIRO's urban water programme is showing that the most profitable sewage treatment plants now are really ones that treat effluent, between 5000 and about 8000 or 10,000 houses, so rather than having sewage treatment plants right at the end of the city and taking all the sewage the whole way down, you would take the sewage from say, 5000 houses, treat it, and then actually pass it down in a dual system through the rest of the city.' As Professor Stuart White writes

> "Designing our sewer systems differently, to reduce the capital and maintenance costs and to improve the performance is an imperative. The basic structure and principles of our sewer systems have not changed since the nineteenth century. While they have achieved their original goal of protecting public health, the

[170] See Seawater Greenhouse Ltd at http://www.seawatergreenhouse.com/ Accessed 7th July 2008.

[171] Hawken, P., Lovins, A. Lovins, L. H. (1999) *Natural Capitalism: Creating the Next Industrial Revolution*, Earthscan, London,

[172] Postel, S. (1999) *Pillar of Sand: Can the Irrigation Miracle Last?,* Environmental Alert Series, CSIRO, Australian Conservation Foundation

economic and environmental costs are ballooning. This is a problem for cities like Brisbane, as it is for cities like Bangkok. New twenty-first century approaches will involve investing more in treatment, rather than transport of waste. Smaller pipes, distributed treatment and reuse systems, absolute maximum efficiency of water use, both here and in developing countries." New developments and buildings should have appliances and landscapes that offer best-practice efficiency in water use and reduce demand by more than 40 per cent. Rainwater can be captured and wastewater treated and recycled in a decentralised way - rather than using drinking-quality water to flush toilets and water lawns. These strategies can reduce the net water demand and sewage discharge by more than 80 per cent. New decision-making methods are needed."[173]

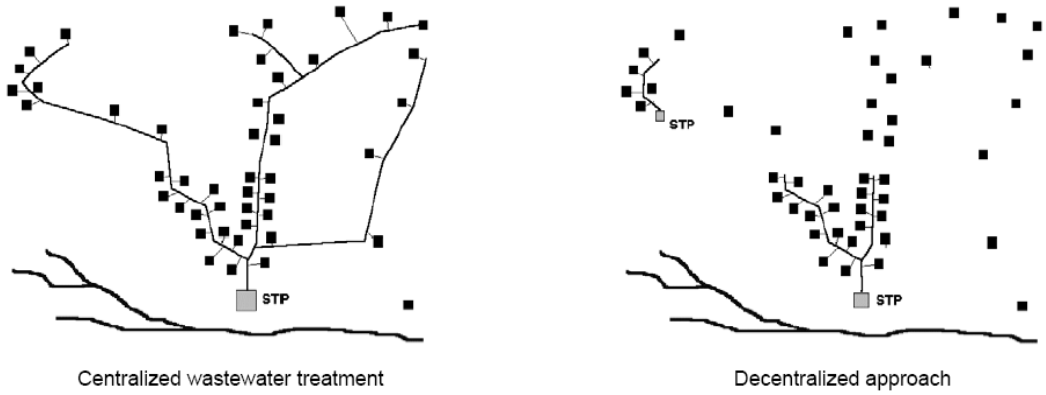

Figure 8.3 Comparison of Centralised and Decentralized Approaches to Wastewater Service. STP indicates a centralised sewerage treatment plant. (Source: Draft Handbook for Management of Onsite and Clustered (Decentralised Wastewater Treatment Systems (US. EPA 2003)[174])

Rocky Mountain Institute (RMI} have published a major report on distributed methods of supplying and treating water. The report[175] reviews the full range of benefits and costs of decentralized wastewater systems relative to conventional centralized systems, and discusses techniques for valuation of the economic benefits of decentralized systems.

The RMI report provides much evidence to suggest that decentralised approaches to water supply and treatment offer significant cost savings to enable developing countries to more cost effectively afford water infrastructure and also help OECD nations upgrade and replace aging water infrastructure.

Decentralised approaches to water supply and treatment offer reduced costs for the same reasons outlined in Chapter 7.3.4 concerning the hidden costs benefits of decentralised energy systems. Decentralised water systems are smaller than centralised systems and thus have both lower up front costs (See Figure 8.4) and shorter construction time reducing the cost of tying up capital unproductively or needing to rely on loans from banks.

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[173] See Professor Stuart White Media Release at http://www.uts.edu.au/new/releases/2003/June/04a.html Accessed July 2008.

[174] Rocky Mountain Institute (2004) Valuing Decentralized Wastewater Technologies: A Catalog of Benefits, Costs, and Economic Analysis Techniques. RMI Available at http://www.rmi.org/images/PDFs/Water/W04-21_ValuWstWtr.pdf

[175] Ibid.

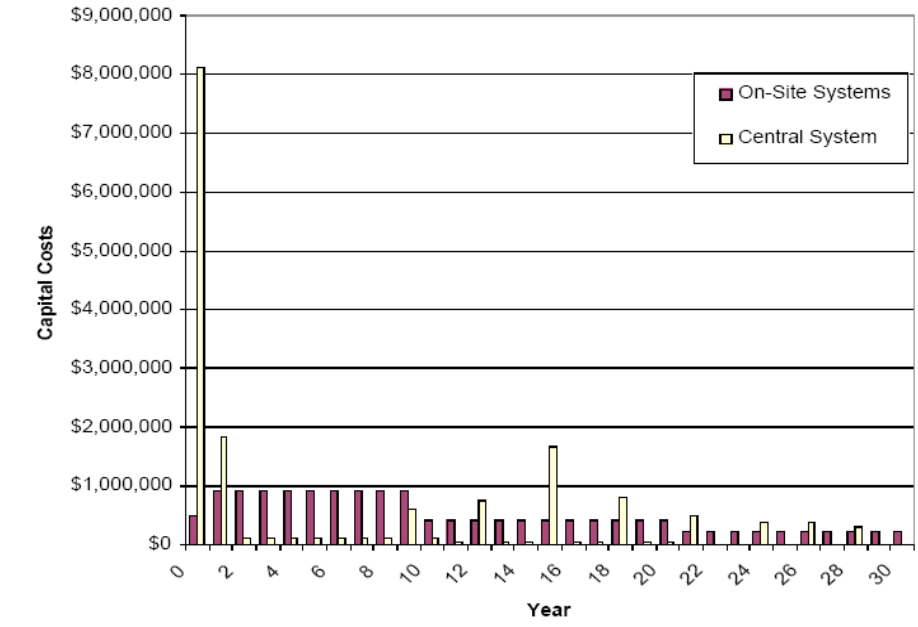

Figure 8.4: Comparison of Up front capital costs (money spent) to build large centralised systems versions smaller distributed supply and treatment water systems. (Source:RMI,2004[176])

Decentralised approaches also overcome the main risks of centralised systems namely that demand will not match the new level of supply. In cases when future demand fails to meet expectations, additional scheduled increments of decentralized capacity can be foregone, avoiding the cost of overbuilt centralized capacity. (See Figure 8.5)

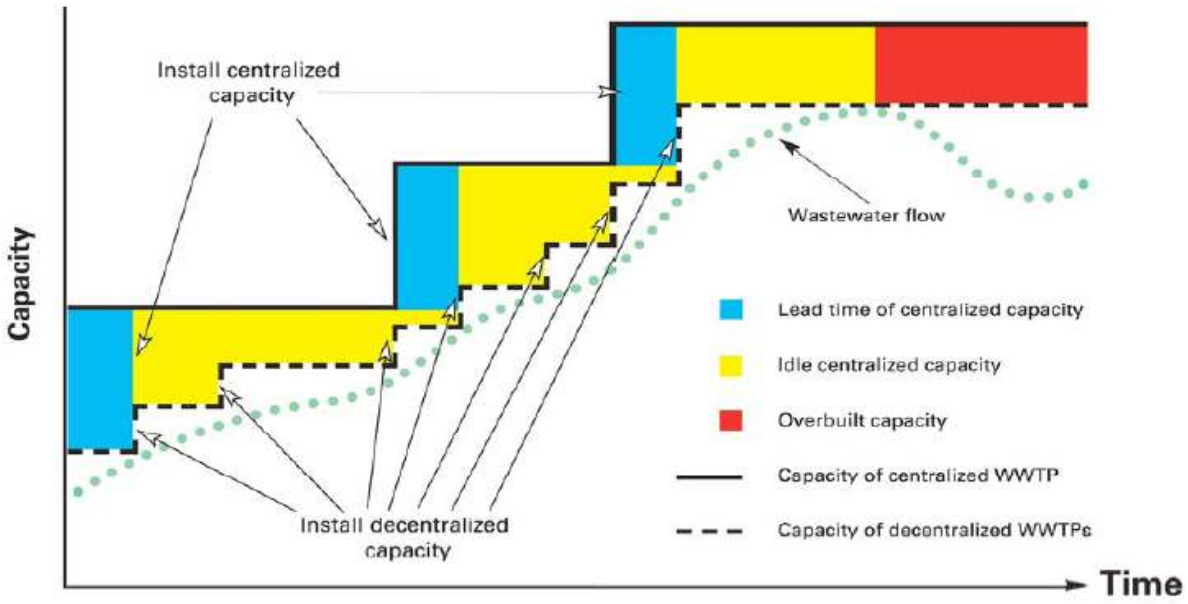

Figure 8.5 Flow versus Capacity For Centralised and Decentralised WasteWater Systems. (Source:RMI,2004[177])

[176] Ibid.

Water efficiency and decentralised approaches to water supply and treatment offer significant potential to improve water productivity. However, the largest potential water productivity potential lies in the agricultural sector. Rural agricultural regions are responsible for ~70 per cent of freshwater usage hence water productivity improvements in rural regions result in significant reductions in freshwater demand. [11] Much greater water efficiency can often be achieved through sealing irrigation channels and/or investing in sealed irrigation pipes and drip irrigation technologies. At the present time, most farming irrigation still occurs without the channels being sealed leading to significant water loss from evaporation or seepage into the soils. Hence, in principle, it is now possible for farmers to use water much more productively and thereby allow environmental flows of half the world's rivers currently damned to be at least partially restored.

The use of fresh water on farms has halved in Israel since 1984, while the value of production has continued to climb. Farmers in India, Israel, Jordan, Spain and the US have shown that drip irrigation systems that deliver water directly to crop roots can reduce water use by 30–70 per cent and raise crop yields by 20–90 per cent. In the Texas High Plains, farmers using highly efficient sprinklers raised their water efficiency to more than 90 per cent while also increasing corn yields by 10 per cent and cotton yields by 15 per cent. Rice farmers in Malaysia saw a 45 per cent increase in their water productivity through a combination of better scheduling their irrigations, shoring up canals, and sowing seeds directly in the field rather than transplanting seedlings. Recycled water has been used for a number of years to irrigate vineyards at California wineries (US), and this use is growing. Recently, Gallo Wineries and the City of Santa Rosa completed facilities for the irrigation of 350 acres of vineyards with recycled water from the Santa Rosa Subregional Water Reclamation System. At Ararat, Australia, treated and recycled grey-water and sewerage (which previously went into a river) is used for irrigation and fertilizer adding AU$40 million per annum to the local wine industry in partnership with Southcorp Ltd. An AU$4 million investment to re-use grey-water now reaps an additional AU$40 million per annum from wine sales.

The Australian private Pratt Water Initiative commissioned CSIRO to undertake economic modelling of investing on a large scale in options for water use efficiency and distribution in the Murrumbidgee Valley. Their report evaluates the economic effects of the various options in terms of increased regional income and employment. It takes a holistic view of the region in estimating the value of water savings and business opportunities identified by the Pratt Project. The focus of this project was to examine the following options to improve the economic, environmental and social outcomes from improved water management

- The identification of potential water savings;

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[177] Ibid.

- The trialling of low-cost technologies to reduce water losses both on farm and off-farm;
- Opportunities for developing greenfield sites at low cost using lay-flat piping;
- Modifying the existing reliance on surface water supply and refocussing the design of water delivery to aquifer recharge and recovery;
- Options for improving supply reliability and overcoming capacity constraints during times of peak demand; and
- Options for cost effectively meeting environmental demands.

The 2005 report by CSIRO showed that 295 gigalitres could be saved from the Murrumbidgee and Coleambally Irrigation Areas while maintaining the current area of crops and reducing significantly the environmental impacts of irrigation.[178] The Pratt Water Initiative conducted a study[179] which found that the various water savings, including horticultural and large area efficiency improvements, have the potential to increase regional income in the Murrumbidgee Valley by between $34 million and $45 million per year. This increase in income will be associated with employment increases of around 220 persons. The above results assume that the water savings are achieved relative to a baseline of current (non drought) water allocations. However, it could be expected that in years to come there will be increasing pressures for environmental flows. To account for this, they have also evaluated the water savings relative to an alternative baseline where total water availability in the region is reduced by 20 per cent. Under this alternative, the Initiative's water savings increase regional income by between $97 million and $162 million per year. These income increases are associated with maintaining employment of up to 2000 jobs. This increase in income is between $1450 and $2400 per household in the Valley.

In addition to water savings, the Pratt Water Initiative also identified a number of business opportunities (including the establishment of plantations and new sources of demand for agricultural commodities) that, while valuable in their own right, could also be used to increase the value of the water savings. They project that these business opportunities, if taken up, will increase regional income by between $75 million and $155 million per year. This increased income is associated with additional employment of around 2500 persons.

The National Heritage Trust in Australia has published two "Innovation in Irrigation" publications featuring 18 individual case studies which broadly support at farm level the macroeconomic results of

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[178] The Australian and New South Wales governments jointly committed $5.3 million from the National Action Plan for Salinity and Water Quality in a partnership with Visy Industries chairman Richard Pratt AC, for the Pratt Water Murrumbidgee water efficiency study. The final report for the Pratt study is entitled The Business of Saving Water - the Report of the Murrumbidgee Valley Water Efficiency Project. For more details see www.csiro.au/files/mediaRelease/mr2005/Murrumbidgee.htm Accessed July 2008

[179] The Pratt Water Initiative (2004) Pratt Water Initiatives An evaluation of potential effects within the Murrumbidgee Valley. Available at http://www.napswq.gov.au/publications/books/pratt-water/working-papers/pubs/socio-economic.pdf Accessed July 2008

the CSIRO study.[180] These case studies confirm that through using existing technologies and approaches significant levels of decoupling are possible. Two case studies from these publications illustrate well the above points

- **Stone Fruit Farmer Cuts Water Use 30%**

  MJ Hall and Son's Stone Fruit Company in Shepparton Victoria is a third generation family company, managing properties for investment schemes as well as owning and leasing orchards around Mooroopna and Tatura. Reducing water costs is so important they have installed new mini-jet irrigation systems on all six farms. This has cut water use by 30 per cent from the flood irrigation they used to use. Peter Hall, the owner says, "*Large orchards require complex control systems. We couldn't find one we wanted, so worked with a supplier to develop the mini-jet sprinkler system and computer controls that produce accurate applications of water.*" As a Director of the Northern Victorian Fruit Growers Association, Peter takes part in many workshops with other irrigators and those supplying them with water. "*Water's definitely becoming more expensive and more of an environmental issue overseas, so efficiency is a competitive advantage when we're so far ahead,*" he said. "*In Europe, it's also a marketing advantage. To sell fruit into the European Union (EU) these days you have to demonstrate your environmental credentials.*"[181]

- **Viticulturalist Cuts Water Use in Half**

  Many farmers like Peter Hall are achieving significant water efficiencies. Since Peter and Jacque Schulz took over Salmon Gum Estates in South Australia's Riverland near Loxton in 1986, they have halved their water use and doubled their tonnage. The couple grow a number of different varieties of wine grapes across nearly 72 hectares of vineyard. In 1998 they installed moisture probes around the vines at five different levels; the first four levels (10, 20, 40 and 70 centimetres) measured the moisture in the root zone, while the fifth, at 120 cm, represented the drainage level. The second big change came in 2001, when the Loxton Irrigation System was regenerated delivering a different level of pressure, so Peter changed from an overhead sprinkler system to a drip system, and the third major change is that Peter's entire irrigation system is controlled by computers. The system's computer program tells growers how much water is available from their pipeline at any given time. Peter now orders his water on an as-needed basis. "*One of the most water efficient things about this system is*

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[180] Department of Agriculture, Fisheries and Forestry (2005) Innovation in Irrigation 6 case studies from across Australia www.nht.gov.au/publications/irrigation-brochure/2005/pubs/innovation-2005.pdf Department of Agriculture, Fisheries and Forestry, (2004) Innovation in Irrigation 12 case studies from across Australia www.nht.gov.au/publications/irrigation-brochure/2004/pubs/irrigation-brochure.pdf.

[181] Ibid.

> *that it has eliminated the use of channels and overflows*" Peter said. "*Using the drip system and the moisture probes… we have almost halved our water use.*"[182]

To conclude, there is significant potential and great need for the world to achieve greater decoupling of economic growth from freshwater extraction. As well as the technical options presented here there is a significant need for policy and institutional reform to enable this. A discussion of what policy reform is required is beyond the scope of this thesis. The reader is referred to the following publications which address this topic in detail.[183]

8.4 Decoupling Economic Growth from Waste Production through Resource Productivity- Recycling, Re-use and Product Stewardship.

Municipal waste generation is still increasing in OECD countries, but at a slower pace since 2000. As the OECD has stated that

> "With continuous growth in the global demand for materials and the amounts of waste generated and disposed of, conventional waste policies alone may not be enough to improve material efficiency and offset the waste-related environmental impacts of materials production and use. New integrated approaches – with stronger emphasis on material efficiency, redesign and reuse of products, waste prevention, recycling of end-of-life materials and products and environmentally sound management of residues – could be used to counterbalance the environmental impacts of waste throughout the entire life-cycle of materials."[184]

To significantly decouple economic growth from waste generation, emphasis needs to be on reducing the amount of resources needed in the first place, designing for re-use of materials, and recovery and recycling of resources as much as possible. Through this 4R approach of *reducing*, *re-using, recycling* and *recovery* of resources, waste of resources is minimised and significant decoupling can be achieved. There is significant potential for improvements in this area. Currently, ninety-five per cent of all raw materials used in production are transformed into waste products within six months of being sold.

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[182] Ibid

[183] Barlow, M. (2006*) Blue Gold The Battle Against Corporate Theft of the World's Water*. Octopus Books, Canada. Gleick, P. (1993) Water in Crisis: A Guide to the World's Fresh Water Resources, Stockholm Environment Institute, Sweden; Postel, S. (1984) *Water: Rethinking Management in Age of Scarcity*, Worldwatch Paper 62, Worldwatch Institute, Washington, DC; Raskin P., Hansen, E. and Margolis, R. (1996) *'Water and Sustainability, Global Patterns and Long-Range Problems',* Natural Resources Forum, vol 20, no 1, pp1-17.

UN/WWAP (United Nations/World Water Assessment Programme) (2003) *UN World Water Development Report: Water for People*, UN/WWAP, Water for Life, UNESCO and Berghahn Books, Paris , New York and Oxford. World Commission on Dams (2000) *Dams and Development: A New Framework for Decision-making, The Report of the World Commission on Dams,* Earthscan, London.

[184] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

> "In the American economy, the material that we extract from the planet, that we mobilise for economic purposes, and process and move around and ultimately dispose of, totals about 20 times your body weight per person per day… only about one per cent of it ends up in durable goods; the system is about 99 per cent waste." [185]

The world is moving steadily into the age of conservation with recovery and recycling as an integral part. Today, separation and recovery of resources/materials and recycling is a significant part of industry internationally. Technologies and techniques are available for a significant percentage of the major waste streams from cities and towns to be separated and recycled now. Ideally it is best to have separation of waste at source. But technologies and techniques exist to now separate the waste stream.

Recycling industries contribute now significantly to national GDP. Recycling employs over 1.5 million employees in more than 50 countries with an annual turnover exceeding US$160 billion dollars. Recycling processes over 600 million tonnes of commodities annually. A recent international review of life-cycle analysis (LCA) work on key materials that are collected for recycling clearly demonstrated that recycling usually has more environmental benefits and lower environmental impacts than other waste management options. From 188 scenarios that included recycling, the overwhelming majority (83%) favoured recycling over either landfilling or incineration.[186] Recycling can also provide considerable economic and social (e.g. increased employment) benefits.[187] The US EPA studies[188] show that recycling and remanufacturing contribute significantly to the US economy. According to the study, the recycling and reuse industry consists of approximately 56,000 establishments that employ over 1.1 million people, generate an annual payroll of nearly $37 billion, and gross over $236 billion in annual revenues. This represents a significant force in the U.S. economy and makes a vital contribution to job creation and economic development. In addition to the economic activity of the recycling and reuse industry itself, other economic activity is supported because the industry purchases goods and services from other types of establishments (such as office supply companies, accounting firms, legal firms, building and landscape maintenance firms, etc.). Economic modelling estimated that nearly 1.4 million jobs are maintained in support businesses because of the recycling and reuse industry. These jobs have a payroll of $52 billion and produce $173 billion in receipts.

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[185] Lovins, A.B. (2001) *Natural Capitalism – A lecture by Amory Lovins,* Radio National Interview, 28 January 2001, Program Transcript, http://www.abc.net.au/rn/talks/bbing/stories/s231834.htm (accessed January 2007).

[186] WRAP (Waste and Resources Action Programme) (2006), Environmental Benefits of Recycling, WRAP, Banbury, UK. www.wrap.org.uk/applications/publications/publication_details.rm?id=698&publication=2838 .

[187] US REI (2001) *US Recycling Economic Information Study*, A study prepared for The National Recycling Coalition by R. W. Beck, Inc., www.epa.gov/epaoswer/non-hw/recycle/jtr/econ/rei-rw/pdf/n_report.pdf

[188] US REI (2001) *US Recycling Economic Information Study: Executive Summary*, A study prepared for The National Recycling Coalition by R. W. Beck, Inc Available At http://www.epa.gov/jtr/econ/rei-rw/pdf/exe-sum.pdf

There are numerous success stories from which other cities and countries can learn. In most European countries landfill levies are significantly higher than for most USA and Australian cities which has resulted in higher levels of recycling. Numerous European countries and, for instance, Japan are introducing product stewardship legislation that places some responsibility on the manufacturer to take back their product and recycle it. European law already requires 90% of certain appliances and cars to be designed to be recyclable. Singapore, in their 10 Year Green Plan for 2002-2012, have committed to a 60% recycling target by 2012. Northern Island introduced a levy on plastic bags that reduced their usage by 90% within 6 months. Twenty-five years ago South Australia implemented a levy on soft drink, beverages and milk cartons that has resulted in 85% being recycled.

In the shorter to medium term, the technical knowledge already exists to cost effectively address the major waste streams of OECD and non OECD countries. There are cost effective recycling opportunities for paper, organics, plastics, oils, packaging, many chemicals and metals. There are also ways of designing plastics to biodegrade efficiently and even recycle construction waste, including concrete. Further, increasing proportions of components in electrical goods can be recycled.

Thus some governments now are even committing to 100 per cent decoupling of economic growth from waste generation. The ACT government was the first to commit to achieving zero waste to landfill. The Australian Capital Territory (ACT) Government became the first local authority in the world to commit to achieving 'No waste by 2010' in the mid 1990s. Since that time, the ACT has reached a point where it now recycles 66% of its waste stream, and in the process has created over 200 new jobs. Not only has this created an additional 200 jobs in the ACT, but also during this period the ACT region has experienced strong economic growth. Numerous local governments now are following suit globally to achieve targets of at least 70 per cent and in some cases 100% decoupling of waste to landfill.

Achieving significant decoupling of economic growth from waste generation globally will involve managing the environmental impacts of extracting, processing, using, recovering and disposing of materials, not only from an environmental perspective but also from an economic and trade perspective. More coherent management policies will be needed, based on a mix of integrated demand and supply-oriented measures. To be successful, such policies will need to be supported by reliable information on waste and material flows, and on resource productivity, and with sound analysis using material flow analysis, input output analysis, life-cycle analysis, cost-benefit analysis and so forth.[189]

Improving resource productivity and putting in place effective and integrated materials management policies within the context of economic development and globalisation are not easy. They require a good understanding of the economic efficiency and environmental effectiveness with which resources

[189] OECD (2007) *Measuring Material Flows and Resource Productivity – An OECD Guide*, OECD, Paris.

and materials are used throughout their life-cycle, and need to be supported by reliable information on material flows. Existing information is insufficient to give a coherent view of how different materials flow through the economy (from their extraction or import to their final disposal). It does not give many insights into how these flows relate to environmental risks and impacts and to resource productivity, or how globalisation and foreign outsourcing affect international flows of materials and related environmental impacts. Knowledge gaps also remain about waste and recyclable materials. This is why the OECD countries have established a common knowledge and information base on material flows and resource productivity. The objective is to enable sound, factbased material flow analysis at the national and international level and to inform related policy debates. The OECD is working on two concurrent streams of activity:

1. Improving the quantitative knowledge base, by providing guidance to countries on how to construct material flow accounts and indicators in a coherent framework and by compiling material flow information from existing data sources.

2. Improving the analytical knowledge base, by using material flows information in policy analysis and evaluation, including in OECD country environmental performance reviews, in work on sustainable materials management and in 3R (reduce, reuse, recycle) activities.

Efforts over the last 30 years have shown that waste policies which take an end of pipe approach have, at best, achieved relative decoupling. As a result of this now many countries have, or are developing, integrated waste and materials policies which address environmental impacts along the whole life-cycle of products and materials. Examples include Japan's 3R-approach (Reduce, Reuse, Recycle), China's Circular Economy, the European Union's Thematic Strategy on Sustainable Use of Natural Resources and on Waste Prevention and Recycling (recycling society), and the US's Beyond RCRA: Waste and Materials Management in the Year 2020. As the OECD states:

> Common elements of these integrated policies are:
>
> - Targeting primarily the environmental impacts rather than material use per se
> - Putting wastes into the material balance context of societies
> - Taking an integrated life-cycle approach
> - Increasing use of economic instruments, such as taxes and tradable permits; and
> - Building partnerships with stakeholders, rather than using command-and-control approaches.[190]

[190] OECD (2008) *OECD Environmental Outlook to 2030*. OECD. Available At http://www.oecd.org/document/20/0,3343,en_2649_37465_39676628_1_1_1_37465,00.html Accessed 22.03.2008

These integrated policies normally target the most environmentally harmful products, materials and activities. They place stronger emphasis on material efficiency, redesign and reuse of products, recycling of end-of-life materials and products (i.e. considering end-of-life materials and products as resources rather than waste), and environmentally sound management of residues (management standards).

Integrated policies such as these are needed to do this because clearly the most cost-effective way to reduce waste is to redesign waste out of processes and products as was discussed and outlined in Chapter 5 and in Appendix 5.1. Encouraging design for greater recyclability through extended product responsibility legislation is key way that nations should try to shift from relative to absolute decoupling of economic growth from waste production.

Conclusion

This chapter has shown that the costs of inaction on environmental protection significantly outweigh the costs of action. This chapter has shown that wise and effective investment in environmental protection is economically efficient. This chapter has also begun to show that there are numerous tools already that can be used to significantly decouple economic growth from environmental pressures. Still decision makers see environmental protection as a cost. Certainly there are upfront investment costs, structural adjustment costs and social and political costs which need to be managed. This chapter has shown that many tools, new designs and technologies to enable cost effectively to reduce pollution whilst achieving higher resource productivity whilst achieving often better population health outcomes. The secret to achieving this is better and more effective sustainable design to meet humanity's needs whilst both reducing pollution and improving resource efficiency.

Since reducing pollution reduces negative health costs and losses of labour productivity and improving resource productivity boosts company profits and the economy, these tools provide new sources of 'green' resource productivity growth which has a high probability of delivering higher long term economic growth than 'business as usual'.

This chapter has shown that to decoupling economic growth from many environmental pressures is the best strategy for long term economic growth.

This chapter has shown that long term economic growth and prosperity are best served by decoupling economic growth significantly and rapidly from biodiversity loss, air, water, chemical pollution and waste generation.