

For professional investors and advisors only

Schroders Ecosystem Services

Where's the discussion?

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Schroders



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Executive Summary

This report builds on a brief survey undertaken by Schroders ahead of the World Forum on Enterprise and the Environment's meeting in June 2011. We asked 14 Chief Economists whether they integrated the value of ecosystem service decline into their medium and long-term economic forecasts and what were the challenges in doing so.

The rationale for doing so comes from the various predictions that by 2050:

- 1 The global population will be 30% bigger than today.**
- 2 The global economy will be 3 times bigger than today.**
- 3 We will need 3 planets to meet our resource demands and to absorb our emissions. We currently need 1.5 planets.**

The response from the Chief Economists was underwhelming, perhaps due to the challenges involved in putting an economic value on ecosystem services, perhaps due to this subject being relatively new or perhaps due to other reasons.

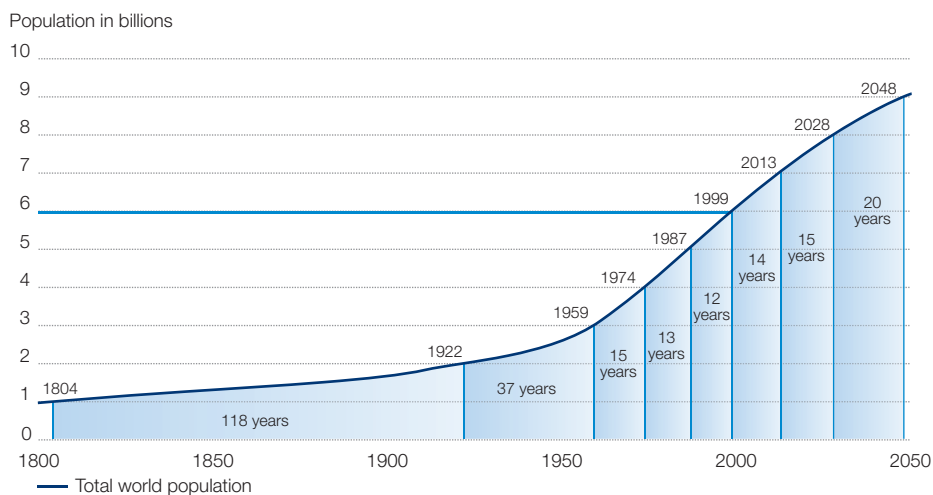
We believe that the integration of ecosystem service valuation into economic forecasting will facilitate client demands for the integration of Environmental, Social and Governance issues into the investment process. This report delves into population growth forecasts, economic forecasts, the failure of technology to improve efficiency (and hence reduce the impacts of population and economic growth on the planet) and the fact that the ecosystem services, in their various guises, are being unsustainably impacted by current models of growth. We hope that this report will help to act as a tool for engaging investors and economists on their assumptions, behind future growth predictions.

Chapter 1: Population Growth Predictions

The World's population is expected to grow by 30% by 2050

Homo sapiens are first thought to have walked the planet some 250,000 years ago, evolving from *Homo erectus* over the previous 150,000 years. Initially, high mortality rates and a predominant hunter-gatherer lifestyle meant that the population growth of *H. sapiens* was very slow and it only reached 1 billion in the early 1800's. Since then, with technological improvements and decreases in the mortality rate, the rate at which each successive billion has been added has become quicker and quicker, as shown in Figure 1. It is expected that the world's population will reach 7 billion sometime towards the end of 2011, not in 2013 as suggested by Figure 1.

Figure 1: Time to successive billions in world population 1800-2050.
(Source: US Census Bureau, Global Population Profile, 2002).



Population growth rate has fallen from its peak of 2% per annum in the 1960's to around 1.2% per annum todayⁱ, with the UN's Population Division expecting that population is likely to reach 9.2 billion people by 2050ⁱⁱ; or to put it another way, over the next 40 years the world's population is expected to grow by almost 30%, which means that by 2050 there will be another 2 billion people wanting to be fed, watered, housed, educated and employed.

This growth in population will not be spread uniformly around the world; in fact nearly all of this growth is expected to come from the developing world (see Figure 2); the developed world's population is expected to remain around 1.2 billion people, (in Europe the population is expected to decline as fertility levels remain below replacement levels)ⁱ.

Figure 2: Global population by type of area and by region 1950-2050 (Source: UN Population Division, World Population Prospects, The 2008 Revision, 2008).

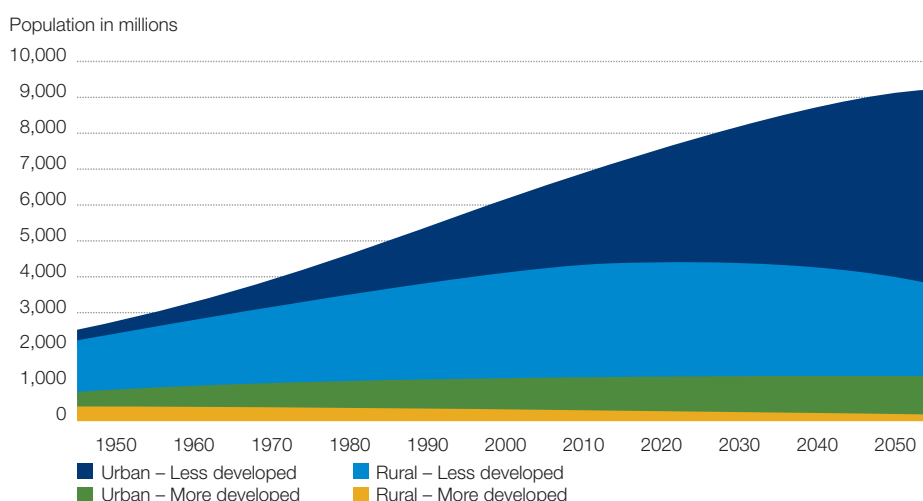
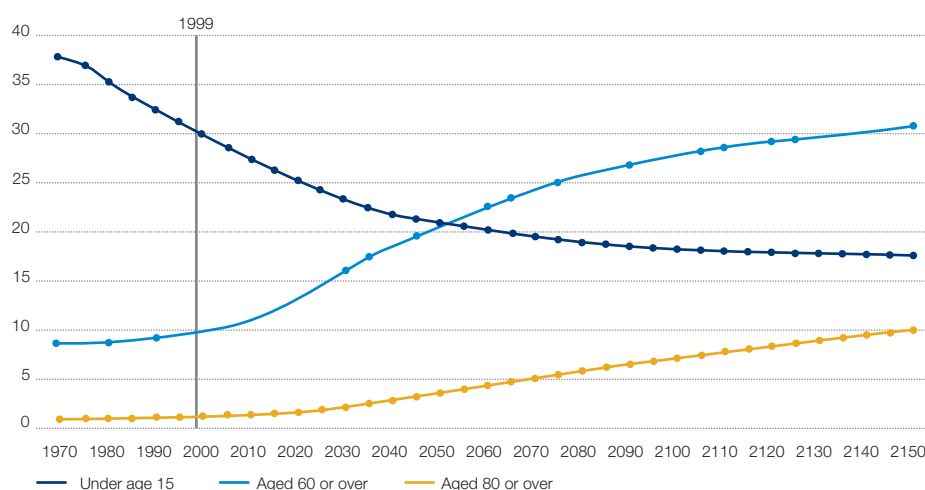


Figure 2 also highlights the increasing number of people who will be choosing to live in urban centres. In 2007 around 50% of the world's population lived in urban areas*, this figure was mostly made up of the populations from the developed world (see Table 3 in Appendix 1), where over 70% of the population live in urban areas, and as Figure 2 shows, this trend for increased urbanisation will be followed in the developing world as well. Increased urbanisation and higher urban populations will create new demands for life's essentials such as food, water, energy, housing and healthcare; some of these changing patterns of demand may be beneficial due to the efficiencies able to be exploited within high density populations, others may not.

*Despite having over 50% of the World's population, cities only occupy 2% of the World's land surface, yet they consume 75% of all natural resources and, in 2006, accounted for 71% of the World's carbon dioxide (CO₂) emissions (Decoupling Natural Resource Use and Environmental Impacts from Economic Growth. Un Environment Programme, 2011).

In addition to there being 30% more people on the planet in 2050 and the numbers of people living in urban areas doubling from around 3.4 billion today to around 6.4 billion by 2050, there will also be a significant change in the age profile of the global population (as shown in Figure 3) as life expectancy around the world continues to improve.

Figure 3: Percentage of the world population under 15, aged 60 or older and aged 80 or older, 1970 – 2150 (Source: The World at Six Billion, Department of Economic and Social Affairs, United Nations Secretariat 1999).

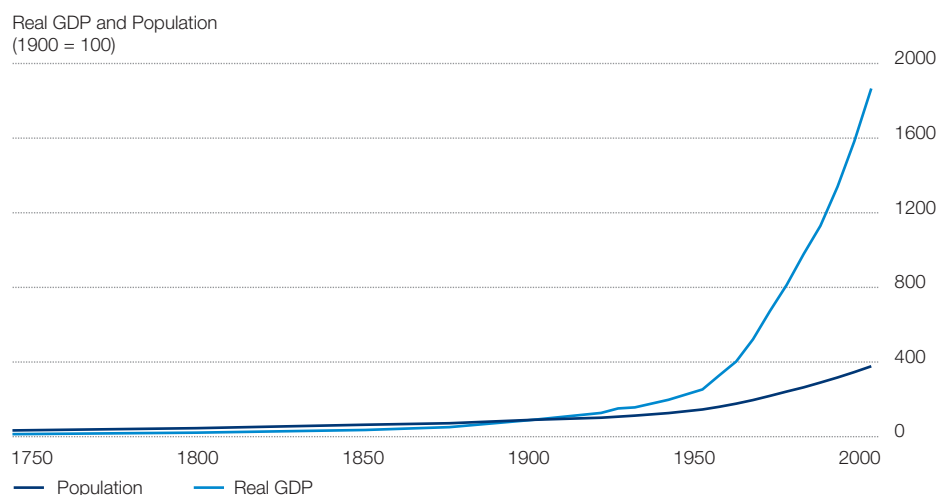


Initially this aging will be seen in the developed world, with the developing world having a younger demographic. Both demographics place demands on the society in which they occur, with older demographic societies facing challenges in workforce composition, economic development, healthcare, transport strategies and changing patterns for food, energy and consumer goods; whilst the developing demographic will see increased rural to urban migration by young people searching for work, resulting in increased pressures on domestic food production and water abstraction.

Chapter 2: Economic growth projections

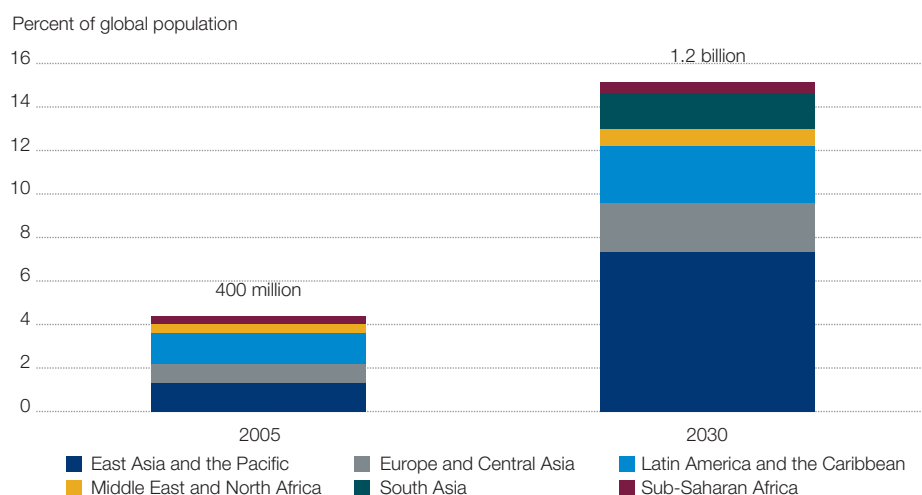
Along with our incredible success in populating the planet, has come our ability to utilise its resources to improve living standards, with Gross Domestic Product (GDP) commonly used as a measure of this success. As with population, the growth in wealth started slowly, but has rapidly increased over the last sixty years (see Figure 4 below), and the global integration of commodity, capital and labour markets (globalisation), has provided consumers with a wide range of products and services at low prices. Such has been the impact of globalisation, that between 1900 and 2000 World GDP increased 20 to 40 times whilst population increased fourfold (urban populations increased 13 times)ⁱⁱⁱ. However this increase in wealth has not been distributed evenly, with the ratio of average incomes per capita between North America and Africa increasing from three at the start of the 19th century to 17 today^{iv}.

Figure 4: World GDP and population growth (1750-2000) (Source: International Monetary Fund, World Economic Outlook 2000 [Washington, D.C.], based on J. Bradford DeLong, Estimating World GDP, One Million B.C.–Present [Department of Economics, University of California at Berkeley, 1998]).



Future projections are that standards of living are expected to continue to rise, with the most rapid growth occurring in Asia and the slowest in Europe and Latin America, as emphasised in Figure 5 below.

Figure 5: Population in low- and middle-income countries earning \$4,000-\$17,000 per capita (purchasing power parity) (Source: World Bank, Global Economic Prospects, 2007).



Indeed, the research read in the background to this report has an optimistic belief that growth will continue to occur.

- HSBC's 'The World in 2050' predicts that world output will treble, with annual world growth projected to accelerate to 3%. HSBC estimates that emerging world growth will contribute twice as much as developed world growth over the next forty years and by 2050 emerging world economies will be five times bigger than today.
- In 2006 PriceWaterhouseCoopers produced a detailed breakdown of where it believes global growth will occur in its report 'The World in 2050' (see Table 1), with the average annual growth rate of around 3%, which, when compounded over 40 years, implies a global economy around three times the size of today's economy.
- The OECD expects the World's economy to double by 2030, with most of this growth occurring in the emerging markets^v.
- Societe Generale estimates that World growth will occur at 2.8% per annum between 2010 and 2020 , which, if this figure were to be extended out to 2050 would imply a global economy three times bigger than today's.

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Country	GDP in US \$ terms	GDP in domestic currency or at PPP	Population	GDP per capita at PPPs
India	7.6	5.2	0.8	4.3
Indonesia	7.3	4.8	0.6	4.2
China	6.3	3.9	0.1	3.8
Turkey	5.6	4.2	0.7	3.4
Brazil	5.4	3.9	0.7	3.2
Mexico	4.8	3.9	0.6	3.3
Russia	4.6	2.7	-0.5	3.3
S. Korea	3.3	2.4	-0.1	2.6
Canada	2.6	2.6	0.6	1.9
Australia	2.6	2.7	0.7	2.0
US	2.4	2.4	0.6	1.8
Spain	2.3	2.2	0.0	2.2
UK	1.9	2.2	0.3	2.0
France	1.9	2.2	0.1	2.1
Italy	1.5	1.6	-0.3	1.9
Germany	1.5	1.8	-0.1	1.9
Japan	1.2	1.6	-0.3	1.9

Table 1: Projected real growth rates for expanded group of emerging market economies: 2005-2050 (% pa). (Source: 'The World in 2050: How big will emerging market economies get and how can the OECD compete?' PriceWaterhouseCoopers, 2006.)

The rise in per capita affluence has caused the increase in demand for consumer goods, energy, food, water, living space, leisure products and travel which all place demands on the natural resources and ecosystem services of the natural world.

So with the average forecast estimating that the global economy will be three times bigger than it is today, it seems illogical not to question what this will mean in terms of consumption and whether the planet can actually support 3% annual compound growth predictions, or a global economy 300% larger than today's (especially given we are already in 50% biocapacity overshoot – as the next chapter discusses – and that this will impact on the well-being of future generations). To emphasise what this prediction of growth may mean we have used a couple of examples below which show what the potential implications are of increasing affluence within China:

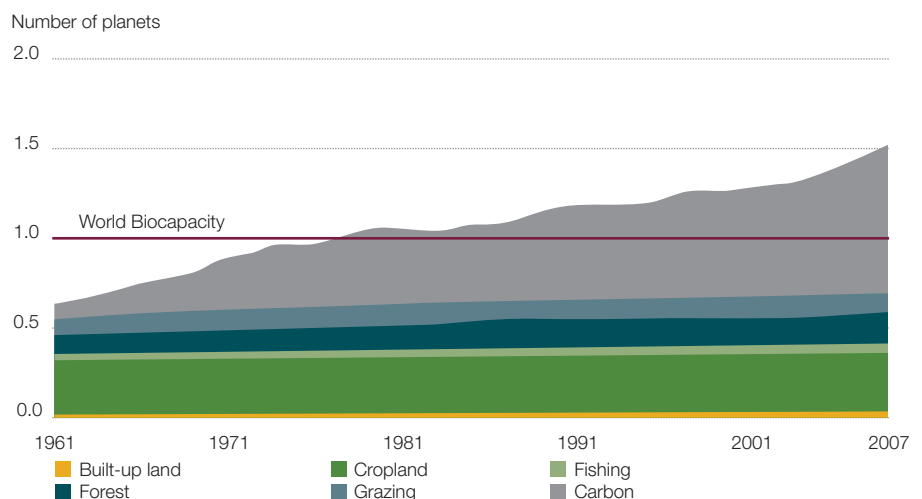
- **If everyone in China started having one more egg a week, this would require an additional 70 billion eggs a year, which would require 250 million more chickens, which in turn would need 8 million tonnes of chicken feed (1% of global corn production) which implies that an additional 3.5 million acres of agricultural land would need to be put to use (assuming no improvement in yields)^{vii}.**
- **Currently there are around 800 million cars in the world. In the USA there are 809 cars per 1,000 citizens or a total of 250 million cars. In China this figure stands at 37/1,000 (49.5 million cars)^{viii}. Now if consumption in China follows the same path as the USA then, based on the current population figures from the World Bank, there would be 1.08 billion cars in China alone – 135% more than in the World today. It is quite easy to state this figure. But then one has to think about the resource demands that this will generate in terms of commodities used in the construction of these cars and the fuel demand for this fleet and one can quickly see that under current models of economic growth the impacts on resource demand and the pollution generated could be quite staggering.**

Chapter 3: Environmental Impact – we are living on 1.5 planet's biocapacity

This massive growth in human population and the economic benefits that have been realised over the last fifty years have resulted in unprecedented changes to the planet's ecosystems. Natural ecosystems have been exploited to create sources of food, fuel and shelter, which has had mixed impacts. This exploitation of our planet has given rise to the huge increases in population and the associated economic growth that has been discussed in the previous chapters, but it has also had negative impacts; the significant and wide reaching implications of which are increasingly being analysed and quantified.

'The Global Footprint Network' has developed a tool which measures humanity's demands for resources (its ecological footprint) against the planet's ability to generate these resources and absorb the waste we produce (the planet's biocapacity) (Figure 10, Appendix 2). Currently this model only includes CO₂ as a waste element within the biocapacity calculation, however, even with the omission of other pollutants, their calculations estimate that we are using 1.5 planets to sustain our global society, or, to put it another way, it would take 1.5 years for the planet to regenerate the resources we used (as shown by the headings of built-up land, cropland, fishing, forest and grazing in Figure 6, below) and to absorb the carbon we produce in a year, which doesn't add up

Figure 6: Humanity's Ecological Footprint 1961-2007 (Source: Living Planet report 2010, WWF, Zoological Society of London, Global Footprint Network).



Perhaps of most use in thinking about the future is in looking at the *per capita* footprints for each nation, which should provide an idea of the challenge we face if, as the previous chapter has suggested, everyone aspires to the lifestyles of the developed world.

Table 2 takes a look at the ecological footprint *per capita* at a national level and shows what this would mean if extrapolated to a global level of consumption. So if everyone were to consume at the same level as an average Indian citizen then we would only be utilising the biocapacity of half of planet Earth, however if everyone were to consume resources in a similar manner to an European then this would need just under 3 planets to support this level of consumption, a figure that increases to 4.5 planets if the World's population were to live like an American citizen.

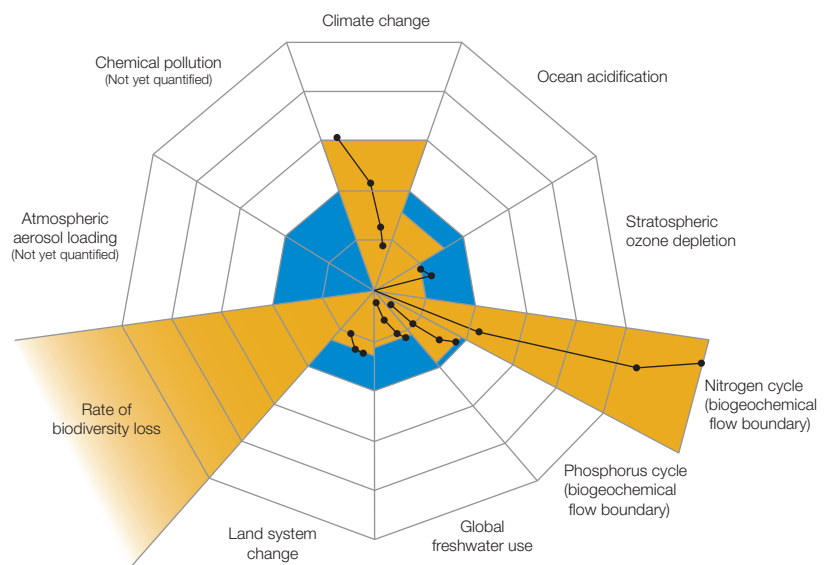
Table 2: Selected national ecological footprint *per capita* data, and planets needed to support these levels of consumption (Source: 'Ecological Footprint Atlas', 2010, Global Footprint Network and Schroders).

Country	Ecological Footprint of consumption (gha per person)	Planets needed to support that level of consumption
India	0.91	0.51
Indonesia	1.21	0.68
China	2.21	1.24
Turkey	2.7	1.52
Brazil	2.91	1.63
Mexico	3.00	1.69
Russia	4.41	2.48
S. Korea	4.87	2.73
Canada	7.01	3.93
Australia	6.84	3.84
US	8.00	4.49
Spain	5.42	3.04
UK	4.89	2.74
France	5.01	2.81
Italy	4.99	2.80
Germany	5.08	2.85
Japan	4.73	2.65

This biocapacity overshoot means that we are rapidly drawing down on the planet's regenerative capacity, and severely influencing the ecosystem services (see Appendix 2, Table 6 for a definition of these various ecosystem services) on which our economy and society depend for services such as food production, soil formation, pollination and climate regulation.

One of the strongest indicators of the impacts of this overshoot is demonstrated by research produced by the Resilience Alliance in 2009, which identified nine planetary boundaries in which humanity could operate sustainably (see Figure 7).

Figure 7: Planetary Boundaries.
(Source: Planetary boundaries:
exploring the safe operating space for
humanity, 2009, Resilience Alliance).



Of these nine boundaries the research showed that humanity has already transgressed three of them: Climate change, the nitrogen cycle and biodiversity loss. The Resilience Alliance's report uses the *Holocene* as a reference point (as it was during this geological period in the Earth's history that conditions were suitable for humans to evolve) and it states that in this current geological period, which is increasingly being referred to as the *Anthropocene*, there is clear evidence that humans are affecting the Earth's systems on a planetary scale (Appendix 2 provides some examples of the exhaustibility of the planet's natural resources). There is an acknowledged degree of scientific uncertainty about the nature of these thresholds; such as how long is it safe to surpass them and how they interact with each other, but the overriding point is that if we have changed the planetary conditions under which humanity has evolved, then what are the implications of living within this ecological overshoot to our current society and our projections for economic and population growth?

It is not infeasible to make similar conjectures about planetary overshoot as have been made about economic and population forecasts; which, under business as usual projections, would show that by 2030 we will be using the biocapacity of 2 planets, rising to 3 planets by 2050^{ix}.

Chapter 4: Where's the discussion?

As the previous chapter has shown, the scientific evidence suggests that we are already in planetary overshoot in 1 out of 3 of the planet's life support systems, and the current rate of consumption by the World's population is 50% over the capacity of the planet to support our society. Given that the economy is a sub-system of the natural system, then the stresses occurring within this system will surely be echoed within predictions about economic growth or population growth. And yet, the background reading of several mid and long term-economic forecasts from international institutions and global investment houses (as referenced in Chapter 3) reveals that only a few made any reference to ecosystem decline challenges in their growth forecasts, let alone actively incorporated this decline into these forecasts. This finding was supported by a survey Schroders undertook of 14 Chief Economists (please see Table 7 in Appendix 3 for a list of the institutions contacted) in the run up to the World Forum on Enterprise and the Environment. Of the 14 questioned on various aspects of Ecosystem Service economics (see Table 6, Appendix 3 for the questions) only three provided any response:

- **one saying the subject was too big for them to contemplate.**
- **another saying that they believed that economic growth in the emerging markets would be inflationary on commodity prices but that externalities are typically underweighted.**
- **and the final saying that this was already incorporated in their report (though one may question whether the following sentence “One of the most significant variables we are not capturing is the natural resources with which an economy is endowed and how this drives its relative terms of trade and its bargaining power in the global economy” at the end of a 30 page, 40-year, economic outlook is really demonstrating integration).**

So the question that arises is why isn't this being integrated into economic models? Some may point to the fact that classical economic predictions of limits to growth and living standards have so far been proved wrong, with the population and the global economy continuing to grow. This is in part due to the fact that this line of argument focuses on natural resources that have an economic value (e.g. fossil fuels, timber, fish stocks) and, thanks to mankind's remarkable ability to innovate and adapt, we have been able to harness new technologies to expand the use of natural resources (e.g. technology is now helping us to extract resources from much more challenging locations, whilst economics makes it possible to exploit much lower quality resources), find alternatives (e.g. wind power as opposed to fossil fuels) and improve the efficiency of resource use.

However, whilst these advances in technology and economic growth have enabled us to continue to exploit the provisioning ecosystem services from the natural world (e.g. food, fuel) they have been able to do so at the expense of the supporting (e.g. soil formation, nutrient cycles) and regulating (e.g. flood regulation, climate regulation) ecosystem services. This is because of gross market failure to recognise the economic value of these services, to fail to recognise the full costs of an activity (often referred to as integration of the externalities) and to not ascribe a suitable discount factor to a renewable resource which means its exhaustibility is not captured by the market.

Externalities

The economic term 'externalities' refers to the fact that the full benefits or costs are not internalised into the costs of an economic activity, creating market distortions. If a product associated with an economic activity or service has a negative impact then the full cost of this product or service is not realised by the buyer causing overproduction or overutilisation of that product or service; whereas the opposite is true for positive externalities.

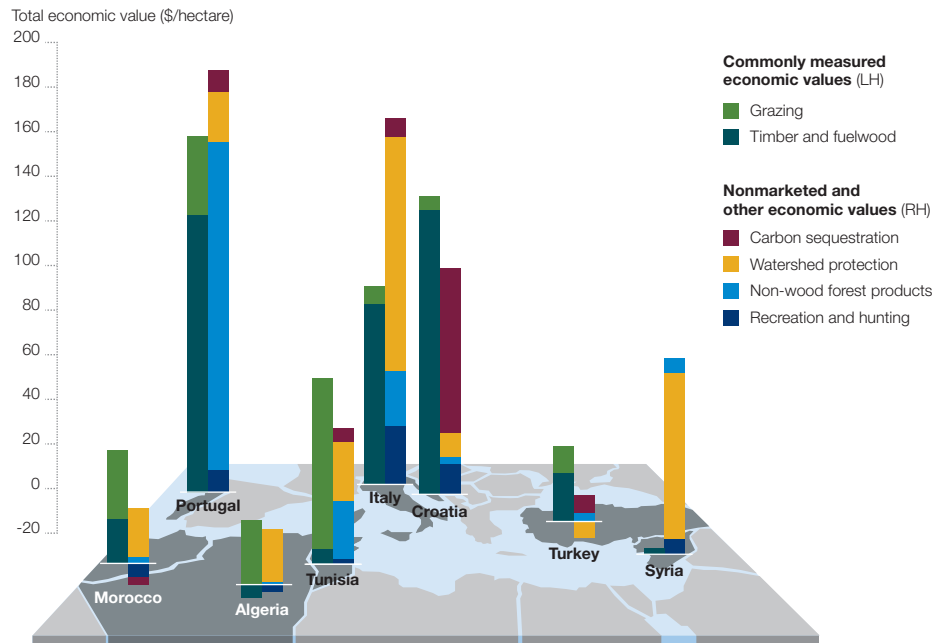
A good example of a negative externality is the extraction of coal (a non-renewable natural resource) and its combustion. The utilisation of coal clearly has a recognised economic value, however this value does not integrate the other costs associated with coal's combustion, namely its negative contribution to climate change* and human health. An article published in the August 2011 American Economic Review* modelled the physical and economic consequences of emissions of six major pollutants (sulphur dioxide, nitrogen oxides, volatile organic compounds, ammonia, fine particulate matter and coarse particulate matter) from 10,000 pollution sources in the United States. In the case of coal fired power stations it found that the costs of pollution (in terms of health, the study did not include the climate change costs) from this industry alone were around US\$53 billion, which the authors estimate as being 0.8 to 5.6 times the value added by the industry.

Another example is deforestation which generates an immediate value when the lumber is sold, but the costs associated with greenhouse gas emissions, soil loss, biodiversity loss and water regulation (amongst other services) are not recognised in this value. Figure 8, from the Millennium Ecosystem Assessment shows that the provisioning value (timber and fuel wood) of Mediterranean forests generally account for less than a third of the estimated total economic value. The report also says that this may well be an overestimate as it is easier to measure provisioning services than other services and that if forests were only to be valued for their timber they would appear much less valuable than they actually are and would therefore only be managed for their extractive uses instead of the other services they provide.

*Please see Appendix 2: Climate Change for more information on this.

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Figure 8: Estimates of the total economic value of forests in selected Mediterranean countries. (Source: Ecosystems and Human Well-being: Current State and Trends, Volume 1. Millennium Ecosystem Assessment, 2005).



With regards to a positive externality a good example comes from New York City and the valuation of the water filtration services provided by the Catskills Mountain watershed. The officials found that the replacement cost of this service with a water purification plant would cost \$6-8 billion in 1996^{xi} and that conserving the wetlands (at a cost of \$1.5 billion) was therefore a cheaper means of providing clean drinking water to New York City.

Externalities tend to only be costed in when the costs to society are too great. For example, in 1929 the UK House of Lords ruled that a coal fired power station had to fit flue gas desulphurisation equipment to stop the negative health and environmental impacts derived from sulphur dioxide pollution of the atmosphere. Similar legislation has been enacted around the World due to the concerns about the impacts of sulphur dioxide emissions on human health, the natural and built environments. This has forced the negative costs of this activity to be internalised (though only with regards to sulphur dioxide) in the form of expenditure on flue gas desulphurisation equipment being fitted to flue gas stacks or, if the costs of fitting the new technology were prohibitive, the closure of the dirtiest power stations.

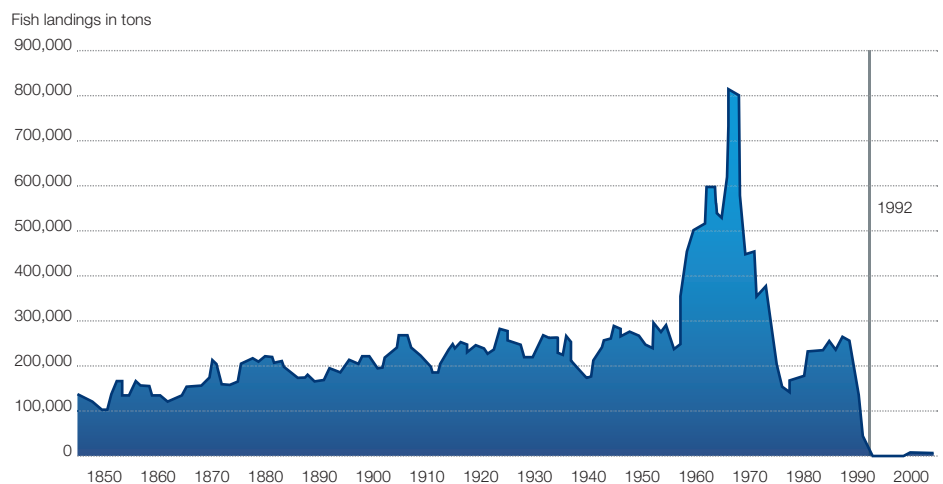
Exhaustibility

Another element of market failure when it comes to ecosystem services occurs if the rate of extraction of a natural resource outstrips the reproductive capacity of that resource, making it a non-renewable resource. This has implications for intergenerational equity because if our rate of consumption exceeds that at which the resource is replenished then every unit that we utilise will reduce the amount that is available for consumption in the future.

An example of the failure to support intergenerational equity is the overexploitation of the oceans which has led to a massive decline in the top carnivores in the oceans which has affected the oceanic food web, and has led to the global decline in fish stocks (see Appendix 2). Figure 9 shows the well documented example of the collapse of the Atlantic Cod stocks off Newfoundland in the early 1990's due to over exploitation. The economic impacts of this exploitation were the loss of tens of thousands of jobs and a cost to the Canadian government (and people) of CAN\$2.66 billion in income support and retraining^{xii}.

Figure 9: Collapse of Atlantic Cod stocks off the east coast of Newfoundland in 1992.
(Source: Millennium Ecosystem Assessment, 2005).

Fish landing in tonnes



What we hope to have highlighted in this report is that if the full value of an economic activity is not reflected in its pricing then this can lead to serious impacts on the ecosystem services on which the economy depends. It is well recognised that the main measurement of Gross Domestic Product has many inherent problems. It measures the market value of all final goods and services produced within a given time period and includes many items that do not actually have a positive social benefit (e.g. expenditure on reconstruction following natural disasters, health care for pollution diseases) and ignores other values such as child care, leisure time and, most relevant to this paper, the value of clean air and fresh water (externalities). This means that the full economic value of natural assets is not accounted for at a national or firm level and decisions are based on the immediate benefits of an activity rather than from a thorough cost-benefit analysis of their overall contribution to society or of the implications arising from their degradation.

There are various studies which have begun to work on establishing a value for the various ecosystem services and hence enabling a more realistic approach to economic forecasting:

- **The 2008 Economics of Ecosystems and Biodiversity study concluded that the degradation of the earth's ecosystems and biodiversity due to deforestation alone costs us natural capital worth somewhere between USD1.9 – 4.5 trillion every year.**
- **The World Business Council on Sustainable Development estimates that shifting to a sustainable global economic model will see markets in natural resources, education and health being worth around US\$0.5-1.5 trillion in 2020 and increasing to US\$3-10 trillion *per annum* by 2050**
- **The US Interagency Working Group on the Social Cost of Carbon determined that the present day value of the damage caused by 1 tonne of carbon was \$21. But when the model was re-run by the Stockholm Environment Institute, with a few changes to some of the assumptions (e.g. changing the rate and economic impact of climate change; as well as the discount rate [which was fairly high and hence giving greater importance to present generations as opposed to future ones]), it produced values ranging from US\$28 to US\$893 per tonne in 2010 rising to between \$64 and \$1550 in 2050.**

The large variance in values shown in the final bullet above emphasises the challenges in recognising the full cost economics of ecosystems services (though this doesn't mean it shouldn't be attempted). Currently there is little economic incentive to conserve natural resources, nor are there large penalties for destroying them. By integrating externalities and exhaustibility into valuations it will, in essence, force people to economically justify the consequences of their actions on current and future generations, as well as on the planet's ecosystems. It is therefore encouraging to detect a gradual recognition of ecosystem valuation at both the national and corporate level. 2011 saw the UK Government publish its first National Ecosystem Assessment, we have also found that companies are increasingly talking about biodiversity and ecosystem services (mostly those companies with a high environmental impact) and some have even started to assess the economic value/cost of ecosystem services to their business though as yet, and as with many studies on this subject, these assessments are small scale and not company wide.

We believe that economic analysis which truly reflects the full costs of economic and population growth is essential for the effective integration of Environmental, Social and Governance issues into stock valuation and selection decisions, as the economics provides the backbone to the investment process. This report provides a high level overview of the issues and should help to further engagement on this issue at both the corporate and the macro-economic level.

Appendix 1

Population growth

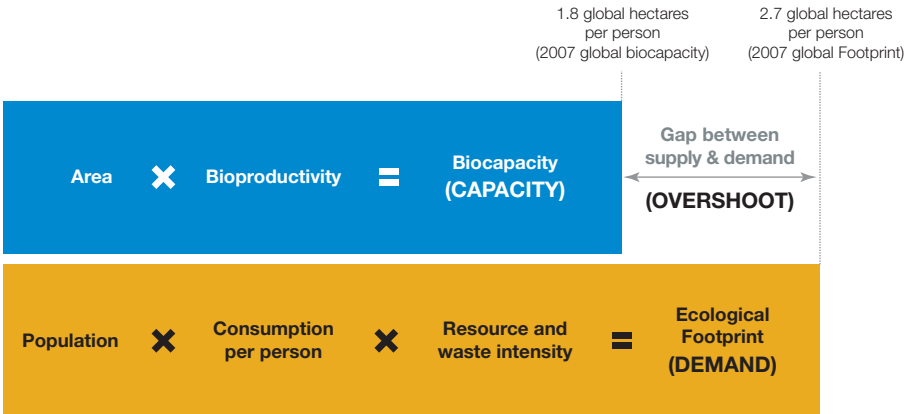
Region	Mid-year population (thousands)			Population density (ppl/km2)	Percentage Urban	Average annual rate of population change (%)	Crude birth rate (births per 1,000 population)	Crude death rate (deaths per 1,000 population)	Total fertility (children per woman)	Life expectancy at birth (years)	Percentage of population	
											Under 15	50+
		2007	2020	2050	Mid 2007		2005-2010					Mid-2007
World	6,671,226	7,667,090	9,191,287	49	50	1.2	20	9	2.6	67	28	11
Africa	964,973	1,270,528	1,997,935	32	39	2.3	36	13	4.7	53	41	5
Asia	4,029,665	4,596,189	5,265,895	126	41	1.1	19	7	2.3	69	27	10
Europe	731,284	722,060	664,183	32	72	0.0	10	12	1.5	75	16	21
Latin America & Caribbean	572,206	659,562	769,229	28	78	1.2	20	6	2.4	73	29	9
Northern America	338,831	379,270	445,303	16	81	1.0	14	8	2.0	78	20	17
Oceania	34,267	39,482	48,742	4	71	1.2	17	7	2.3	75	24	15

Table 3: World Population Prospects (Source: Adapted from World Population Prospects, The 2006 revision. UN Population Division, Department of Economic and Social Affairs, UN 2006; Schroders)

Appendix 2

State of ecosystem services

Figure 10: Footprint and biocapacity factors that determine global overshoot (Source: Ecological Footprint Atlas, Global Footprint Network, 2010).



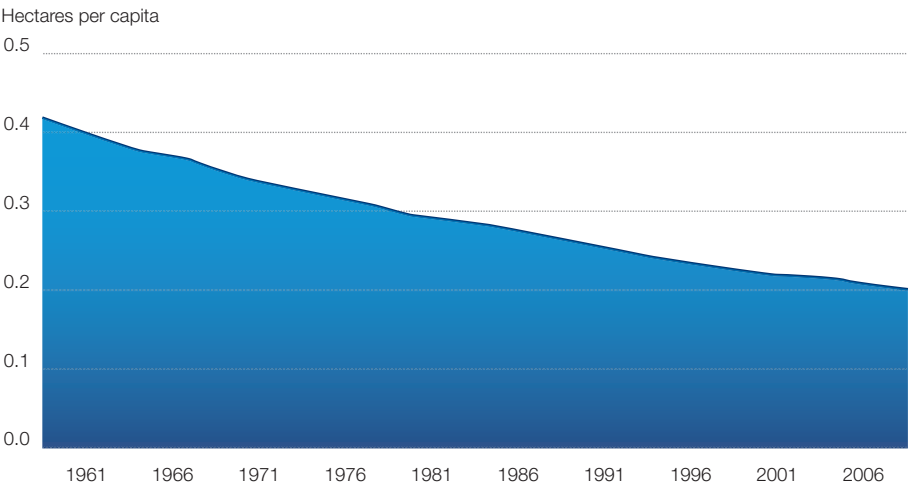
Exhaustibility

Table 4: A breakdown of some of the ecosystem services.

Supporting	Provisioning	Regulating	Cultural
Nutrient cycling	Food	Climate Regulation	Aesthetic
Soil formation	Fresh water	Flood Regulation	Spiritual
Primary production	Wood & Fibre	Disease Regulation	Educational
	Fuel	Pest Regulation	Recreational
	Dyes	Water Purification	Ecotourism
	Medicines	Waste processing	
		Erosion control	
		Air Quality regulation	

Land

Figure 11: World hectares of arable land *per capita* – Source: UNFAO, US Census, GMO quarterly letter, separating the dangerous from the merely serious, July 2011.

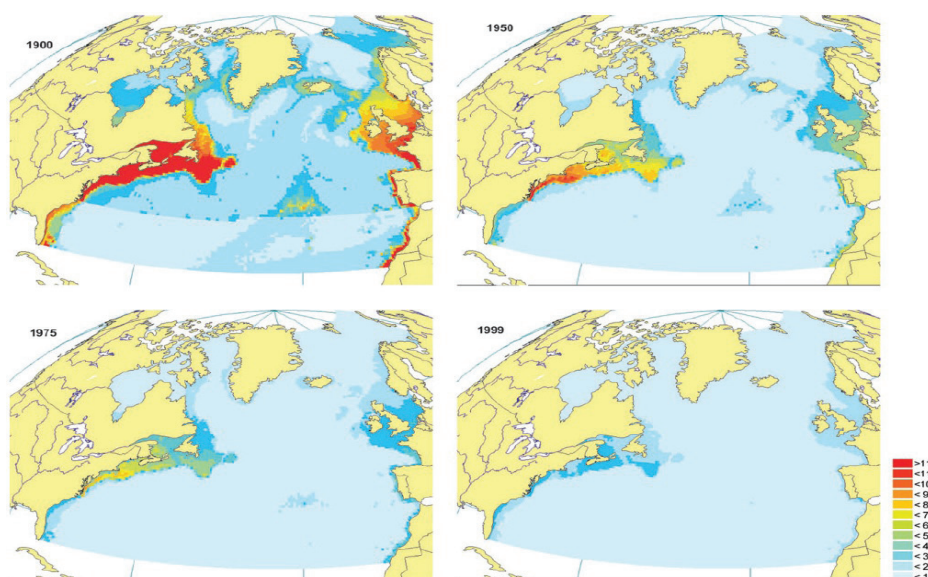


Due to population growth, the available land per person is decreasing, meaning that more productivity is required from less land to fuel increased population demands. Over the past decade *per capita* cropland has declined 20%. Each year, more than 10 million hectares (ha) of cropland are degraded and lost due to soil erosion. Only 0.23ha of cropland *per capita* are available, whilst the minimum that is needed to support a diverse food system, such as that of the US's or Europe's is 0.5ha^{xiii}. Research by Cornell University shows that over the last 40 years, nearly 1/3rd of the World's arable land has been lost by erosion and continues to be lost at a rate of more than 10 million hectares per year (in the US it is estimated that 40 billion tonnes of soil are lost each year). Whilst the natural replacement rate for soil is around 2.5 tonnes per acre per year, with it taking between 50-1,000 years to replace one inch of sub-soil^{xiv}.

Fisheries

As population has grown and annual GDP *per capita* has increased, the change in diets has seen an increase in demand for sea food. During the period of 1990 to 2007 the total world export of fish has increased 60% from 33 million tonnes to 53 million tonnes, with the proportion of world trade in fish production increasing from 34% to 38% over the same period. However the proportion of this figure that has come from ocean and fishery catches has stayed flat at around 90 million tonnes, with nearly all the growth in recent years coming from aquaculture^{xv}. Figure 12 shows the gradual decline in marine biomass in the North Atlantic over the last 100 years, demonstrating the impacts of over-extraction on this natural resource.

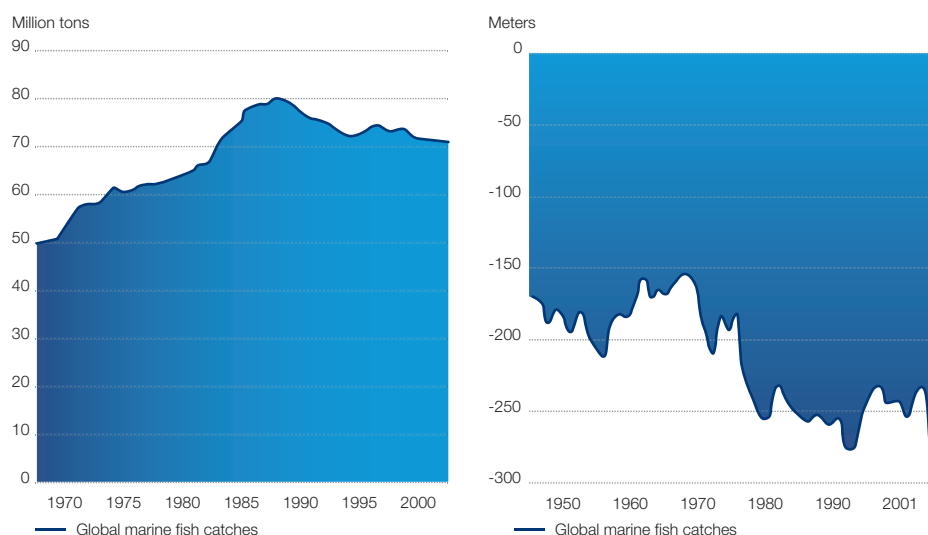
Figure 12: Changes in Marine Biomass in North Atlantic in 1900, 1950, 1975, and 1999 (in tons per square kilometre) (Christensen et al. 2003).



Figures 13 and 14 show that whilst fish catches (by weight) over the last 30 years have increased (though are declining more recently) this has only been possible by fishing at deeper and deeper depths to land the catches, as the easier to catch, shallower fisheries have been fully exploited.

Figure 13: Estimated global fish catch (Source Millennium Ecosystem Assessment).

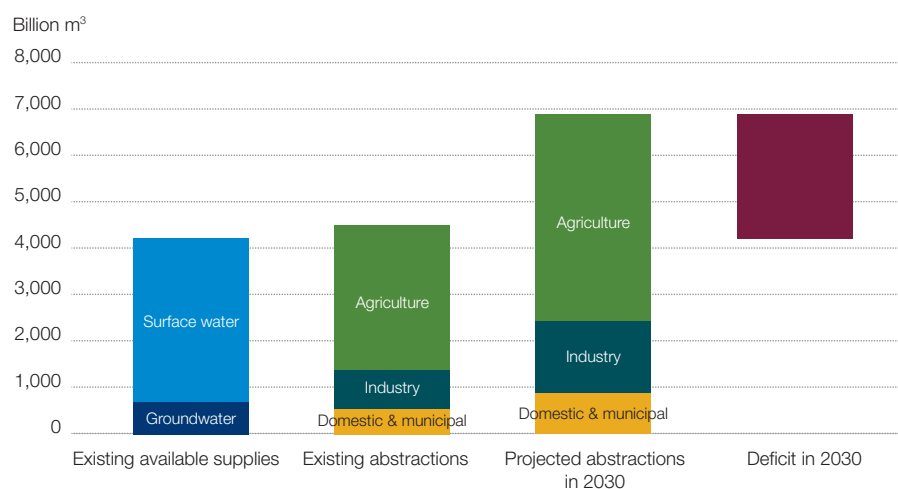
Figure 14: Trend in mean depth of catch since 1950 (Source Millennium Ecosystem Assessment).



Water

Water scarcity is likely to be a severe global issue within the next 15-20 years (as highlighted in our 2007 report 'Water: Cheap and abundant, but not for long'). Whilst at the global level, there may be enough water to meet demand, the distribution of water reserves is not equal and the physical nature of water means that it is difficult to transport from regions of abundance to regions of scarcity. This has given rise to the concept of virtual water, with countries that have water scarcity concerns importing water-intensive products from regions of abundance, which creates water savings in importing countries as it frees up water reserves for other uses. However trade in virtual water can also exacerbate water scarcity issues, for example: Thailand experiences water shortages as too much water is used to irrigate crops for export; whilst the flower growers in Lake Naivasha, Kenya are realising economic gains, but are also depleting the water resources there^{xv}. Figure 15, shows the potential water supply and demand gap that is expected in 2030.

Figure 15: Fresh water abstraction and supplies (bn m³) through to 2030. (Source: Feeding the World in 2020: Investable opportunities in agricultural productivity, GS Sustain July 2011).



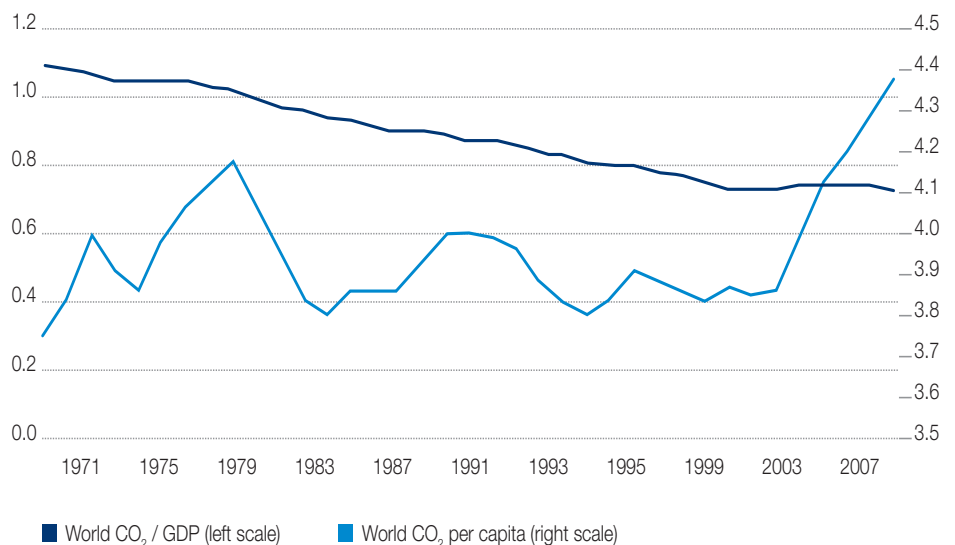
In addition to supply and demand concerns, is the issue of clean fresh water with over 1 billion people lacking access to safe drinking water, and 2.5 billion lack access to adequate sanitation. This also has implications for industries which need clean fresh water in order to operate.

Climate Change

According to the International Energy Agency, annual World CO₂ emissions from fuel combustion more than doubled from 14.1 billion tonnes in 1971 to 28.9 billion tonnes in 2007. Global CO₂ emissions per person grew by around 17% during this period, with sharper growth towards the end of this period on account of rapid growth within emerging economies^{xv}. The European Commission's Joint Research Centre and PBL Netherlands Environmental Assessment Agency published more recent figures, in June 2011, that showed that despite the impacts of increased energy efficiency and the growing use of non-fossil fuel based energy sources, demand for power and transport outstrips these improvements and global CO₂ emissions have continued to increase with an all time high of 33 billion tonnes being emitted in 2010.

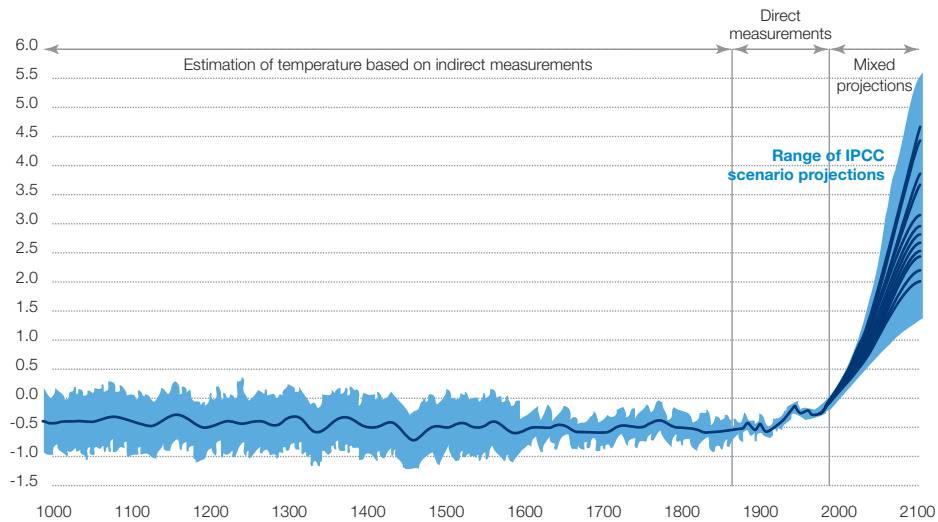
Figure 16 shows that whilst there has been some success in separating CO₂ emissions from economic growth through efficiency improvements, these benefits will be undermined by the sheer volume in growth of CO₂ /capita.

Figure 16: World CO₂/GDP and CO₂/capita, 1971-2007. (Source: World Trade report 2010, Trade in natural resources, World Trade Organisation).



Rising atmospheric CO₂ levels due to anthropogenic emissions will contribute to the rate of climate change with it already being widely accepted that there is already a 2°C level of warming above pre-industrial levels by the end of this century locked in to the system (Figure 17 shows the Intergovernmental Panel on Climate Change's projected increases in average global temperatures under different scenarios). The extent of global warming will have wide ranging impacts on food supplies, fresh water reserves, health, sea level rise and glacial melt as well as other ecosystem services and resources. In the 2006 Stern Review on the Economics of Climate Change it was postulated that under current emissions rates we are likely to reach 550 parts per million CO₂ - equivalent by 2035; at this concentration there is a 77-99% chance of **dangerous climate change** (a warming of 2°C above pre-industrial levels). The Stern Review calculated that the impacts of a 2-3°C warming would have a 0-3% permanent annual decrease in global GDP then would have been expected if climate change didn't occur, but that the annual costs of mitigating this level of climate change could be around 1% of GDP per annum (with a range of -1 to +3.5%).

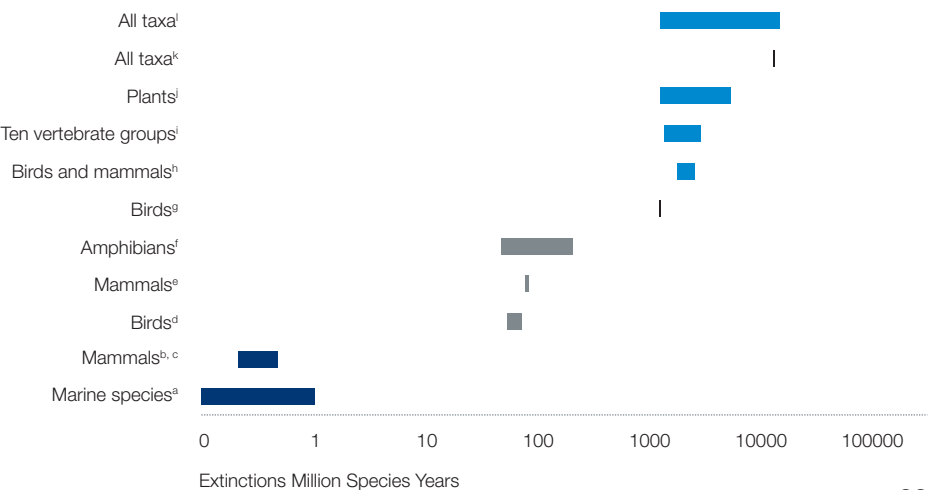
Figure 17: Historical and projected variations in Earth's surface temperature. (Source: IPCC, 2002 (Millennium Ecosystem Assessment: Ecosystems and Human Well-being. Opportunities and Challenges for Business and Industry, 2005).



Biodiversity

Figure 18: Background and Contemporary Extinction Rates. Background extinction rates are in dark blue, extinction rates based on observed extinctions over the past 100 years are in grey and estimated contemporary extinction rates using a number of different approaches are in light blue. Based on background extinction rates from the fossil record: a May (1995), b Alroy (1998) (lower estimate of 0.21), c Foote (1997) (higher estimate of 0.46). Observed extinctions over the past 100 years: d, e, f Baillie et al. (2004). Projections based on threatened species: g Pimm and Brooks (1997), h Smith et al. (1993) (also uses recently extinct species), i Mace (1994). Plant extinctions using species-area curve with assumptions about habitat loss from agricultural/urban expansion and from climate change: j MA Scenarios, Chapter 10. Increased energy consumption: k Ehrlich (1994). Species-area relationship from deforestation rates: four studies in l Reid (1992). (Source: Ecosystems and Human Well-being: Current State and Trends, Volume 1. Millennium Ecosystem Assessment, 2005).

Another outcome of population and economic growth has been an increase in the rate of species extinctions several orders of magnitude greater than the background rate (Figure 18). The sheer range of biodiversity has played an essential role in human development, as we have been able to use it for agricultural, health, industrial and cultural benefits. The loss of biodiversity will clearly impact these benefits we most easily recognise, however it will also impact on the resilience of ecosystems and the services they supply. This loss of resilience impacts the ability of an ecosystem to respond to any disturbance to it, and if this disturbance is of a sufficient magnitude or duration then it may cause the ecosystem to breach a threshold from which it cannot recover. More often than not these breaches result in an ecosystem with less desirable and more degraded services, which will ultimately negatively affect the ecosystem services that we had derived from the previous ecosystem.



Appendix 3

Economics of Ecosystem Services

Ecosystem	Alternative Compared	Services included in TEV calculations	Private benefits	Total economic value	Source
Comparison of benefits of sustainably managed ecosystem to converted ecosystem					
Tropical forest, Cameroon	comparison of low-impact to small-scale farming or conversion to oil palm and rubber plantation	benefits from agricultural or plantation output, sedimentation control, flood prevention, carbon storage, and option, bequest and existence values; 10% discount rate over 32 years	small-scale agriculture had greatest private benefits	across five study site, average TEV of sustainable forestry was approximately \$3,400 per hectare; and that of small-scale farming \$2,000 per hectare; across four of the sites, average TEV of conversion to oil palm plantation was \$1000 per hectare	Yaron 2001
Mangrove, Thailand	comparison of existing uses of mangrove system to conversion to shrimp farming	benefits from shrimp farming, timber, charcoal, NTFPs, offshore fisheries, and storm protection. 10% discount rate over 20 years	conversion to aquaculture had greatest private benefits	TEV value of intact mangroves was a minimum of \$1,000 and possibly as high as \$36,000 per hectare; TEV of shrimp farming was about £200 per hectare	Sathirathai and Barbier 2001
Wetland, Canada	comparison of intact wetlands to conversion to intensive farming	benefits of agriculture, hunting angling, trapping; 4% discount rate over 50 years	conversion to agriculture had highest private benefits (in part due to substantial drainage subsidies)	TEV was highest for intact wetlands (average for three wetlands types of approximately \$5,800 per hectare) versus TEV of converted wetlands of \$2,400 per hectare	Van Vuuren and Roy 1993
Tropical forest, Cambodia	comparison of traditional forest uses to benefits associated with commercial timber extraction	examined benefits associated with swidden agriculture and extraction of non-timberforest products (including fuelwood, rattan and bamboo, wildlife malva nuts, and medicine) and ecological and environmental functions such as watershed, biodiversity, and carbon storage; 6% discount rate over 90 years	private benefits associated with unsustainable harvest practices exceed private benefits of NTFP collection	total benefits were greatest for traditional uses, ranging from \$1,300 to \$4,500 per hectare (environmental services accounted for \$590 per hectare while NTFPs provided between \$700 and \$3,900); private benefits for timber harvest ranged from \$400 to \$1,700 per hectare but after accounting for lost services the total benefits were \$150 to \$1,100 per hectare	Bann 1997

Table 5: Economic Benefits of retaining and converting Ecosystems (Source: 'Ecosystems and Human Well-Being' Millennium Ecosystem Assessment, 2005).

Figure 19: Economic benefits under alternative management practices (Source: Millennium Ecosystem Assessment: Ecosystems and Human Well-being. Opportunities and Challenges for Business and Industry. 2005).

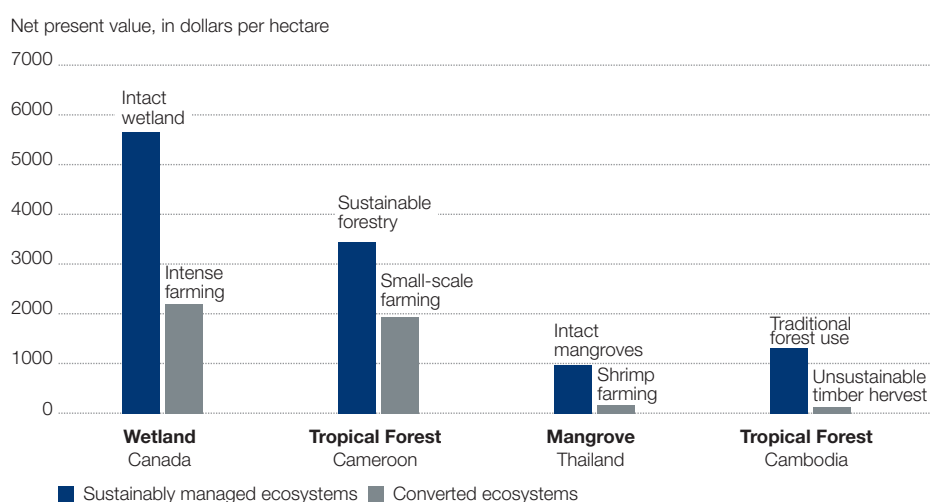


Table 7: List of organisations contacted about Ecosystem Service integration in economic forecasts. (Those in italics provided a response to our questionnaire).

Table 6
How do you incorporate a consideration of ecosystem services into your economic models?
What impact do you estimate the current depletion of these ecosystem services is having on global economic performance, in terms of output, inflation and other metrics?
If you have incorporated a consideration of the decline in ecosystem services into your models, what are the results for your short and long-term (40 year) models?
What are your expectations of the economic response to ecosystem services constraints in terms of market volatility, policy shifts and technological innovation?
If you have not addressed these factors in your models, please could you explain why not?

Table 6: Questions posed to 14 Chief Economists of major city institutions, in a July 2011 e-mail, around the subject of including ecosystem service economics in their forecasts. Source: Schroders.

Table 7	
Bank of America Meryll Lynch	HSBC
Barclays Capital	JP Morgan
Citigroup	Macquarie
CLSA	Nomura
Credit-Suisse	Society General
Deutsche Bank	UBS
Goldman Sachs	Unicredit

The Elephant in the Economics

This short document is intended to support the question about why current mainstream economic analysis isn't recognising the implications of declining ecosystem services and resource shortages to economic growth (and by implication the impacts of economic growth on ecosystem services and resource shortages). Its arguments are based on the work of Tim Jackson ('Prosperity without growth', Paul Gilding 'The Great Disruption' and the recent article by the CEO of GMO, Jeremy Grantham, 'Time to wake up').

Starting from the thesis encapsulated in Paul Ehrlich's equation:

$$I = P \cdot A \cdot T$$

Where

I = Impact of human activity

P = Population size

A = Affluence expressed as income per person and

T = Technological intensity of economic output or impact associated with each dollar spent.

Impact of human activity

Currently, the best estimates for the impacts of human activity suggest we are running the planet at 140% of its biocapacityⁱ (the biocapacity refers to the ability of the world to produce resources our economies need and absorb the waste our economies produce).

Population growth

Population is expected to increase by a third, to 9bn people, by 2050 (an average growth rate of 0.7% per annum)ⁱⁱ.

Economic growth

We expect to grow per capita income by 2.5% paⁱⁱⁱ (according to the IMF and the Australian Treasury), meaning that by 2050 the World's economy is expected to be 3x larger than 2005. If you factor in the population growth this would mean an economy that is between 3.5 and 5 times today's economy.

Technological improvement

Over the thirty years to 2009 world resource use per unit of GDP decreased by 30%, meaning that there is an annual efficiency improvement of 1.2%^v, and energy use has seen an improvement of 1.1% each year^{vi}. If these trends continue we'll be using resources 38% more efficiently by 2050. But take into account that since 1990, greenhouse gas emissions have risen by 40%, despite these efficiency gains, due to population growth and increased affluence.

P*A*T = I

As Paul Gilding says in his book 'Beyond the limits – The great disruption':

"when each of us demands and expects our incomes to increase 2.5 percent a year, using 1.2 percent less resource per dollar of income doesn't avoid the overwhelming logic – our environmental impact continues to grow and grow"

Based on the figures above we would expect to be running the planet at somewhere between 300 and 400% of its biocapacity by 2050. The Global Footprint Network estimates that by 2030 we will be running at 200% capacity^{vii}.

Every government policy is based on economic growth and, based on the PWC estimate of 3.5% compound growth, this implies that the economy will double every 22 years, meaning that we will be running the planet at 280% of capacity by 2031. Whilst T is going down, demonstrating a relative decoupling, the only way for I to be reduced as well is for T to out run the pace of P and A, which currently seems improbable given that few governments are actively managing their populations and none are suggesting economic growth should be curtailed.

ⁱLiving Planet report 2010' WWF, Zoological Society of London, Global Footprint Network ⁱⁱ<http://www.un.org/esa/population/>

ⁱⁱⁱAustralian Treasury and Department of Climate Change and Water. Australia's Low Pollution Future: The Economics of Climate Change Mitigation, 2008.

^{iv}The world in 2050: How big will the major emerging market economies get and how can the OECD compete?' John Hawksworth, PWC, 2006.

^v'Resource Efficiency for Sustainable Growth: Global trends and European policy scenarios', background paper for the UN Industrial Development Organisations International Conference on Green Industry In Asia.

^{vi}'Prosperity without growth', Tim Jackson, UK Sustainable Development Commission, 2009.

^{vii}'Beyond the limits – The Great Disruption' Paul Gilding, 2011.

^{viii}WWF and the Global Footprint Network, Living Planet report, 2008.

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