Navigating an uncertain future:
Environmental foundations for long-term success

By Rick Boven, Catherine Harland & Lillian Grace

Acknowledgements

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The authors:

Rick Boven is the Director of Stakeholder Strategies
Catherine Harland is a Research Fellow with The New Zealand Initiative
Lillian Grace is an Associate with Stakeholder Strategies

Please send any correspondence to rick@stakeholderstrategies.co.nz

A one hour film of this project can be found at http://www.youtube.com/watch?v=EXYCJ4cE-sw

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Executive summary

The global environment is changing and people are becoming more concerned about implications for the future. The purposes of this paper are to describe the global environmental status and trends, offer some explanations for why responses are slow and weak, examine the implications for New Zealand, and propose a strategy development agenda to reduce risks and take advantage of opportunities.

Globally, population and output per capita have increased very rapidly during the last 200 years, combining to produce an estimated 64-fold increase in global output between 1800 and 2000. A further increase to four times the 2000 output is projected by 2050 if current trends continue.

Ecological footprint analysis indicates the global economy already requires the resources of around one and a half Earths to operate. By 2050 more than two Earths would be required with current behaviour. Returning to sustainability by 2050 would require the ecological footprint per capita to halve.

Burning fossil fuels and other human activities have increased greenhouse gas concentrations in the atmosphere, raising the Earth's temperature by approximately 0.8 degrees since 1900. The current concentration of greenhouse gases commits the Earth to approximately 0.6 degrees of further warming.

Unless the scientific community has got it very wrong, there will either be much more change to reduce greenhouse gases than many nations and businesses are planning for or there will be a lot more change in the Earth's climate than planned for, and most likely both.

Meanwhile, the International Energy Agency (IEA) projects that with current policies primary energy demand will increase 51% from 2009 to 2035; with about 80% of that growth provided by coal, oil and gas. The climate driven need for a very large reduction of fossil fuel emissions is incompatible with the IEA business as usual projection of a very large increase in fossil fuel use.

While the world's leaders are working out how to reduce fossil fuel emissions, the supply of conventional oil is becoming constrained. Fossil fuels are not going to run out soon but the world is already adjusting to emerging scarcity of oil as access becomes more difficult and expensive. In 2000 the average price of oil was around US$20 per barrel. The average long run marginal cost of oil is now around US$70 per barrel.

Energy costs are built into the prices of almost everything consumed. The oil shocks of 1973 and 1979 and the oil price peak in 2008 all contributed to the onset of recessions.

The world faces a daunting challenge to meet energy needs at affordable costs while reversing emissions trends.

Globally, real food prices have increased by over 50% since 2000, reversing a long-term downward trend. Low income countries which import food and energy face cost increases and the threat of being crowded out of markets as more wealthy countries pay increasing prices and secure their supply chains.

Demand for water is projected to increase by more than 60% between 2005 and 2030. The combination of demand growth and supply constraints is projected to increase the proportion of the world's population exposed to water scarcity from 36% in 2010 to 52% by 2050, if current management and usage behaviours persist.

Agriculture and industry also depend on a diverse range of materials including metals and other minerals. After a long period of materials price reductions the price trend has reversed recently. Real prices for metals and minerals have almost trebled since 2000.

Absolute scarcity is not the issue yet but resource costs are increasing because energy costs are increasing and because resources are becoming more difficult to access and so more costly to extract.

Healthy ecosystems and biodiversity underpin human survival and well-being. The annual value of global ecosystem services was estimated to be about US$180 trillion in the year 2000, 4.5 times the Gross World Product of US$40 trillion.

Nearly two-thirds of the services provided by nature to humankind are in decline. Current trends are edging the world closer to potential tipping points; abrupt, catastrophic reductions in the capacity of ecosystems to provide the services needed to sustain present and future generations.

Earth's resources are being used in an unsustainable way and environmental constraints are affecting prosperity and well-being already. Unless there is sufficient effective action to reverse the trends causing environmental damage it will be necessary to adapt to live in a world that is very different.

Four obstacles are combining to delay and weaken action to reduce environment damage. The first obstacle is the requirement to work together, cooperating for everyone's benefit. Each person, business or country recognises that changing their own environment damaging activity will be costly or inconvenient and will make little difference unless others change too. In a self-centred and competitive world it is difficult to establish effective large scale cooperative agreements.

Secondly, we cannot rely on businesses or governments to respond sufficiently because both are affected by a bias to avoid or delay action. Reducing environment damage often requires short-term costs to achieve long-term gains. Directors of businesses are constrained by law to act in the interests of their company and those interests are usually defined as short-term profits. Democratic governments face regular elections so they must provide what voters want. Voters expect on-going increases in consumption and governments that fail to perform in delivering short-term economic growth are replaced. Business and government leaders are keen to pursue those win/win opportunities where environment and economic gains are both available but tend to ignore, downplay or resist change if short-term economic gains are threatened.

Thirdly, most influential people and opinion leaders have a paradigm that leads them to think that continuing economic progress is assured. Paradigms frame our understanding of the world. The dominant economic paradigm has been learned by policy makers and business leaders and adopted by most influencers and opinion-leaders. That paradigm involves continuous progress achieved by improving technologies and growing pools of capital and labour. In the dominant paradigm resources can be taken from the environment without limit and wastes can be disposed of into the environment without limit.

Fourth, the primary value in economics, and arguably in the modern world, is consumption. As long as people want more consumption and remain unconcerned about risks, comforted by their paradigm, it will be impossible for business and government leaders to act vigorously to reduce environment risks.

As a result of these obstacles, risks continue to increase as the environment deteriorates. The evidence indicates it is time for a vigorous response to reduce environment risks but the response remains weak.

We should all care about these increasing risks even if we are self-centred because the numbers indicate that progress cannot continue as it has for very much longer. The risk is now a personal risk for everyone except those who are very old or very ill and those unconcerned about what life will be like for their children.

Humanity has advanced because humans are clever, co-operative and adaptable. The challenge now is to be clever enough to perceive the risk, despite our thinking being constrained by the dominant paradigm, and then to co-operate to change our behaviour so that we can adapt effectively to our new circumstances.

New Zealand has limited ability to change global outcomes, though we can contribute via setting an example, exerting influence and doing our share of the change. However what New Zealanders do can have a large effect on how we are affected by global changes.

Each country has unique circumstances and those must be taken into account when developing mitigation and adaptation strategies. New Zealand has land and water resources for food production, is well endowed with renewable energy and some other resources, and is protected from some risks by relatively low population density and remoteness.

Climate risks make it prudent to plan to join a likely future international agreement to reverse the growth of greenhouse gas emissions and plan for a changing climate. Reducing emissions is difficult here because a large proportion is from agriculture and potent technical solutions have not yet been identified.

The high proportion of energy from hydro means there is limited potential for reduction of emissions in electricity generation so transport will be an important area for future focus. Rising energy costs, including for liquid fuels, are an additional reason to focus effort on reducing transport energy use and emissions.

There may be economic benefits from petroleum extraction but as a whole the world needs to reduce fossil fuel burning. A decision about whether to extract petroleum should take account of the direct economic gains, supply security benefits, emissions created, reputation effects on the clean and green brand, and local environment risks. A future global greenhouse gas agreement might restrict fossil fuel use, creating an additional risk.

As an exporter of food, New Zealand has benefited from increasing global prices and stands to benefit further if global food supply issues become more serious. However, New Zealand's surplus available for export would be reduced if population grew a lot, or if productivity fell because of climate change or shortages of important inputs.

New Zealand imports many materials and technologies that are important to maintain essential supplies and living standards. Recent supply disruptions due to natural disasters have highlighted the importance of supply chain security.

New Zealanders are already quite aware of ecosystem risks because the natural environment is already threatened by past imports of animals and plant pests. Biosecurity risks to agriculture and forestry are also important.

If global growth continues as planned and environmental conditions continue to deteriorate, an overshoot crisis will develop, leading to forced reduction of global output, implying some combination of reduced population and reduced consumption per person. It would be prudent to understand the risk well and have population, supply security and resilience policies to be well prepared.

These implications of global environmental trends for New Zealand mean that national strategy should anticipate a future that is different from the past. The environment strategy can be developed within three themes:

- **No Regrets strategies** that allow New Zealand to take advantage of or respond to expected changes in ways that realise benefits or have only low costs if changes do not occur as anticipated;
- **Mini-max strategies** that protect against catastrophes by minimising the maximum loss; and
- Developing New Zealand's **capability** to manage and adapt to expected and uncertain environment futures.

No Regrets strategies should include growing high value agri-food based exports, developing a more technologically advanced economy, growing the green economy, improving resource use efficiency, resolving emissions issues, preparing to adapt to climate change, protecting and restoring the environment, and developing an environmentally informed population and migration strategy.

Mini-max strategies that should be prepared in case there are more catastrophic outcomes include ensuring supply chain security for critical inputs, selectively investing in self-sufficiency for essential technologies and other inputs, and reviewing security and foreign policies.

To improve the capability to manage and adapt to anticipated and uncertain environmental issues of the future, New Zealand should establish a futures focused institution, build organisation capabilities to anticipate, navigate and respond to unexpected eventualities, broaden economic performance metrics, pursue institutional innovation and build public understanding.

It is hard to think about life in a world that could be fundamentally different from our world today. It would be a shame to focus so much effort on succeeding short-term in the economic growth race that we fail to prevent or be well-prepared for an environmentally-driven crisis.

1. Introduction

Thirty years ago newspapers and scientific journals contained few reports of environmental damage and environment processes. More recently we have become accustomed to a steady stream of reports about observed and expected environment changes and their consequences. Environmental research reports, activist groups and policies have become familiar.

Recent polls indicate the environment is important to many New Zealanders and is rapidly becoming more important. The Roy Morgan Research State of the Nation Report in October 2011 found that environmental issues were ranked as most important by 19% of respondents, up from 7% in November 2010. Prior to the November 2011 general election 1,000 voters rated 21 issues on their importance to them with the 'cleanliness and quality of our natural environment' topping the list (3 News Reid Research, 2011).

Many people are concerned by damage events and reports of increasing environmental risks but are not sure what to do. This paper is not about responding to specific environmental damage such as oil spills, bird extinctions or polluted rivers. It is about emerging large scale, long-term environmental issues, and how they are understood and managed.

The approach is to assess the global status and trends for important aspects of the global environment, identify implications for New Zealand and propose a strategy development agenda to be well prepared.

Chapter two begins by describing and explaining the highest level global processes that have led to the environment becoming so important today. A summary of the status and trends for some important environmental issues follows. Each summary includes a brief introduction to the policy responses adopted or proposed for the issue. The issues included are climate and energy, food and land, fresh water, minerals and materials, and ecosystems. The chapter concludes with an exploration of the long-term global consequences of the trends.

The data presented in chapter two has been sourced where possible from mainstream and authoritative sources to avoid becoming drawn into unproductive debates about facts. Some of the evidence presented may be disputed but the conclusions drawn are not based on a single data set. Conclusions are based on patterns identified from a wide range of evidence, focusing on implications for the next few decades.

Many people who follow environmental research and policy on the environment will learn little from the data provided in chapter two. However, other readers will not be familiar with the data. Without shared understanding of the data it is difficult to agree what should be done so we have summarised important data and provided high level interpretation.

The paper argues that long-term environmental issues are even more serious and urgent than most of us think. It is tempting to focus on improving the economy now, leaving the big environmental challenges for others to tackle later. However, the evidence shows that it is time for a more vigorous, comprehensive and coordinated effort to prepare for environmentally-driven changes and to reduce environmental risks.

Despite research, warnings, environmental policies and behaviour change, responses so far are insufficient to reverse or even slow environment deterioration. Chapter three examines why responses are not more vigorous. Obstacles to collective action, constrained leaders, obsolete paradigms and dominant values combine to prevent a stronger response.

Powerful established damaging trends and response obstacles combine to create risk. Chapter four examines the implications of global environment trends for New Zealand and the local responses so far. As a small isolated developed nation with a relatively low population density, New Zealand will be affected differently. With many energy options and abundant food, land and water, New Zealand is relatively well protected against some of the direct effects of environmental constraints.

However, New Zealand is exposed to the direct effects of climate change, increasing resource costs and ecosystem decline as well as to the indirect effects of responses elsewhere. The indirect effects include the potential for binding emissions agreements, changing customer preferences and supply chain disruptions.

Further, as a member of the international community, as a country with 4.4 million consumers contributing to environmental damage and as an exporter, New Zealand will be expected to play its part in global responses.

Chapter five argues that to be sufficiently prepared, a more vigorous and broader response is required. The response should include pursuing 'No Regrets' strategies to improve outcomes that have low or negative incremental costs, 'mini-max' strategies to better protect against catastrophic risks and building stronger capabilities to understand and manage environmental issues. Some proposals are specific responses to New Zealand's circumstances while others are generic and would be applicable to many countries.

Government regulation and business actions to be better prepared for environment changes are not feasible without public support. Therefore, accelerating and strengthening responses to reduce risk and take best advantage of the opportunities from environment change depends on building public understanding.

This paper will contribute by encouraging more people to join the conversation about the long-term future of New Zealand. Many people think that they can leave management of the environment to others or that the environment is somehow in competition with the economy. The argument set out is that long-term future well-being depends directly on better public understanding of the environment. Public understanding depends in turn on the messages conveyed by New Zealand's opinion leaders.

2. Global status and trends

Prior to the development of industrialised agriculture around 1800, populations and incomes grew slowly due to environmental constraints (Maddison, 2010). Agricultural output was limited by the amount of suitable land and by the human and animal energy available to produce food. Populations would increase rapidly due to high birth rates but limited food supply meant food-seeking people would go to war, or famine or disease would emerge, leading to constantly fluctuating populations (Cipolla, 1993, p.3).

Three changes caused acceleration of output growth from around 1800. First, increasing pressure on supplies of wood for fuel, shipping and construction created energy shortages that stimulated the use of coal as an energy source. The steam engine, and later the internal combustion engine, meant each worker could produce a lot more output.

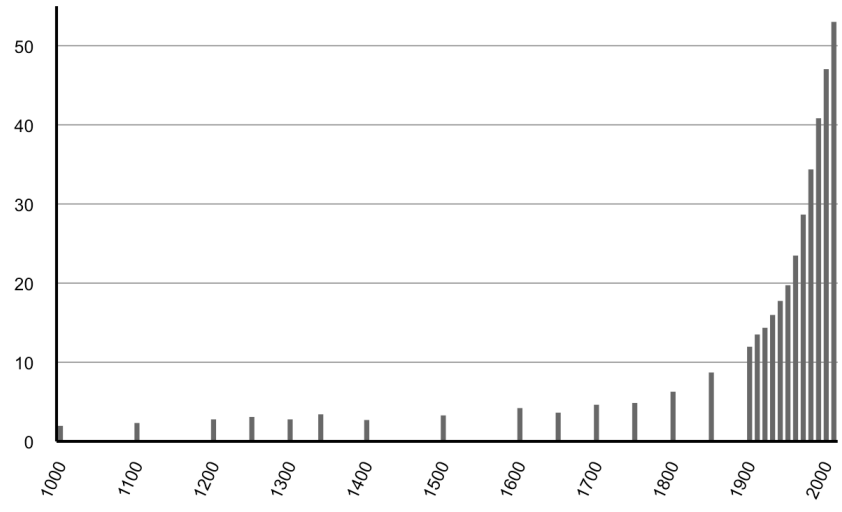
Secondly, importing resources from other parts of the world and exporting manufactured goods enabled increased output, benefits from scale and specialisation, and accumulation of wealth.

Thirdly, the acceleration of scientific and technical innovation which began in the Enlightenment meant resources could be combined in many different ways to produce goods and services not available previously.

Population has increased eight-fold from an estimated 800 million in 1800 to about 7 billion today (U.S. Census Bureau, 2011). Real GDP per capita in 1990 dollars has grown from an estimated Int.$850 per person in 1800 to around Int.$8,000 in 2010 (Maddison, 2010; U.S. Census Bureau, 2011). Global life expectancy at birth has increased from 29 to 69 years (Riley, 2005, pp.537-538; United Nations, Department of Economic and Social Affairs, Population Division, 2011a).

Figure 1 shows the estimated global population density from the year 1000 to the present.

FIGURE 1: GLOBAL POPULATION DENSITY, 1000-2010, PERSONS PER KM^2 LAND

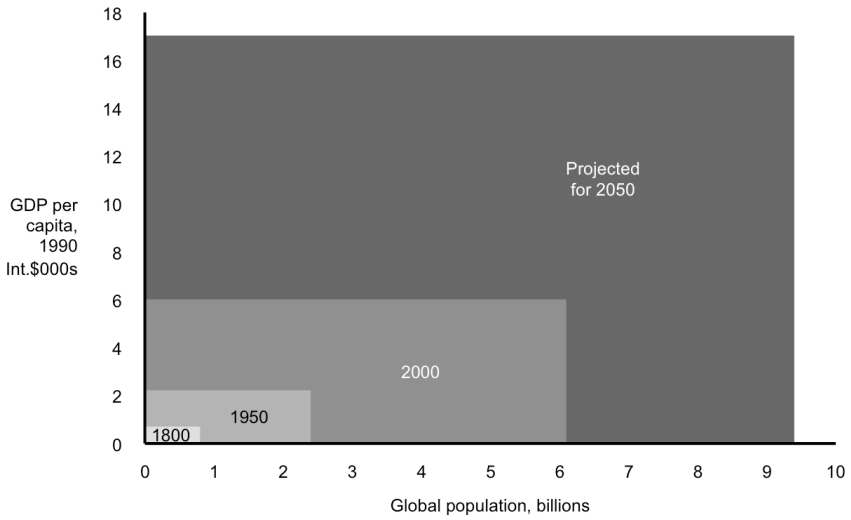


Source: The World Bank (2011a); U.S. Census Bureau (2011).

Figure 2 illustrates the growth of global output and shows business as usual output in 2050 estimated from current GDP per capita growth rates and projected population. Accelerated output growth occurred because the new technologies allowed a lot more yield from the physical environment.

Imagine a field in the 18th century where a farmer using traditional agriculture with an ox ploughs the ground and grows wheat. Output is constrained by the energy and technology available. Now imagine the same field using industrialised agriculture in the 20th century. A farmer and tractor can work the same field in a fraction of the time. Modern fertilisers, hybrid seeds and other agricultural technology mean the output from the field is many times what it was 200 years before.

FIGURE 2: ESTIMATED GLOBAL OUTPUT



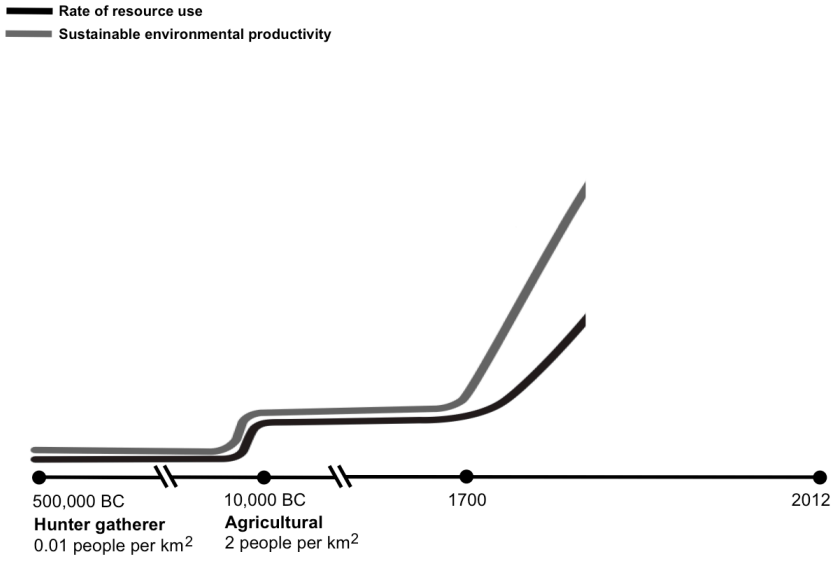
Source: Maddison (2010); U.S. Census Bureau (2011).

The field is the same physical size in the 20th century as it was in the 18th but the yield that can be drawn from it is much greater because of fossil fuels and modern agricultural technology. In effect the environment has become larger because it provides a larger sustainable yield.

The increase in sustainable yield enabled by fossil fuels, trade and technologies meant that the environmental constraints that had limited population and output became irrelevant because the potential output was so much larger than the actual output in 1800.

The evolution of population density and sustainable food yield is illustrated in Figure 3. We often imagine civilisation's development as continuous progress from fire and stone, through bronze, iron, steel, computers, genomics and nanotech to the world portrayed in science fiction. Figure 3 shows a different view, highlighting long eras of slow growth punctuated by technology-driven transitions between eras leading to step changes in sustainable population density. The current rapid growth phase is possible only because the environmental constraints that limit population and output have been temporarily relaxed.

FIGURE 3: TECHNOLOGY LIFTS SUSTAINABLE POPULATION DENSITY



Despite gradual regeneration of some resources, the finite size of the Earth means environment constraints must eventually re-emerge if growth continues. Environmental constraints observed over the last few decades indicate the economy and human impacts have grown so much that they are once again large relative to the size of the environment that supports them.

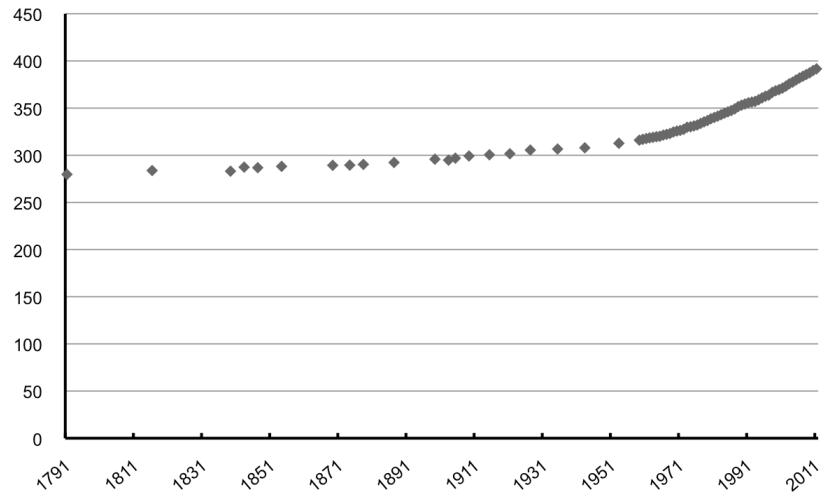
The following sections describe how emerging environmental constraints are now affecting global climate and energy, food and land, fresh water, minerals and materials, and ecosystems. The sections also summarise the responses being offered by leading organisations and commentators or adopted by leading countries to respond to address these global issues and trends.

CLIMATE

Carbon dioxide and other gases released by human activity are changing the composition of the atmosphere and causing more of the sun's heat to be retained instead of radiated back into space.

In 1800 the carbon dioxide concentration in the atmosphere was around 280 ppm. Since 1800, the carbon dioxide concentration has increased to 394 ppm, much through the burning of fossil fuels and other human activity, and it is now growing by about 2 ppm each year (NOAA, 2012; IPCC, 2007b, p.37).

FIGURE 4: CARBON DIOXIDE CONCENTRATION IN ATMOSPHERE, 1791-2011, PPM



Source: NOAA, National Oceanic and Atmospheric Administration (2012); Neftal et al. (1994).

The Earth's temperature has increased by approximately 0.8 degrees since 1900, with most of the increase within the last few decades.

Temperature does not respond immediately to increases in carbon dioxide and other greenhouse gas concentrations because it takes time for drivers of the climate to adjust; especially the oceans and ice sheets (IPCC, 2007a, p.68).

The International Panel on Climate Change (IPCC) estimates the current concentration of greenhouse gases commits the Earth to approximately 0.6 degrees of further warming, meaning that if no greenhouse gases were added to the atmosphere from today, average global temperature would still increase to about 1.4 degrees above the temperature in 1900 (IPCC, 2007a, p.79).

The expected effects of increases of greenhouse gases on the Earth's climate are assessed regularly by the IPCC. With temperature increases of 1 to 2 degrees, climate change is expected to increase the frequency and severity of storms, floods and droughts, raise the sea level and change climate patterns so some plant and animal populations will have to alter their ranges or evolve to survive (IPCC, 2007c, pp.7-14).

The temperature increase so far has caused shrinking and thinning of the Arctic ice cap, retreat of glaciers and melting of the Greenland and Antarctic ice (IPCC, 2007c, p.2 & p.12). Floods, droughts, and storms are already increasing and many people have been adversely affected (IPCC, 2007a, pp.81-82).

In 1990 the IPCC developed scenarios describing future emissions and climate change pathways. Emissions data to date are tracking near the upper end of the range that has been considered in climate models. If emissions continue to follow the worst-case scenario considered, climate models give a range of 2.4 to 6.4 degrees for warming by 2100, with the best estimate being 4 degrees (IPCC, 2007c, p.8).

Increased concentration of greenhouse gases causes the Earth's temperature to increase. The increased temperature causes release of more greenhouse gases and other processes that speed or increase warming, establishing a positive feedback. That means climate change, once started, leads to more climate change. Several positive feedback mechanisms have been identified including:

- When warming shrinks the ice cover it exposes darker surfaces; land or water. The dark surfaces absorb more sunlight and reflect less back to space, heating the Earth faster. The summer extent of the Arctic ice cap has reduced by about 36% since 1979 (National Snow and Ice Data Center, 2011);
- Tundra in Canada and Siberia contains methane that is trapped in frozen soils. It is expected that when the soil thaws, methane will be released. Methane is a powerful greenhouse gas with a strong short-term warming effect;
- Oceans have been acting as a buffer and absorbing an important proportion of the carbon dioxide released by burning fossil fuels. However, the rate at which oceans can absorb carbon dioxide is expected to decrease and there is some evidence that this is already occurring (IPCC, 2007a, p.387);
- Droughts and fires release carbon dioxide from trees into the atmosphere. Until recently tropical forests such as the Amazon have been absorbing carbon dioxide but there are indications that these forests are already becoming net releasers of carbon dioxide (Davidson, 2012);
- Increasing carbon dioxide and other greenhouse gases causes an increase in water vapour that more than doubles their direct effect (IPCC, 2007a, p.116);
- Warmer temperatures create more rainfall by evaporating more water, which increases cloud formation, but there is some scientific uncertainty about the effect of clouds; and
- Aerosol particles that are released by combustion fall to the ground within a few days. While they are in the atmosphere aerosols have a net cooling effect (Hansen, 2003). When fossil fuel use reduces because of emissions controls to reduce long-term warming, lower concentration of aerosols will mean less cooling, contributing to short-term temperature increase.

Forecasts of expected climate change, including the worst-case scenario, use approximations for these positive feedback effects and may not include all of their aspects. The IPCC scenario timelines are shown as smooth curves, which can lead to the idea that climate changes gradually.

However, the paleontological record shows that climate should not be expected to change smoothly and gradually. Large changes can occur quickly, sometimes over a few decades and possibly faster. The current rate of change of variables that cause climate change is very rapid and unusual in the context of past changes (IPCC, 2007a, pp.454-455 & 465).

Climate risks are taken sufficiently seriously by climate scientists and global leaders that a target has been agreed to reduce global emissions so the increase in global temperature is held to less than 2 degrees above the pre-industrial baseline with a further review to consider strengthening the long-term global goal to 1.5 degrees (UNFCCC, 2010, p.5 & p.7).

The basis for the target is that an increase greater than 2 degrees would lead to effects that are seriously damaging for human populations, would risk triggering positive feedback effects that could lead to further climate change and would create an unacceptable risk of triggering abrupt climate change. More warming implies greater risk.

Targets for atmosphere composition and emissions are developed from this reasoning. The most commonly used target for peak carbon dioxide composition to avoid 2 degrees temperature increase is 450 ppm (den Elzen & Meinshausen, 2005, p.2). At conferences of the United Nations Framework Convention for Climate Change (UNFCCC) in 2007 (Bali) and 2009 (Copenhagen) the 2 degree target

was considered along with carbon dioxide being limited to 450 ppm. The IPCC concluded that a reduction of emissions from Annex I Parties of 25-40% relative to 1990 levels would be required by 2020 to achieve the targets set (IPCC, 2007e, p.776).

A 2 degree increase of temperature may seem small but it is half of the 4 degree difference between the current warm period and an ice age. Further, more recent research proposes a 350 ppm target for carbon dioxide to avoid a 2 degree temperature increase (Hansen et al., 2008). A 350 ppm target is especially challenging given it is less than today's level of 394 ppm.

Many scientists and observers now conclude that it will not be possible to avoid a 2 degree temperature rise. Existing atmospheric composition commits the Earth to an increase in temperature of 1.4 degrees above the 1900 baseline. There is on-going growth of emissions and little prospect of a strong and binding global agreement near term. Some scientists believe that the 2 degree target can now only be achieved by immediately reducing emissions to zero in addition to removing carbon dioxide from the atmosphere (Arora et al., 2011).

Unless the world's scientific community has got it very wrong then there will either be much more change to reduce greenhouse gas emissions than many nations and businesses are planning for, or there will be a lot more change in the Earth's climate than planned for, and most likely both.

Responses

The foundation of responses to climate change risks is scientific understanding of possible climate pathways and means to influence them. The IPCC collates, integrates and interprets climate research, providing reviews of climate change experiences, climate forecasts and response options.

Technologies are being developed and deployed to grow the contribution from non-fossil fuel energy sources, for carbon sequestration, for increased efficiency and for use of electric and hydrogen fuelled vehicles.

Governments subsidise these and other emission reduction technologies partly to ensure future availability but also to build technical and scale advantages for domestic businesses as new global industries emerge.

More generally, businesses and governments are transitioning to a low-carbon economy. Many businesses recognise opportunities being created by customers seeking lower emission options. Some customers are willing to pay price premiums for low carbon options while others will not pay price premiums but choose low carbon options when they are available.

Governments are recognising climate change risks, preparing to respond to the requirements of international agreements and encouraging businesses to adapt and pursue opportunities created by the need for emissions reductions.

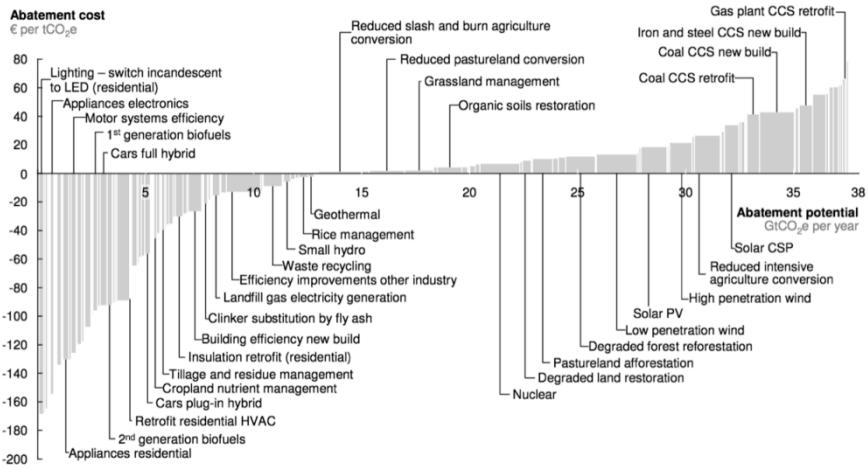
Many of the opportunities to reduce emissions reduce costs too. However, as Figure 5 shows, many sources of emission reduction imply higher costs so businesses are less likely to make those changes voluntarily. In response, governments may provide incentives or introduce policies that encourage emission reduction.

Carbon taxes increase the costs of activities that produce emissions to encourage switching to lower emission activities. Quotas, which may be traded in emissions trading schemes, allow governments to specify the level of emissions. Some governments are introducing emission intensity targets, aiming to reduce emissions per dollar of GDP, but usually planning for overall emissions growth.

Many people and organisations are recognising that efforts so far are not reducing emissions sufficiently. In response, some cities, industries, NGOs and individuals are taking action voluntarily.

The effects of business opportunities, voluntary actions and government initiatives launched and anticipated will not be enough by themselves to reduce emissions sufficiently to lower climate risk to an acceptable level. So Countries are working together to develop an international agreement that will replace the Kyoto Protocol, extending it to include developing countries.

FIGURE 5: GLOBAL GHG ABATEMENT COST CURVE BEYOND BAU - 2030



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures costing less than €80 per tCO2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: McKinsey & Company (2010) p.8.

There is widespread agreement that collectively people would be better off if we all cooperated to reduce climate change. Despite that, each country would prefer that others pay the costs and current governments may prefer to defer the costs, leaving the issue for future governments.

Despite meetings of world leaders in Copenhagen, Cancun and Durban there is no legally binding global climate agreement yet. The outcome from the Durban meeting is tentative agreement to extend the Kyoto Protocol and to form a binding agreement targeted for implementation in 2020 or earlier (Figueres, 2012). A binding global agreement sufficient to reduce climate risk to an acceptable level would require much larger emission reductions than are currently being planned by most countries.

In aggregate, a reduction of 12 GtCO2e is required relative to business as usual to get on a path compatible with limiting the temperature increase to 2 degrees Celsius in 2020. Confirmed national reduction proposals amount to around 1 GtCO2e and conditional pledges contribute another 5 GtCO2e, leaving a gap of 6 GtCO2e (Blok et al., 2012, pp.471-472). Many of the conditional pledges depend on commitments by other countries or financial compensation so there is a large gap to be closed.

Blok et al. (2012) propose that a grand coalition of global organisations should jointly commit to ambitious emission reduction targets, claiming that 21 “wedges” can jointly close the gap. The wedges are mostly accelerating existing initiatives including items such as banning incandescent lamps, improving energy efficiency of electrical appliances, accelerating solar energy adoptions, phasing out subsidies for fossil fuels and reducing deforestation.

Denmark is setting an example. It has set a target of converting the energy and transport system to be 100% based on renewable energy by 2050. Intermediate targets include converting half of electricity generation to wind by 2020 and phasing out coal fired power plants and oil burners by 2030 (The Danish Government, 2011, p.5).

Reducing emissions is not the only way to slow climate change. Technologies and policies are being developed for storing, or sequestering, carbon dioxide in forests, soil and caverns. There are also proposals for ‘geo-engineering’ solutions; large scale interventions in the atmosphere or oceans to reduce warming, though these are contentious because of concern about unanticipated consequences.

Some countries, especially large northern countries, may benefit from modest climate change because their land will become more productive. Others, such as Middle Eastern oil exporters would face unacceptable costs from phasing out fossil fuels. Still others may believe they will cope well with climate change or be able to improve their relative position as other countries are affected.

However, global integration means large scale climate effects on some countries are likely to have seriously detrimental spill-over effects on other countries. Economic disruption, disease and conflict are hard to contain in a connected world.

ENERGY

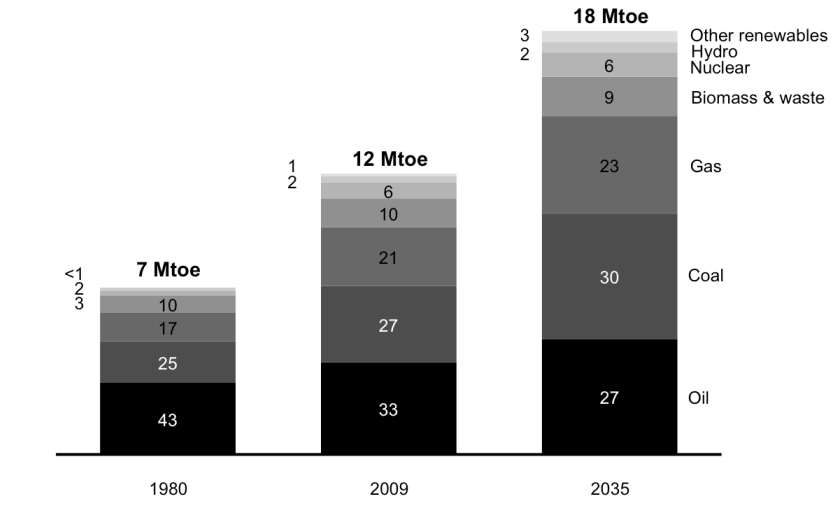
Energy is required for the extraction, processing and distribution of other resources, to provide electricity for industry and consumption, and for transport fuels. As the population grows and the demand for goods and services increases, so does the demand for energy.

Primary energy demand increased by 68% from 1980 to 2009. The International Energy Agency (IEA, 2011, p.71) estimates that with current policies the demand for energy will increase by another 51% from 2009 to 2035, much faster than the rate of population growth.

The early stages of the economic development process are energy intensive, as infrastructure is being built. More advanced economies have experienced reductions in energy intensity, meaning that less energy is required for each additional unit of economic output. Despite that, energy consumption per capita in developed countries is nearly 12 times that of developing countries (UNEP, 2011, p.74).

About 80% of the world's energy supply comes from fossil fuels; 33% from oil, 27% from coal and 21% from gas. The IEA projection for 2035 has the proportion from fossil fuels remaining unchanged with current policies, meaning that if there are no policy changes then fossil fuel use is expected to increase by 51% from 2009 to 2035 (IEA, 2011).

FIGURE 6: WORLD PRIMARY ENERGY DEMAND BY FUEL WITH CURRENT PRICES, %



Note: Mtoe=Million tonnes of oil equivalent
Source: International Energy Agency (2011) p.71.

The supply of conventional oil is becoming constrained. The IEA has reported that output from most of the biggest oil fields has already peaked (IEA, 2008, pp.221-222). In 2010 the volume of oil produced was more than 50% larger than discoveries (IEA, 2011, p.119).

Fossil fuels will not run out soon but the world is already adjusting to an emerging scarcity of oil. Growth of non-conventional liquids, fracking, coal-to-liquids and gas-to-liquids combines with international investment, diplomacy, regime change and war in efforts to secure energy supplies.

Energy accounts for about three-quarters of greenhouse gas emissions (MacKay, 2009, p.15) and global climate management agencies have called for an overall reduction of emissions of around 80% relative to 1990 levels by 2050. The climate driven goal of a very large reduction of greenhouse gas emissions from fossil fuels is in stark contrast to the IEA's projection of a very large increase in fossil fuel use.

With current policies, coal will increase from 27% of energy supply to 30% by 2035. Coal is the most emissions-intensive fossil fuel and rapid growth of coal as an energy source is a strong indicator that energy supply remains far from the sustainable path. China's forecast growth of coal fired electricity generation is large and by itself contributes 17% of forecast fossil fuel energy growth to 2030 (IEA, 2011, p.357).

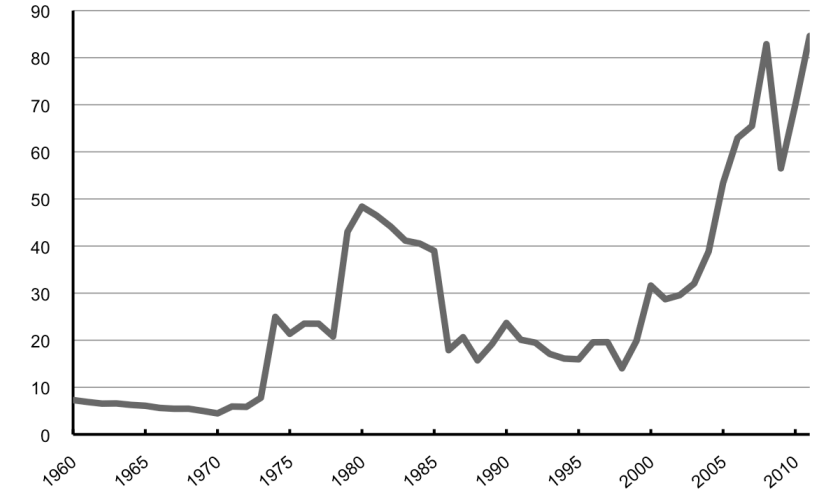
Accelerated replacement of fossil fuels by some combination of renewables and nuclear energy could allow energy supply growth without the climate consequences, if it was achievable in practice. Reducing fossil fuel use by 71% over the next 25 years to get on track to meet an 80% reduction relative to 1990 levels by 2050 would require renewables and nuclear combined to grow dramatically to contribute about 84% of energy supply by 2035.

That challenge is huge. Despite all the wind farms being constructed and solar potential, Figure 6 shows 'Other renewables' contributing only 1% of primary energy today and 3% in 2035.

Marginal sources of energy are no longer low cost so high energy prices are expected to remain or increase. Oil was first extracted from land and then the continental shelves. More recent major oil discoveries are often in remote places (IEA, 2011, p.119). As the locations become more difficult, the cost of extraction rises. The average long run marginal cost for new oil is now around US$70 per barrel, compared to a price of around US$20 per barrel in 2000 (Department of Energy & Climate Change, 2011).

Figure 7 shows the oil price trend from 1960 to the present. Prices increased in the two oil shocks of the 1970s as OPEC exploited supply control to grow revenue. The price increase since 1998 has been much larger.

FIGURE 7: CRUDE PETROLEUM PRICE, 1960-2011, CONSTANT 2005 US$ PER BARREL



Source: The World Bank (2012).

Vigorous action to reduce greenhouse gas emissions would produce further upward price pressure.

Energy costs are built into the prices of almost everything consumed. So when energy costs rise the entire economy is affected. The oil shocks of 1973 and 1979 and the oil price peak in 2008 all contributed to the onset of recessions.

In a few decades energy costs may reduce. With renewable infrastructure in place and a big contribution from emerging and innovative technologies, cheap energy might become widely available. Meanwhile there is a very difficult near-term challenge to ensure energy supply security at affordable costs without unacceptable climate change risk.

Responses

Countries like Canada and Russia with large fossil fuel resources are developing their capacity for export to earn foreign exchange. Policies in many countries encourage energy development for near-term economic benefits, despite the longer term risks from climate change.

While conventional oil is becoming scarce, there is more than sufficient coal and gas to fuel the economy for many decades. However it seems likely that eventually climate risk will limit growth of fossil fuel use.

Growing non fossil fuel energy sources provides potential to meet energy needs without growing carbon dioxide emissions. Wind, solar, wave, tidal, biofuels, geothermal and nuclear technologies are being developed and there is some deployment.

Some countries are developing integrated energy development plans. For example, India has set an ambitious target of deploying 20,000 megawatts of grid connected solar power by 2022. Reducing the cost of solar power generation in India has four elements: "(i) long-term policy; (ii) large scale deployment goals; (iii) aggressive R&D; and (iv) domestic production of critical raw materials, components and products" (Government of India, 2010).

Long distance energy distribution systems are being developed and integrated to provide supply and to balance loads. Russian gas goes by pipeline to Europe and there are plans for large scale solar and wind power generation in deserts to meet local demand in North Africa and the Middle East but to also allow producing countries to export energy to Europe (Desertec Industrial Initiative, 2012).

Reducing energy demand via efficiency or activity reduction is not attractive from a conventional economic point of view because it reduces GDP. However, population and income growth, energy cost increases, energy security concerns and emissions restrictions are likely to make demand reduction much more attractive in the future.

Substitution of information for physical activity is an important opportunity for energy demand reduction. The Internet allows more effective communications with lower costs.

Energy importing countries are taking steps to secure supply. For example the United States is expanding extraction of domestic gas while using foreign policy to secure oil supplies from the Middle East.

The International Energy Agency (IEA) provides forecasts of energy supply and demand under different scenarios, conducts research and advises states on energy options and supply security. Member states, mainly the developed economies, are required to hold 90 days of physical stocks.

FOOD AND LAND

For almost all of human history, food has been the most important scarce resource. Populations were limited by their ability to secure food and most human effort was dedicated to food supply.

Food output growth has been achieved mainly by increasing yields. In the 1960s and early 1970s, rapid population growth created food shortages that triggered research to increase food productivity. The result was the Green Revolution. It involved using hybrid cereals, fertilisers, pesticides and herbicides to dramatically increase yields. Higher yield more than compensated for increased input costs and the shortages were relieved.

Cereal yield growth results from increasing average yields towards the maximum for each cereal crop but that cannot continue forever.

The amount of land used to grow cereals has been relatively stable for almost two decades. Land lost to production because of urbanisation, roads, salination, desertification and erosion is being approximately matched by forest clearance and use of less productive slopes (Boven, 2003, pp.104-110). Land that is suitable and available for agriculture is already in use in most parts of the world. There is reserve land in the less developed parts of Africa and Latin America but much of it is under

tropical rainforest and ideally would be protected to slow climate change. There is also reserve land in protected wildernesses in developed countries but that land is not likely to be made available to supply food to marginal consumers in developing countries.

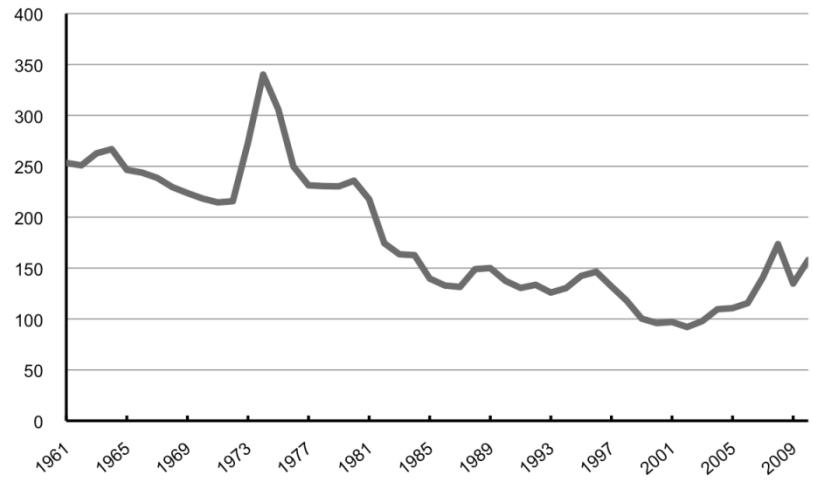
The population density of developing countries on average is already about 8 times that of developed countries and future population growth will be concentrated in those developing countries. Climate change is expected to reduce food productivity, more so in developing countries.

Rapid growth of the middle classes in developing countries is creating increased demand for protein. About one-third of cereal produced globally is consumed by livestock to produce meat (FAO, 2012) and each kilogram of beef requires about seven kilograms of cereals (Rosegrant et al., 1999, p.220).

Cereals are also fed to crustaceans and fish in aquaculture and there is competition from biofuels for agricultural land.

Real prices for food have increased over the last few years, reversing a very long period of food price decreases.

FIGURE 8: FOOD PRICE INDEX, ADJUSTED FOR INFLATION, 1961-2010



Notes: Index calculations began in 1990; data has been extended back to 1961 using proxy price information. Index 2002-04=100
Source: FAO (2011a) p.11.

Households in low income countries are severely affected when food and energy prices increase because food is a large part of the household budget (FAO, 2011a, p.14). The total number of hungry people in the world increased from around 850 million in 2006 to around 920 million in 2010 (FAO, 2010). Higher energy costs exacerbate the problem because energy is an important input to food production and distribution.

Protests about food price increases contributed to the civil unrest in North Africa and the Middle East. Reporting has labelled the removal of dictatorial governments as the 'Arab Spring', but an important underlying problem is real price rises for essentials and that will not be solved by regime change (Lagi et al., 2011).

When food supplies became scarce and prices rose in 2007 and 2008, 25 countries restricted or banned exports to strengthen supplies for local populations (FAO, 2009, pp.6-7).

Low income countries which import food and energy are facing the threat of being crowded out of markets as more wealthy food importers invest to secure their supply chains.

More than 40% of food harvested in developing countries is lost because of storage or transport conditions. In developed nations there is less producer waste but more than 40% may be wasted at the retail and consumer end (FAO, 2011b, p.5).

Responses

With current trends, by 2050 there will be an additional 2.5 billion people to feed, many people will eat more food and more of the food consumed will be protein. Increasing productivity, ensuring sustainability of food supplies and building resilience to respond to supply shocks are responses.

With arable land supply becoming restricted, yield will remain the main driver of food production growth. Intensification supported by irrigation, plant improvement and plant protection will continue.

Removal of subsidies allows high prices to encourage investment in food production.

Information will be more widely used, especially to guide best practice methods matched to local conditions. As local climates change, growing methods will adapt and different crops will be substituted.

There may be efforts to encourage consumption of primary food rather than foods that have been produced using other foods as inputs. Many livestock and farmed seafoods consume cereals and small fish that could be consumed by humans.

Reducing food waste is an important opportunity too, because of the high wastage rates. However, waste is a local, distributed issue and complex to reduce.

Ensuring sustainable food supplies depends on conservation to reduce the rate of resource degradation and polices to encourage the use of land for food. Conservation opportunities include more sustainable irrigation and fertiliser practices, fisheries protection, marine reserves and biosecurity. Land availability for food can be increased by protecting food production land from urban encroachment or switching to biofuels. Forestry clearing is an important source of land for food but has adverse climate consequences too.

Risks to vulnerable populations can be reduced by establishing food production closer to where there is demand.

Recent food supply shocks have led to increased attention to resilience in response to short-term shortages. Proposals to protect against shocks include information systems to match food availability with food need, trade policies to limit export controls, local buffer stocks and safety net supply arrangements.

FRESH WATER

The largest use for fresh water is agriculture (70%) followed by industry (22%) and households (8%) (UNESCO, 2005).

Water is cheap where it is abundant, so human activities tend to be located where suitable water is available, with transportation of fresh water usually limited to high value uses such as drinking.

Use of water may introduce pollutants into rivers and aquifers, but damage to aquifers may not be apparent until several decades after the pollution is released. Increasing population and demand growth means there is a long-term trend for drawdown of water from rivers and aquifers with contention for secure supplies. The more water taken the less there is to dilute pollutants so water quantity issues are inextricably linked with water quality issues.

Water supplies are needed in the right amounts at the right time. Regularity of supply is crucial for agriculture. Too little water makes land unproductive and dust may form and be blown away, reducing both the quality and quantity of soil. Too much water can flush soil away and damage other farming infrastructure. Climate change is increasing both droughts and flooding, adversely affecting food production.

Demand for water for agriculture and other uses is projected to increase by more than 60% between 2005 and 2030 (Boccaletti et al., 2010, p.68). If current management and usage behaviours persist, the combination of demand growth and supply constraints is expected to increase the proportion of

people exposed to water scarcity from 36% in 2010 to 52% by 2050 (Veolia Water, 2010, p.2). Water scarcity leads to problems with food production, human health and economic development.

Water scarcity is local and regional rather than global. Like energy and food, the burden is falling disproportionately on those in the poorest countries but scarcity is increasing and quality deteriorating in some places within developed countries too.

There is potential for conflict over water supplies where people upriver are using or want to use water that would otherwise be used downstream. Potential hotspots for water conflict include the Tigris and Euphrates River basin, the Nile, the Indus, the Mekong, the River Plate, the Jordan and several fresh water basins in southern Africa (Munchmeyer, 2009, p.2).

Responses

Water pricing is introduced and water subsidies removed to increase the incentive to manage water well. Pricing of water encourages repair of leaks, efficient use, re-use, re-cycling and development of technologies to make better use of water.

Another response is to increase the supply and availability of water. Rainwater is harvested and water that would otherwise run-off can be captured. Water can be desalinated, purified or otherwise improved for higher value uses. It can also be stored so it is available when needed. Large scale canal systems can distribute water over long distances; for example the South-North Water Transfer Project in China.

High quality governance of water use is a foundation of efforts to reduce scarcity and its impacts. Best practice water management can be identified, understood and made available for application in other jurisdictions. Water is an important input for other domains, especially food, energy and ecosystems so allocations and linkages must be managed well. Water contention increases as scarcities emerge so water conflicts should be avoided, especially where catchments are shared between political jurisdictions.

MINERALS AND MATERIALS

Agriculture and industry depend on a diverse range of inputs including minerals and other materials. For a long time, exploration innovation has maintained discoveries of high quality, well-located sources of materials. Reducing energy costs, improving extraction methods and more efficient processing have also contributed to the long-term downward real price trend for most materials and manufactured products.

However, after a long period of materials price reductions from the 1960s, the price trend for minerals has recently reversed (Figure 9). Energy and minerals are important inputs to manufactured products. Real prices for metals and minerals have almost tripled since 2000.

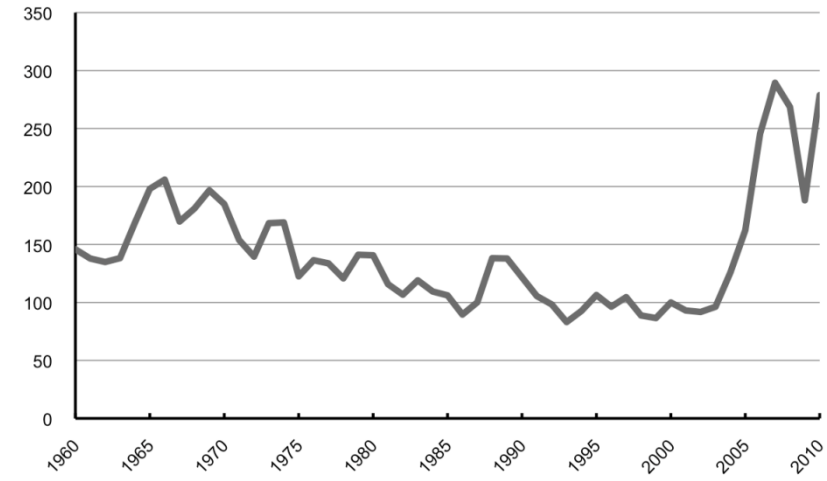
Absolute scarcity is not the issue; minerals are not running out yet either. But they are becoming more difficult to access. They may be deeper and less well located relative to transport (Mudd, 2007, p.121) and of a lower grade, which requires more energy for processing. Input costs for energy and materials used for extraction and processing have increased too.

High prices stimulate exploration and development so high prices are normally followed by capacity expansion and then a reduction of prices.

However, the recent reversal of the long-term price decline trend, together with observations of lower quality and therefore higher cost new resources, along with higher costs expected for energy and other inputs, suggests that real prices may continue a long-term upward trend.

When production volumes are growing and prices are declining, supplies are usually readily available. When scarcities emerge, costs are likely to increase and supply chains become more exposed to event risk. Observations of commodity price increases, China's rare earths policies, Fukushima nuclear incident and the floods in Thailand have led to increased focus on supply chain security.

FIGURE 9: METALS AND MINERALS ANNUAL PRICE INDICES, 1960-2010



Note: Base 2000=100
Source: The World Bank (2011b).

Responses

Emerging scarcities and rising prices increase the incentive for innovation to improve resource use efficiency and exploration to expand production.

Scarcities also alter the way countries influence markets. The recent experience with China's rare earths provides useful insight into the way a powerful exporter can manage supplies of a scarce commodity.

Rare earths are critical inputs for many high-tech products and for clean energy. Yttrium, dysprosium, europium, terbium and neodymium are important rare earths with supply risk in the years ahead (US Department of Energy, 2011).

China has about 30% of the world's reserves of rare earths and provides 97% all of the world's total supply (People's Daily Online, 2011). The near-monopoly position results from rapid expansion of low cost capacity during the 1990s.

The mining process causes local environment damage and China has restricted exports to limit that damage and preserve supplies for the future. China would not want to sell all its resource for a low price and then have to buy from others later when prices are much higher.

Critics have observed that China's policy provides advantage to domestic industries that use rare earths. Export customers will face supply reduction and loss of share while Chinese customers can grow, expanding their positions in downstream industries. The United States, European Union and Japan have lodged a joint complaint at the World Trade Organization.

High prices are stimulating re-commissioning of production capacity in rare earths and other minerals. The United States is making more use of its own production potential because of domestic demand, vulnerability to imports and availability of high prices.

If exporters channel commodities to develop domestic industry and importers expand production capacity to secure lower cost supply the result will be a tendency to reduced trade and an increase of self-sufficiency.

The United States has released its National Strategy for Global Supply Chain Security with the aim of integrating efforts to manage risks, building a layered defence, identifying and resolving threats as

early as possible, and fostering a resilient system that can absorb and recover rapidly from unanticipated disruptions (The White House, 2012).

The European Union is dependent on imports for a large proportion of its metals and other minerals so it is focusing on ensuring that trade rules preserve open markets while using foreign relations to ensure secure trade relationships.

Many countries are trying to develop mineral supplies from more difficult and costly places, notably under the sea, including in the Arctic, and in countries that have more political risk. Antarctica may become a source too, if the prohibition on mineral resource activities is not replaced by a new binding legal agreement once the Protocol on Environmental Protection expires in 2041 (British Antarctic Survey).

China is investing in minerals in Africa, Australia and other places to secure long-term supplies. Political risk that had deterred purely commercial investment in Africa is reduced by establishing strong government to government diplomatic and development relationships alongside the resource investment relationships.

Investment and contention to secure resources is not unusual, especially before and during wars. Emerging scarcity is making it more common so countries are responding to take advantage where they can and to secure supplies where they are vulnerable.

ECOSYSTEMS

Ecosystems are a dynamic complex of plant, animal, human and microorganism communities interacting with one another and their non-living environment. Ecosystem services are the benefits people obtain from their membership in functioning ecosystems. Biodiversity is the variability within and between living species. In combination, healthy ecosystems and diversity among organisms underpin human survival and well-being.

Everyone in the world depends on the environment. Natural resources are the foundation for much of the wealth of countries (UNEP, 2007, p.4). The annual value of global ecosystem services was estimated to be US$180 trillion in 2000, or 4.5 times the value of Gross World Product of US$40 trillion (Boumans et al., 2002, p.556).

Economic development to meet growing demands for energy, food, fresh water, fibre and other materials improves the lives of billions but some impacts have weakened the environment's ability to provide some important services (Millennium Ecosystem Assessment Board, 2005, p.3).

Much of the world's natural environment has transitioned to human-dominated ecosystem types. The photographic impression in Figure 10 shows degradation from a highly natural ecosystem to a highly cultivated or deteriorated ecosystem with less diversity and so less resilience. Degradation can be halted or reversed by land management methods.

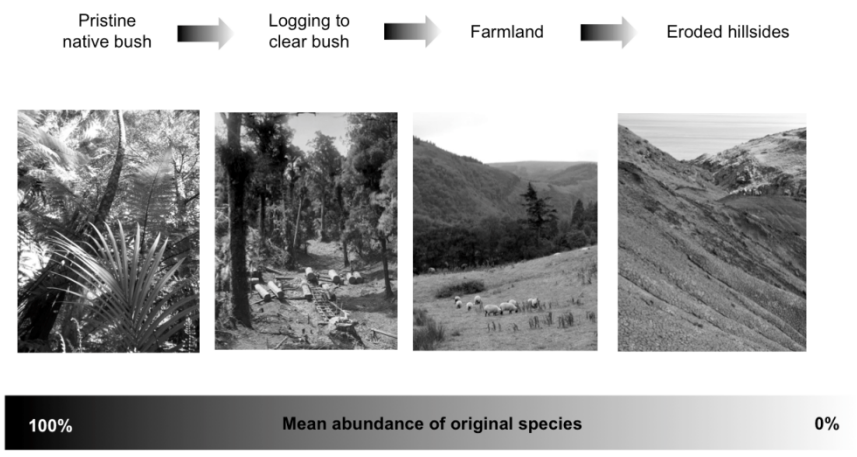
If land use change and biodiversity declines continue on the current path, the loss of economic value of world ecosystem services in 2050 compared to 2000 levels for land-based biomes is estimated to be €14 trillion, or 7% of the estimated GDP in 2050 (ten Brink, 2008, pp.16-17).

Nearly two-thirds of the services provided by nature to humankind are in decline (Millennium Ecosystem Assessment Board, 2005, p.5).

The natural world humans depend on evolved over a long time, affected recently by repeated ice ages but not by temperature increases as high as are now expected. Relative stability has allowed co-evolution to establish complex ecosystems whose species have specialised and become interdependent.

Rapid environmental change leads to decline of habitat and some populations, causing in turn a breakdown of the interdependencies and ripple effects that are wide-ranging but difficult to predict and manage. Species that have adapted to survive in ecological niches and those most tightly dependent on others are most vulnerable to change. Generalists like rats, cockroaches, mosquitoes and weeds are relatively resilient.

FIGURE 10: DEGRADATION PATHWAY EXAMPLE SHOWING POSSIBLE TRANSITION PHASES BETWEEN NATURAL AND HUMAN DOMINATED ECOSYSTEMS



Note: Logging image by Burton Brothers, Museum of New Zealand Te Papa Tongarewa.
Source: Adapted from Braat & ten Brink (2008) p.101.

Ecosystem damage is diverse, with local, regional or global effects. Observed and expected examples include:

- Nutrients from rivers causing dead zones and ocean acidification threatening fisheries and coral reefs and causing plagues of jellyfish;
- Sea ice and glacier retreats threatening species and altering the Earth's albedo;
- Northward shift of the tropical rain band drying out farmland in the tropics;
- Warmer temperatures causing large scale forest die-offs due to pests, diseases and fires; and
- Changes in river flows causing water shortages, flooding, loss of food supply and conflict.

Current trends are edging the world closer to potential tipping points; abrupt, catastrophic reductions in the capacity of ecosystems to provide the services needed to sustain present and future generations. Poor people, who are most immediately dependent on local ecosystems, suffer first and most severely (Ban Ki-moon, Secretary-General United Nations, in Secretariat of the Convention on Biological Diversity, 2010, p.5).

FIGURE 11: ECOSYSTEM SERVICE TRENDS

Improving ↑

- Crops, livestock, aquaculture production
- Global climate regulation (via increased albedo due to forest clearing)

Mixed ↑↓

- Timber and forests
- Regulation of water flows
- Biological control
- Recreation and tourism opportunities

Declining ↓

- Fish stocks and wild foods
- Productive land quality
- Fresh water supply
- Fresh water quality
- Wood fuel
- Species diversity including crop varieties
- Species groups closer to extinction
- Atmosphere cleansing of pollutants
- Local climate regulation via land cover
- Natural buffers against extreme events
- Wild and domestic pollinators
- Medicinal resources
- Quantity and quality of aesthetically pleasing natural landscapes

Sources: Secretariat of the Convention on Biological Diversity (2010); UNEP (2011); Hassan, Scholes & Ash (2005); Gallai et al. (2009); Elmqvist et al. (2010).

Responses

The scale of interference with natural ecosystems is so large that many are in decline and it would be unwise to rely on natural processes to remedy the damage being done. However, ecosystems are very difficult to manage because they involve complex interactions that are only partially understood and many cross national jurisdictions.

There are many local and national efforts to improve biosecurity and protect biodiversity. Habitat protection, restoration and efforts to protect species from extinction are widespread but in aggregate insufficient to reverse the overall ecosystem decline trends.

One important obstacle is that many people who live in cities want goods and services that place demands on ecosystems but do not understand the consequences for ecosystems because they do not observe those consequences directly. People are most concerned about direct ecosystem effects such as the availability of recreational opportunities and water quality. In response there are efforts to increase the visibility of ecosystems and public awareness of their value.

There are also efforts to understand and value ecosystems as a foundation for management and tracking changes. National accounts and other measurement systems are being established in many countries. Valuation is a foundation for sound management of investments to improve ecosystems and for making trade-offs between ecosystem outcomes and other goals.

The 10th Conference of the Parties to the Convention on Biological Diversity agreed a 2011-2020 strategic plan for biodiversity, the Aichi Biodiversity Targets and a strategy for resource mobilisation. For example, one of the targets adopted was that the rate of loss of natural habitats, including forests, is at least halved and where feasible is brought close to zero.

More than 170 countries have established National Biodiversity Strategies and Action Plans and those plans will be updated to be consistent with the newly agreed targets.

Actions proposed include removing subsidies that encourage ecosystem damage, internalising costs to deter damaging activity, quotas and other restrictions to protect ecosystems, and investment to remedy ecosystem damage.

The UK National Ecosystem Assessment (2011) is an example of a national scale analysis of the value of the country's natural environment taking account of the economic, health and social benefits obtained from nature. It was developed to assist in the identification and development of effective policy responses to ecosystem service degradation.

In 2010 the United Nations General Assembly approved establishment of an Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2011). The IPBES will identify and prioritise information needs, assess knowledge, support policy formation and implementation, and prioritise capacity building needs.

IPBES will be the leading global body providing scientifically sound and relevant information to support decisions on how biodiversity and ecosystem services are conserved and used around the world. Like the Intergovernmental Panel on Climate Change, IPBES is being established to ensure the best science is made available to governments and other decision makers. It will have strong peer-review processes and will draw on multidisciplinary expertise from around the world. It is supported by the UNEP working in partnership with the UNDP, UNESCO and FAO.

As governments face the need to tighten budgets along with public demands for greater fiscal accountability, decisions about how to allocate funding to protect ecosystems and biodiversity are becoming more important and society is being forced to "rethink how to incorporate the value of these services into societal decision-making" (de Groot et al., 2010, p.4).

Puma, a sports footwear and apparel brand, announced in April 2011 that it had commissioned PwC to help it develop an Environmental Profit & Loss statement to internalise costs that have been ignored in the past and to account for the full economic impact of the brand on its ecosystem. The aim is for the model being developed to be robust enough for adoption by other businesses (Chouinard et al., 2011).

Valuation initiatives will assist decision-making which involves trade-offs or allocations of natural resources. They require an understanding of public values as well as economic analysis to assess alternative projects, to identify optimal solutions, and to provide a transparent means to maximise environmental benefits per dollar spent.

George Monbiot, a writer and political activist, has made the point that quantifying the value of some aspect of nature creates the opportunity to quantify a higher value for using up that natural asset, leading to a tendency to consume natural assets (2011).

A somewhat different approach to protecting ecosystems has been taken in Bolivia. The Earth spiritual entity, Pachamama has been given legal rights. Bolivians believe that humans belong to a big family including plants and animals. Instead of valuing nature only as a source of inputs to the economy, nature is valued for its own existence (Vidal, 2011).

GLOBAL OUTLOOK

Human activity is having a large effect on the functioning of the atmosphere. The concentration of carbon dioxide in the atmosphere has increased 40% in around 200 years, the temperature increase trend is well-established and having important effects already, and energy needs will make it difficult to reduce greenhouse gas emissions.

Humanity is heading into unknown territory. Temperatures are expected to increase well beyond the current level, which is already a high point of recent climate history. The reason for the increase is new too. Temperature is not rising for the past reason of Earth's orbital patterns; it is rising because the atmosphere is being directly changed.

If the temperature continues to increase unchecked, eventually there will be important consequences. Melting of the Greenland and West Antarctic ice would increase the sea level by around 12 metres (IPCC, 2007d, p.793). Heating the oceans sufficiently could release methane hydrate from the continental shelves into the atmosphere, leading to even more warming.

Agriculture and civilisation evolved only in the last 10,000-12,000 years, while the climate has been relatively stable. Humanity has no history of living in a materially different and variable climate, other than as hunter-gatherers with small populations.

As biodiversity declines and ecosystem damage proceeds, the services humans depend on are going to be degraded further. That would not be such a problem if the human population was small. People would simply adapt by going to live somewhere better or would find another way to secure the ecosystem service. The difficulty today is that there are few available attractive places where people can easily migrate to and for many ecosystem services there is no viable and cost-effective substitute. The scale of humanity creates a risk that would not exist if the population was much smaller.

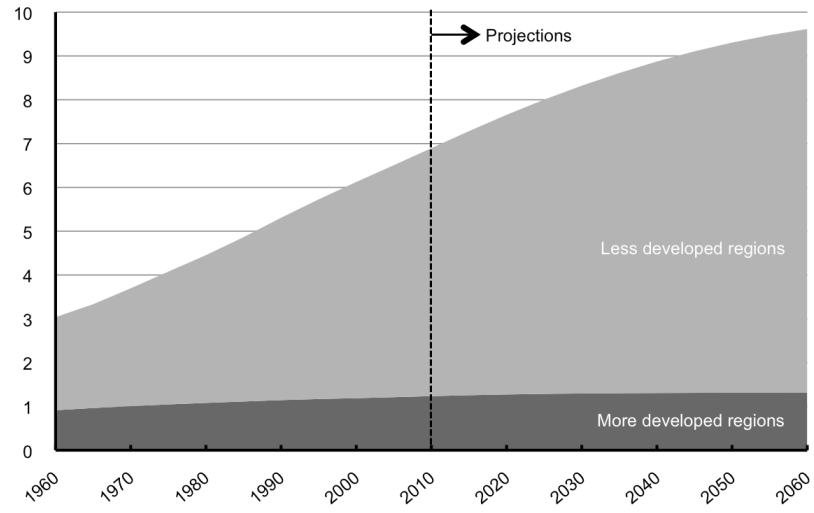
As Figure 12 shows, nearly all of the population growth is expected to occur in developing countries where industrialisation will be progressing, leading to increasing resource requirements per capita.

On-going increases in the extraction and use of finite resources must eventually lead to scarcities. Initially the emergence of scarcities is signalled by price increases as marginal supply costs increase. Price increases are followed by contention for supply and crowding out as the scarcities become more severe.

Today, about 20% of the world's population does not have access to electricity (IEA, 2011, p.39), 36% are exposed to water scarcity (Veolia Water, 2010, p.2) and 13% are undernourished (FAO, 2011a, p.44). Increasing affluence alone will not solve resource scarcity issues because richer people use more energy, more food, more water and more materials.

Prices rise during booms and fall during recessions, but prices remain high now and the world's economy is no longer booming. The price data presented in previous sections for energy, food and land, and minerals suggests that the long period of real price decline experienced during the 20th century may now have reversed. Renewed economic growth could trigger price rises for energy, food and other resources, which would constrain further growth.

FIGURE 12: WORLD POPULATION, 1960-2060, BILLIONS



Source: United Nations, Department of Economic and Social Affairs, Population Division (2011b).

Developed countries have incomes that allow them to purchase much of the Earth's resources. They are now being joined by strong emerging economies, the BRICs and Tigers, which are wealthy enough to continue to purchase increasing volumes of resources despite increasing prices.

Economic competition is intensifying. Rapidly developing emerging economies are combining access to technology, production and market scale, and low labour costs to grow manufactured exports to developed countries. The developed countries are facing higher resource costs, more competitive markets for their own manufacturing output, and unemployment pressures in the middle of the skills structure because of competition from imports, robotics and computers.

Many countries are being left behind because they have not been able to establish strong economies with high value exports. Unless they are self-sufficient they face increasing costs for energy, food and materials and risk being unable to afford supplies if scarcities increase further.

The argument above explains why the environment has become important again and the effects on economies, but quantitative analysis is required to fully appreciate the position today.

Figure 2 presented earlier shows aggregate global output expanded by about 60 times between 1800 and 2000 and is expected to expand a further four times by 2050 if recent economic growth trends persist and population grows as expected. The issue for humanity is whether policies, technologies and behaviour change can more than offset the effects of resource scarcity, ecosystem decline and climate change to support that growth.

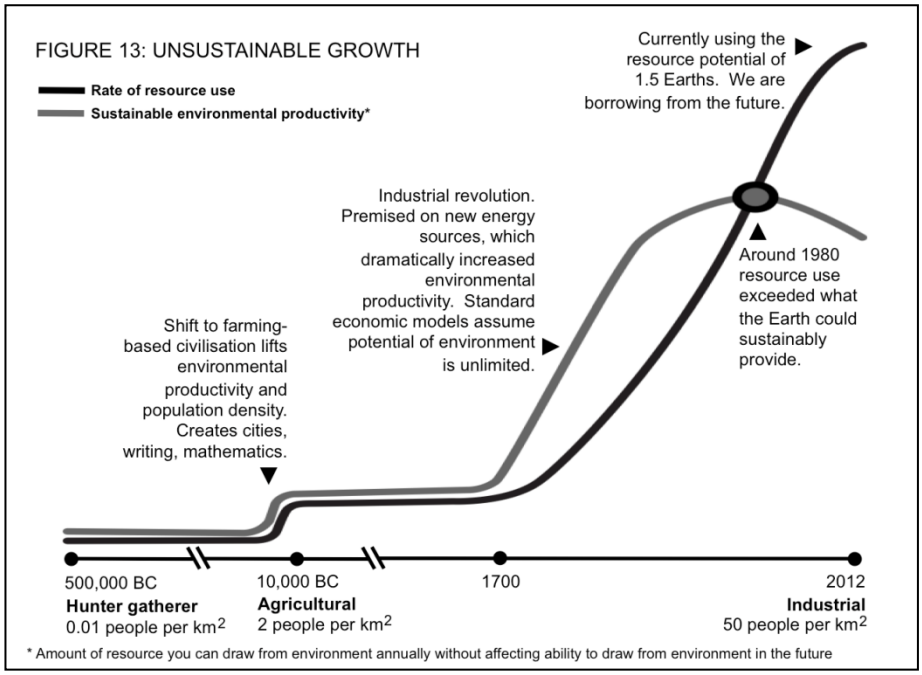
Ecological economists have developed a way to gain insight into the relative scales of economy and environment using a tool known as the ecological footprint. The idea is that each individual consumes resources to support his or her lifestyle and those resources must be provided by the Earth. The ecological footprint provides a measure of human impact on the environment.

The intuition behind ecological footprint calculations is simple, though the calculations themselves are complex. Each individual needs food and the production of that food requires land. Clothing requires cotton or wool and housing requires timber from forests. Products such as nylon require large amounts of energy for production. The ecological footprint calculation measures how much land and water area is required to produce the resources a human population consumes, and to absorb their waste, carbon dioxide emissions and other pollutants. Countries differ in resource productivity and the ecological footprint calculation reflects this when working out how much land would be required to support all of the people on Earth (Global Footprint Network, 2011).

One simple way to summarise the ecological footprint results is to determine the proportion of the Earth's total resource capacity required to sustainably support the current population at the current standard of living. Ecological footprint research concludes that the global economy passed one Earth around 1980 and is now around one and a half Earths. Put another way, it now takes the Earth one year and six months to regenerate what is used in one year (Global Footprint Network, 2011). The inhabitants of the Earth are operating in an unsustainable way, borrowing from the future.

Continuation of the current population and economic growth trajectories will increase the unsustainability. If the Earth's leaders continue to plan for an increase of population from approximately 7 billion today to around 9.5 billion in 2050 and to grow consumption per person at the current rate, then more than two Earths will be required by 2050 (Global Footprint Network, 2011).

The longer the Earth is operated in an unsustainable way the greater the accumulated damage, which will reduce the Earth's ability to provide the resources that will be needed.



Consider the consequences of humanity collectively deciding to return to living in a way where only one Earth is required for the population of 9.5 billion in 2050. As more than two Earths would be required with current behaviour, the ecological footprint per capita would need to halve. That would be difficult given the consumption growth aspirations of the world's population.

If that seems surprising, it is because people have learned to ignore the warnings of scientists and environmental activists. Population understanding and responses will be explored in the next chapter.

If consumption becomes unsustainable, then either future technological advances must increase resource use efficiency sufficiently to compensate, or future consumption must be reduced to a sustainable level. Future consumption reductions can only be achieved by less consumption per person or a smaller population.

Meeting current needs and growing demands will require widespread adoption of methods that improve resource productivity and reduce waste. Many policy options have been proposed to reduce environment damage and to increase resource use efficiency.

Investment in innovation is a common response as countries try to develop green industries with sustainable competitive advantage. There is huge potential for technology to address many resource scarcity concerns, and many useful solutions have already been invented.

But it is not enough to have technologies and policies that will theoretically help address the challenges. Deployment of sufficient solutions to where they are needed at a competitive cost is crucial.

3. Obstacles to a more vigorous response

The evidence indicates that the Earth's resources are being used by humans in an unsustainable way and that environmental constraints are affecting prosperity and well-being.

When forces emerge that threaten prosperity and well-being there is usually a vigorous response. Increased incidence of famines triggered the Green Revolution and the hole in the ozone layer triggered the Montreal Protocol. A lot is being done to build understanding and encourage sustainability but responses so far to the environmental challenges described in the last chapter have been insufficient to reverse or even slow the adverse trends.

As the ecological footprint continues to grow beyond the sustainable level it will become more difficult to secure the resources needed by human populations so further environmental damage will accumulate.

If that process continues then damage to the Earth will reduce the size of the population that can be supported sustainably. That has happened in coastal areas of the Mediterranean which remain damaged following overshoot by the Roman civilisation.

Without sufficient effective action to reverse the trends causing environmental damage it will be necessary to adapt to live in a world that is very different. This chapter describes how important obstacles prevent a vigorous response to reduce environmental risk.

We should be concerned about the risk of insufficient response because the evidence reveals human populations do fail to anticipate quite fundamental changes in circumstances and can be surprised and disappointed as a result.

For example, in the mid-2000s there was widespread belief that economies and asset values would continue to grow, stimulating debt-fuelled speculation. Observation of a strong asset appreciation trend led many to believe the trend would continue indefinitely.

Now, only a few years later, a very different economic reality is recognised. Paradigms, over-confidence, failure of imagination and lack of robust analysis can easily produce unrealistic assumptions about the future.

Recent economic changes have reminded people that economies have cycles. People may soon re-learn that civilisations have cycles too and are prone to overshoot if resources are temporarily abundant and a growth trajectory proceeds unchecked.

Long-term plans, including the financial forecasts in the New Zealand Treasury's Long Term Fiscal Model (2010), explicitly assume continuous and on-going economic growth for the next 40 years. The forecasts do not appear to include rigorous examination of the risks from environmental constraints but implicitly assume those risks are immaterial or can be managed.

Treasury's forecasts in 2006 and 2007 assumed on-going growth too (The Treasury, 2007, p.15). There was no anticipation of the Global Financial Crisis or of the recession.

There may be no practical alternative in economic forecasting other than to assume continuous trends. However, we should be aware that such forecasts are likely to be disrupted by unexpected surprises.

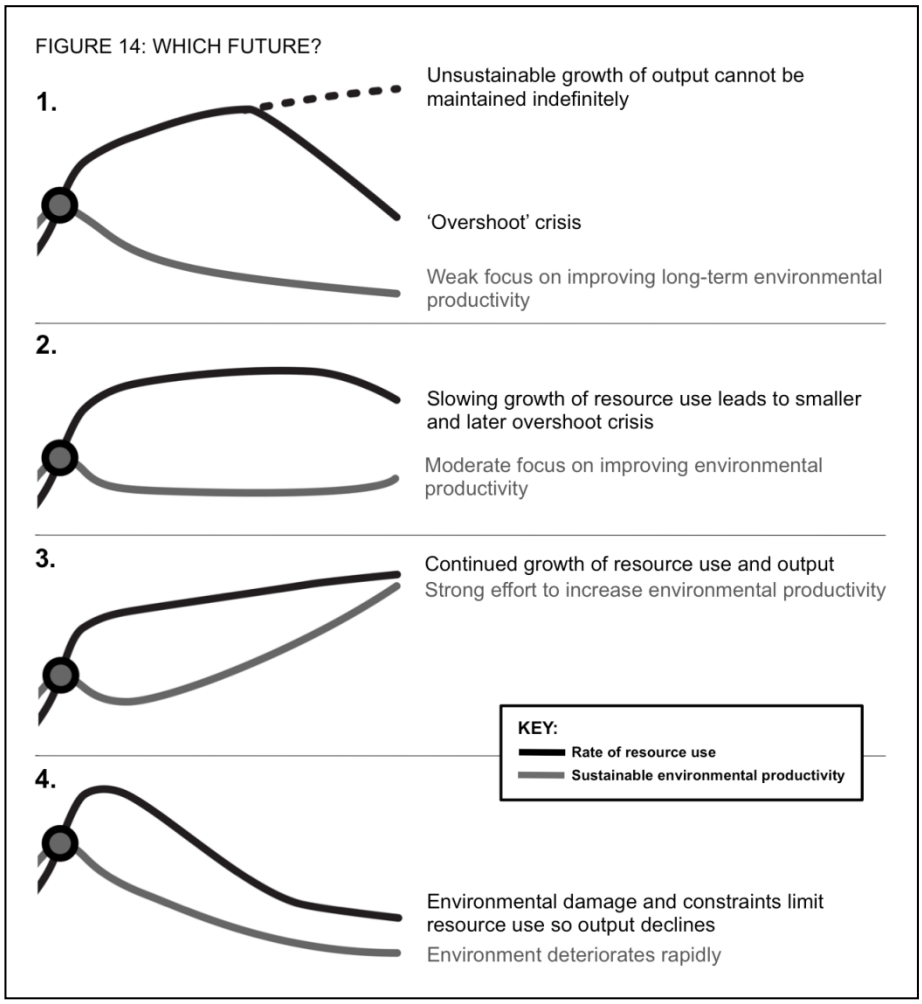
IS A MORE VIGOROUS RESPONSE NEEDED?

Ecological footprint analysis and examination of climate, resource and ecosystem data reveals the global population and economy are growing beyond the sustainable level.

Population, life expectancy and resource use are still increasing strongly, which indicates humanity is still in the growth phase. At some time in the future, either technological innovation will increase the effective size of the environment dramatically or there will be some combination of reduced population and reduced consumption.

Figure 14 shows four possible futures to illustrate what might happen next. All four futures look forward from when Figure 13 ends in the present.

Future 1 is the consequence of maximizing growth with a limited environment. Growth continues with growing resource use (top line) and the environment deteriorates (bottom line) until the environment can no longer support the output so an overshoot crisis develops.



Future 2 is the outcome of compromise. Resource use is slowed and there is effort to reduce environmental damage. In Future 2 the resource use remains much higher than the sustainable productivity so eventually a correction occurs, but it is deferred.

Future 3 is the outcome that growth maximisers should seek. Growth and resource use continues to grow but restoration and improvement of the environment combines with technology development to rapidly increase the sustainable output. The prospects for technological innovation are unknown and many people argue for reliance on future technological developments to solve current and emerging environmental issues. It might be possible to invent environmentally benign cheap energy and technologies that allow material transformations to alleviate resource scarcity. Future 3 illustrates that growth maximisers should be the strongest advocates for protection of the environment and for green technologies.

Future 4 illustrates the path that may lie ahead if the recent energy, food and materials cost increases are signalling the end of the age of abundance. As the environment deteriorates and resource costs increase, output growth turns into output decline.

Change takes place gradually so people may not be fully aware that environmental damage is accumulating. Global warming and resource price increases occur against a background of fluctuations and other changes that may make it difficult to recognise important trends.

There are often long time lags between activity that causes environmental damage and the emergence of the damage. One example cited earlier is that the carbon dioxide already in the atmosphere commits the Earth to approximately 0.6 degrees of warming that has not yet happened. Another is that damage to aquifers may not become apparent until several decades after pollution is released.

Environmental damage may be irreversible once it has accumulated sufficiently. Once resources are depleted, ecosystem tipping points are reached or biological populations have collapsed, it may become impossible to restore the previous state.

While firms and individuals can profit, at least in the short-term, from unsustainable resource use and pollution, the degradation of resources and environmental quality do not generally send price signals and so remain for the most part un-priced externalities.

Managing the environment is quite different from managing an economy. Most economic opportunities and risks have their effects within a few years. Economic issues can be responded to relatively quickly and interventions have impacts within a few years. As a result, institutional arrangements are mainly focused on the relatively short-term. Politicians face re-election every 3 to 5 years and that also reinforces the relatively short-term focus.

When important longer term issues emerge, there is an understandable temptation to put off dealing with the issues, implicitly making their management the responsibility of later generations. But as financial crises and failing states illustrate, once a crisis has emerged it becomes much more difficult to afford the remedy.

Genuine scientific uncertainty and satisfaction with current lifestyles also contribute to reluctance to act to reduce environmental damage.

Uncertainty about the future state of the environment and therefore of the future for modern civilisation has two sources: the severity of the environment threat and the strength of the human response. One interpretation of the evidence presented in earlier chapters is that continuing on the current course will inevitably lead to a nasty correction with population and output collapsing to bring aggregate activity down to a sustainable level.

A more optimistic interpretation is that the threat has been exaggerated and many remedial technologies will be developed and deployed successfully. These two possibilities are labelled high and low environmental threat respectively in Figure 15.

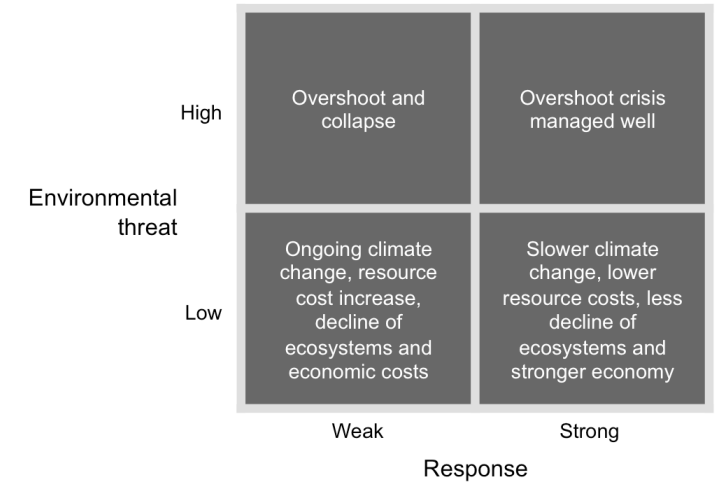
The response may be weak or strong. Regardless of how severe the threat is assessed to be, a strong response has advantages over a weak one.

It is now impossible to avoid further environmental damage because of existing damage and established momentum. That leaves individual countries and the world as a whole deciding how much effort to allocate to reducing environmental damage and how much to allocate to adaptation.

The seriousness of the threat and the availability of technologies and policies that would improve outcomes imply a stronger response is required. However, the trends and forecasts described earlier in this paper demonstrate that the response remains weak.

The remainder of this chapter examines obstacles to a strong response.

FIGURE 15: RESPONSE OUTCOME MATRIX



COLLECTIVE ACTION

Individuals, businesses and governments may all recognise a need to change activities in ways that would improve environmental and economic outcomes.

The collective action obstacle is that each individual, business or government has an incentive to continue the damaging activity, though all would benefit if everyone stopped, but there is no mechanism available to establish cooperation to prevent the activity.

For example, there is widespread agreement that collectively people would be better off if they cooperated to reduce climate change. The difficulty is that despite potential for business opportunities and the risk of catastrophe, slowing climate change has costs. Each country would prefer that other countries pay the costs and each country's current government would prefer to leave the costs for future governments to pay.

For example, the United States did not join the Kyoto Protocol because it anticipated economic costs (Leggett, 2011, p.3). Canada withdrew late in 2011 (Kent, 2011), saving the country US$13.6 billion due for penalties resulting from their fossil fuel extraction and use.

The world is now trying to form a collective agreement to slow climate change that will replace the Kyoto Protocol but progress is slow because countries aim to avoid costs for themselves, especially costs that would be politically unpopular at home.

There is a technical game theory literature on the collective action problem, including the 'tragedy of the commons' and the 'prisoner's dilemma', which are particular forms the problem takes. These problems of coordination do not arise when economic potential is large and environmental constraints are economically irrelevant.

When there are no environmental constraints greed and competition are adaptive because they promote acceleration of economic growth. Individualistic values strengthened in the West when the growth phase began, and they arose during rapid growth phases in Venice and Japan too (Boven, 2003, p220).

However, when environmental constraints become important again, as they are now, greed and competition get in the way of effective cooperation. Those motives and values become dysfunctional.

Cleverness and cooperation are the features that allowed humans to adapt and become the dominant life form on Earth. We now face the challenge of being clever enough to recognise that we must cooperate to adapt successfully in response to environmental constraints returning.

LEADERSHIP

When difficult issues arise, people look to businesses and governments for solutions.

For different reasons, individuals should not rely on businesses or governments to respond sufficiently because both can be affected by a bias to avoid or delay action.

Businesses make roads and cars, sell petrol, mine coal, drill oil, cut down forests, and operate manufacturing facilities, power stations and farms. Businesses carry out those activities to provide goods and services which individuals value and to build wealth for their shareholders. In aggregate, because of the scale of the global economy, those business activities damage the environment.

It is unwise to rely on sufficient businesses stopping environmentally damaging activities voluntarily because many business decisions about environmentally relevant activity are constrained by two important influences.

First, the board of directors of a company is responsible for outcomes for the company and the board is legally required to act in the interests of the company. That means acting in the interests of the environment only if those interests are aligned with the interests of the company.

For many business decisions, the interests of companies are aligned with environmental health.

Many businesses can relatively easily gain price premiums, reduce costs or improve their reputations by actions that also improve environmental outcomes. Many business leaders have become environmental champions and they are often very effective because they are well-organised with access to resources.

However other businesses whose activities cause a lot of environmental damage may not have affordable or feasible options to reduce the damage their activities cause. For those businesses, short-term business interests and long-term environmental interests are not aligned. If there is a conflict between the company's interests and the interests of the environment the board is legally required to choose actions which benefit the company, provided those actions are legal.

Secondly, businesses aim to produce dividends for their shareholders by earning and distributing profits. When businesses make decisions about the value of activities that affect profits they use discount rates that translate the value of future income into its equivalent value today. Discount rates encourage preference for income that is earned sooner rather than later. Income and costs more than 10 years in the future are usually not very important for current business decisions.

These two influences compel some businesses whose activities contribute to environmental damage to pursue their own short-term interests, harming the long-term health of the environment. When industry conditions change, incumbent businesses are often displaced by new entrants so important regulatory threats are taken very seriously.

Businesses that are threatened may lobby to avoid or reduce the effect of proposed regulations, acting in their own interests as they should.

When introducing regulations governments must retain support from businesses and individuals whose short-term economic interests may be harmed by the regulations. The need to retain support means governments may be unable to act as vigorously as would be required to reduce environmental risks.

The constraint is illustrated well by President Obama's record on climate change. Early in his presidency, Obama claimed he would act vigorously to reduce climate change. Following expenditure of political capital on healthcare reforms and recognition that effective climate change policies would be more politically challenging in the recession, he focused on regulatory steps that did not require

Congressional actions, which limited the scope of potential progress. Long-term climate gains are not worth the short-term political cost.

Governments introduce regulations only if they have sufficient support from individuals.

Individuals' beliefs and values are therefore the primary determinant of responses to environmental issues because:

- Individuals' consumption preferences affect business decisions about the goods and services that will be offered and the way those goods and services are produced and delivered;
- Governments will only introduce environmental regulations when there is sufficient support from individuals; and
- Individuals lead businesses and governments so if leaders are personally concerned about environmental outcomes they are likely to look very hard for ways their organisations can simultaneously improve economic and environment outcomes.

When governments do introduce regulations they may use environment taxes or regulate quantities of damaging activities directly.

The economic theory behind environmental, or pigovian, taxes is based on the observation that price signals often do not include the cost of the environmental damage that results from an activity. For example, the cost of damage to the atmosphere is not included in the prices paid for operating a car. The damage is referred to as an externality, and environmental taxes may be imposed to internalise the externalities. Businesses and consumers then face the cost of the damage so are encouraged to find less damaging options.

One drawback of environmental taxes is that it is difficult to set the level of the tax so that it achieves the desired environment outcome. Identifying the tax level that produces the target amount of behaviour change is difficult and lobbying by potentially affected parties may reduce the size of the tax.

Compared to environmental taxes, the option of regulating the quantity of damaging activities has the advantage that activity volume targets can be determined based on scientific assessments and then policy can specify the quota that will achieve the desired outcome. Trading the quotas improves economic efficiency. Tradable fishing quotas and emissions trading schemes are examples.

When regulations change behaviour, values and beliefs may change in response. People learn and change as they come to understand the regulation and its rationale. Further, people change their values and beliefs to bring them into alignment with their behaviour.

Despite the value of taxes and quotas for constraining environmentally damaging activity, there are important advantages from directly influencing values and beliefs too. For example, many people would not change their consumption behaviour very much if prices were increased. However, most people are strongly influenced by social norms so would change behaviour quickly if their activities were disapproved of by respected others.

PARADIGMS

Individuals' beliefs are strongly influenced by the paradigms they use. Paradigms frame understanding of the world. Our thinking is organised and constrained by paradigms learned through upbringing, education and social influence.

The influential economist John Maynard Keynes wrote, "Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist" (1936, p.383). The paradigms that guide much of our thinking and therefore our lives are strongly influenced by the theories of influential economists who lived long ago.

Two important paradigms are in conflict today. The dominant one is based on economic models that assume free gifts from and free disposals to the environment. It is a paradigm developed by economists in the 19th and 20th centuries during the period when aggregate global environmental constraints were not economically relevant.

When the Cobb-Douglas production function was published in 1928 the drivers of output were technology, capital and labour (Cobb & Douglas).

Mainstream modern economics continues to assume that environmental constraints are unimportant, implicitly using the 'free gifts and free disposals' assumption. The economy is assumed to function independently of its environment. It is assumed that resources can be drawn from the environment and wastes disposed into the environment without constraint (Perrings, 1987, pp.5-9). In effect, businesses pay the costs of extraction of resources and sometimes the costs of disposal too, but opportunities for resource extraction and waste disposal are assumed to be unlimited.

The free gifts and free disposals assumption has been a reasonable approximation because cheap energy, "discoveries" of new continents and countries, available materials and technologies temporarily made the available environment very large relative to the economy.

The Cobb-Douglas function describes an economy that can continue to grow indefinitely as long as the free gifts and free disposals assumption remains approximately valid.

PARADIGMS

Paradigms are frameworks for thinking. They help people make sense of the world they live in and guide beliefs and behaviour. The idea of paradigms is often explained by reference to physics.

Prior to Copernicus and Galileo, the Earth was widely believed to be at the centre of the Solar System with the Sun, Moon, planets and stars orbiting around the Earth.

Copernicus first developed the theory that the Earth rotated around the Sun and his theory was adopted and promoted by Galileo a century later.

Galileo's arguments triggered a paradigm change and eventually the Sun became widely recognised as the body at the centre of the Solar System with the Earth and other planets rotating around the Sun.

Paradigms do not change quickly or easily. For each individual they are strongly held belief systems. So when someone makes a breakthrough of understanding there is usually a lot of resistance from those who defend status quo thinking. Galileo got in a lot of trouble and was forced to recant and retire.

In the modern world, large scale paradigm change usually only occurs when a generation of thinkers who have adopted the new paradigm replace defenders of the older paradigm in positions of power and influence (Planck, 1950, pp.33-34).

The importance of the dominant paradigm's goal of growing economic output to allow on-going consumption growth is illustrated by the emphasis on real GDP per capita as the most widely used measure of success of a society (Stiglitz et al., 2009, p.12). With the exception of some regulatory or conservation roles, governments generally seek economic growth above all other goals. They emphasise economic benefits and costs from environmental issues rather than environmental risks, indicating they are followers of the dominant paradigm.

COBB-DOUGLAS PRODUCTION FUNCTION

$$Y = A K^{\alpha} L^{\beta}$$

The Cobb-Douglas production function describes the conventional modern economic understanding of how aggregate output is produced. Capital (K) is combined with labour (L) using technology (A) to produce output (Y). Alpha and beta describe how capital and labour combine in the production process.

The output is used to enable consumption, to support growth of the population and supply of labour, and to increase the stock of capital. Developing better technologies means that more output can be produced from each unit of capital and labour.

The environment is not economically relevant as a constraint on output.

The alternative paradigm can be labelled the 'ecological paradigm' because it highlights how ecological constraints affect the potential for on-going output growth. Proponents of the ecological paradigm fear that on-going consumption maximisation is producing output growth overshooting what the Earth's environment can sustain and creating a material risk of a painful correction. For followers of the ecological paradigm, altering economic management to reduce overshoot risk, or reducing specific forms of overshoot risk, is more important than maximising economic growth.

The two paradigms are in conflict but it is a dispute not widely recognised. When people debate an environmental issue like climate change, peak oil or habitat degradation, the paradigm used influences how they approach the issue. 'Economic paradigm' people know that technologies and

policies have overcome many obstacles in the last 200 years and believe technologies and policies will address climate change at some time in the future so the primary goal should remain output maximisation.

Ecological paradigm people claim not enough is being done to reduce climate risks, thereby making a painful correction inevitable, so efforts should focus now on reducing emissions and increasing carbon sequestration. When difficult choices must be made, the option people choose is usually determined more by the paradigm they use than by careful consideration of evidence from a variety of sources.

The argument is difficult to resolve because differing paradigms lead to people talking past one another rather than focusing on the issues that divide them and on identifying and conducting the analyses that would bring them to agreement. Economists think the point being raised by climate advocates is irrelevant or exaggerated while ecologists wish everyone would understand how important the risk is.

It is difficult to find an analysis that the two groups can agree on that will resolve the issue between them. Economists can claim there will be a future technology-policy combination that will remove climate risk while ecologists can claim not enough is being done now given the size of the risk. It is not primarily a debate about theories or facts. It is a conflict between paradigms.

An important feature of paradigms is that if a person is committed to one, it is very difficult to see the merits of another. If someone has been brought up to believe that the future course of humanity is on-going progress and development sustained by technology change, as has occurred during their lifetime and those of their parents and grandparents, then it is hard to imagine anything different.

The more the debate is partitioned into topics the easier it is for economic paradigm advocates to support their case that technological innovation and future policies will overcome constraints. However when long-term outcomes are considered in a broader biological and historical context, the merits of the ecologists' position become more apparent.

At the heart of the paradigm conflict is different views about the nature of progress. Economic paradigm adherents can extrapolate backwards from the progress of the last 200 years and see a history of roughly continuous development of humanity from its earliest roots. That provides comfort in projecting forward to see on-going progress and they can also claim, correctly, that our civilisation is different from previous ones because it has unlocked the potential of technology.

Ecological paradigm adherents see a different history; one where populations grow and then collapse. Research by Zhang et al. (2011) has shown that in the 1,100 years prior to the industrial era, 90% of 88 population collapses in northern hemisphere countries or regions occurred during periods of climate change that reduced the carrying capacity of the land. Famines, wars and epidemics were the dominant triggers for population collapses which peaked during periods of climate change.

Ultimately the population's beliefs influence behaviour and therefore outcomes. However, the general population has limited understanding of the risks, strong motivations to continue to grow output and consumption, and an understandable preference to avoid costly or disruptive change.

If governments tend to follow individuals and individuals tend to follow governments who is going to lead change?

VALUES

Choices by individuals will determine future outcomes and those choices are determined not only by what people believe but also by what they value.

Kaitiakitanga is defined by the Resource Management Act 1991 as "the exercise of guardianship by the tangata whenua of an area in accordance with tikanga Māori in relation to natural and physical resources; and includes the ethic of stewardship".

Stewardship positions the environment as something to be valued, looked after and preserved, not simply as a resource available to be exploited. It alters the way decision-makers trade-off outcomes for current generations against outcomes for future generations. Value choices affect behaviours and behaviours affect outcomes.

The primary value in modern economics, and arguably in the modern world too, is consumption. People are assumed to value increases in consumption and most do.

Many people are proud to show off their possessions, desire more and envy others who have more. People compete to have more or better material possessions. Competition is regarded as not only a means to encourage improved performance but also as a value to be encouraged so people will strive for more.

Many people think things have always been that way. Many believe people everywhere should always prefer more consumption to less and many believe that values are universal and unchanging.

However human populations in other situations adopt values, beliefs, norms and laws which produce consumption-limiting behaviours to encourage sustainability. Examples of such values are hunter-gatherers who leave hunting grounds to restock and agriculturalists who leave their fields fallow.

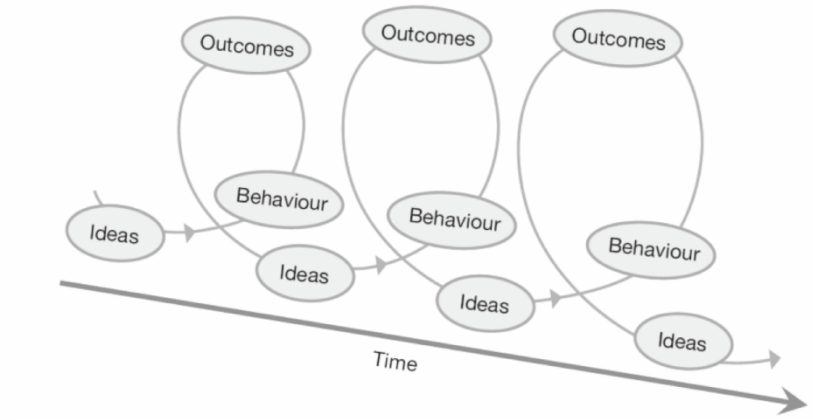
During the agricultural era, prior to industrialisation, resources were constrained and values functioned to limit consumption in the interests of the community. Pride, greed, gluttony and envy were negative values, included among the seven deadly sins because they encouraged consumption. Actions based on these values today do not carry the same censure, and are often encouraged.

Viewing beliefs and values as malleable and adaptive allows a co-evolutionary view of the way history unfolds. People may begin with values and beliefs that encourage behaviours which are adapted to circumstances. If circumstances change, as they did when the environment stopped being an important constraint, then outcomes are affected. So values and beliefs change in response. The changed behaviour - competing to increase consumption - eventually leads to a further change of circumstances - re-emergence of environmental constraints - and so beliefs and values change again. The process is illustrated in Figure 16.

When the period of accelerated economic growth began in the late 18th and early 19th century, many new opportunities became available. Values and beliefs changed in response because individuals who unilaterally adopted the new beliefs and values benefited personally and immediately. Their success was observed and imitated, and the values and beliefs that encouraged and supported success became widespread.

Today's environmental risks are future possibilities not yet realised. Beliefs and values supporting on-going consumption maximisation are well-entrenched. Individuals unilaterally choosing to reduce environmentally damaging behaviour incur immediate costs from higher expenses or reduced consumption but should expect no risk reduction benefit because environmental risks depend on aggregate not individual behaviour.

FIGURE 16: CO-EVOLUTION OF IDEAS, BEHAVIOUR AND OUTCOMES



Ideas affect behaviour, behaviour affects outcomes and outcomes affect ideas.

Source: Adapted from Boven (2003) p.303.

OUTLOOK AND IMPLICATIONS

The importance of individual paradigms, beliefs, values and behaviours means the state of the population's understanding of environmental issues has a critical influence on environment outcomes. Technologies and policies to reduce environment damage are being deployed slowly because there is, as yet, insufficient support for more rapid change.

Entrenchment of the dominant economic paradigm combines with characteristics of environmental risks and other obstacles to make it very difficult to materially accelerate the response to environmental issues. We should anticipate the possibility that humankind will continue to maximise economic output until environmental constraints curtail growth.

The future remains highly uncertain because we do not yet understand when environmental constraints will impose hard output growth limits. Recent real price increases for important resources may signal the onset of an age of scarcity, constraining economic growth permanently.

It is also difficult to assess how rapidly paradigms, beliefs, values and behaviours might change. People can sometimes change rapidly. For example when wars commence, widespread understanding of risks, strong leadership and community social pressure produces rapid and large changes of beliefs, values and behaviour.

Leaders, activists and others who wish to reduce environmental risks should focus more of their effort on changing the paradigms, beliefs and values of the general population.

4. Implications for New Zealand

The scale and momentum of environment change and the obstacles to effective response mean that New Zealanders should anticipate continued deterioration of the global physical environment.

Some global environmental trends affect New Zealand directly. Others have more indirect effects, via effects on global conditions. The implications of environmental change for New Zealand will be summarised in this chapter, along with responses adopted and proposed.

CLIMATE AND ENERGY

Globally, climate change and energy are inextricably linked because fossil fuel use is the largest contributor to greenhouse gas emissions. Climate risks, energy demand growth and the scale of the energy production transformation required to slow climate change imply that it would be prudent to anticipate binding international agreements or some other effective mechanisms to reduce emissions materially, along with further climate change and increasing energy costs.

Climate change is already affecting New Zealand directly. Average annual temperatures have increased by almost 1 degree Celsius from 1931 to 2008 (NIWA).

Modelling indicates that New Zealand is relatively less exposed to future climate change than many other places. More rainfall is expected in western regions and less in the east so some regions will get more floods while others will be at greater risk of drought. Ex-tropical cyclones are expected to become more severe for the north-east, snowlines are expected to rise and changes to habitats and species distribution is expected, especially in the South Island.

The current expectation is that the sea level will rise by 0.5 to 2 metres by 2100 (Bell & Ramsay, 2012, p.24). While that does not seem a lot, it would increase the incidence of coastal flooding in some low-lying locations. The base case estimate is around 1 metre (Bell & Ramsay, 2012, p.40) and this should be planned for, with provision for the possibility of a larger increase. Increasing understanding from research on ice shelf and glacier melting processes is leading to upward revisions in expected melting and potential sea level rise. Greenfields developments with long lifetimes should be located outside high risk zones.

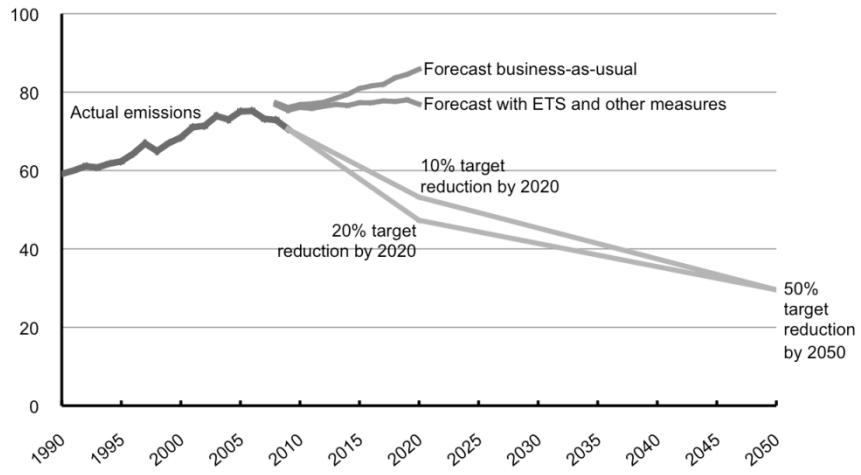
Climate change will impose adaptation costs for more resilient infrastructure and responding to weather events. New Zealand's agricultural production will be affected too, but production losses are likely to be at least partly compensated for by price increases as competing producers are affected as well.

New Zealand is participating in international efforts to reduce emissions. On ratifying the Kyoto Protocol, New Zealand agreed to reduce its greenhouse gas emissions to 1990 levels on average over the 2008-2012 commitment period, or take responsibility for buying emission units from other countries for emissions over that level (Ministry for the Environment, 2010).

By 2010, New Zealand's emissions had increased by approximately 20% relative to 1990 levels (Ministry for the Environment, 2012, p1). The Kyoto obligation position was much better, however, because of the credits gained from forestry (p7). Like many other countries, New Zealand has found ways to avoid the major changes of behaviour that would be required to reverse long term emission growth trends.

Government has established a 2020 emissions target of a reduction to 10 to 20% below 1990 levels, and a 2050 target 50% below (Ministry for the Environment, 2011c).

FIGURE 17: NEW ZEALAND'S GREENHOUSE GAS EMISSIONS, FORECAST AND TARGETS, CO_2e MILLION TONNES

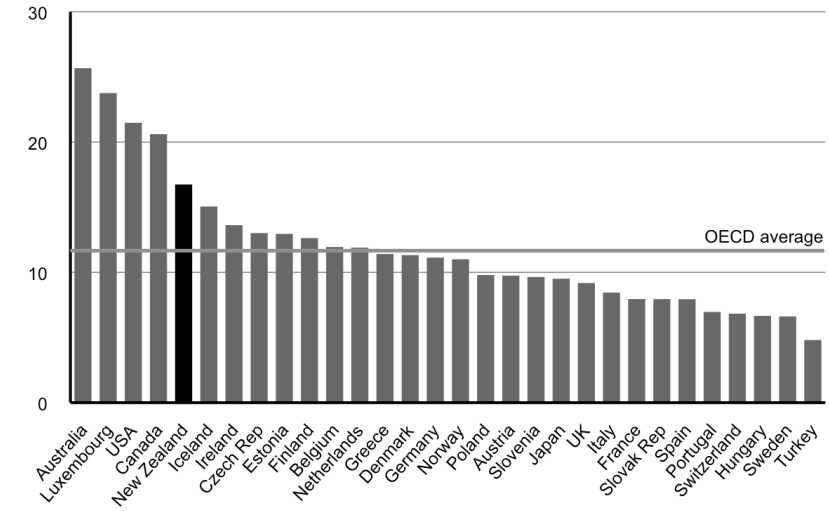


Note: Excludes LULUCF emissions.
Source: Ministry for the Environment (2009); UNFCCC, United Nations Framework Convention on Climate Change (2011a).

The United Nations March 2011 review report on New Zealand's emission policies expressed "great concern about the uncertainty associated with the timeline for inclusion of the major sectors under the ETS" and other policies and measures needed to reach the 2020 national target (UNFCCC, 2011b, p.35)

New Zealand has the fifth highest greenhouse emissions per capita among OECD countries. The rate is higher than average largely because of the number of ruminant animals, with 47% of emissions from agriculture (Ministry for the Environment, 2011b, p.viii). High vehicle ownership rates, long distances travelled, a relatively old and inefficient vehicle fleet and absence of emission standards are also factors. Electricity generation is a relatively low emissions contributor because a high proportion is hydro, though coal is burnt at Huntly.

FIGURE 18: GREENHOUSE GAS EMISSIONS PER CAPITA, 2009, CO_2e TONNES



Note: Data excludes land use, land-use change and forestry (LULUCF).
Source: UNFCCC, United Nations Framework Convention on Climate Change (2011c).

Agricultural emissions are difficult to reduce because it is hard to re-engineer the ruminant digestive process. Economically attractive alternatives to ruminant farming have not been identified. Efforts are

being made to identify ways to reduce greenhouse gas emissions from agriculture, with a domestic research programme being established and New Zealand taking a leadership role in international research efforts.

Inclusion of agriculture in the Emissions Trading Scheme (ETS) has been deferred, with Government wanting to see technologies available and international competitors also reducing emissions. Increasing farming costs here because of the ETS could lead to meat and dairy production moving offshore, using cereal feed systems that would have higher emissions than New Zealand's pastoral farming system.

The ETS and other greenhouse gas reduction initiatives have reinforced the message to New Zealanders that emissions matter and have got many people thinking about emissions reduction options. If tougher settings are required by international agreement, or some other mechanisms, climate policy can be strengthened by altering the ETS parameters.

As customers in other countries become more focused on climate outcomes, they are asking New Zealand exporters to comply with their expectations about the climate impact of production and distribution activities. Food miles and carbon footprints influence purchasing choices by retailers and consumers while some products earn price premiums by having strong environmental credentials, effectively marketed.

Scarcity of low cost conventional energy sources, especially liquid fuels, is likely to combine with climate policies to increase energy costs. New Zealand is relatively well positioned in electricity because of the contribution from hydro dams, which in 2011 generated 58% of all electricity (Ministry of Economic Development, 2012a, p.102). There are opportunities to increase renewables generation too, from wind and a variety of other technologies, so thermal generation from fossil fuels could be phased out if there was sufficient political will.

New Zealand has a target to increase the proportion of electricity generated from renewable sources to 90% by 2025 (New Zealand Government, 2011, p.3). In the 2011 calendar year renewable sources had climbed to 77% (Ministry of Economic Development, 2012a, p.102). Increasing renewable energy's contribution improves emissions and energy security.

In the March 2012 quarter, domestic production of the oil products used mainly for transport was only sufficient for about one-third of domestic consumption, with imports making up the balance and providing for international transport by sea and air (Ministry of Economic Development, 2012b, p.4).

With prices for liquid fuels likely to continue to increase and the potential for contention for supply there are incentives to switch to electricity for transport, to improve efficiency and to become more self-sufficient.

To manage an uncertain climate and energy future, three important issues must be resolved. The first is how much effort should be made to improve the energy and emissions performance of the vehicle fleet. Emissions standards, car size, engine efficiency, public transport investment and demand management are available options but they are not yet being progressed vigorously.

There are many plausible rationales for a relatively modest effort including not believing climate risks are material, prioritising short-term economic growth over long-term outcomes and preferring to wait until change is required to avoid making unilateral changes that might not get credit in an eventual climate agreement. Regardless of the reasons, the transport response remains relatively weak and emissions continue.

The second issue is exposure to risks from high and increasing energy costs. Relatively large and inefficient vehicles, low density cities and low public transport use mean that if fossil fuel energy costs increase a lot more then New Zealanders will be exposed to high absolute costs for transport, export businesses will be competitively disadvantaged and low income people will find transport costs a large burden.

One approach might be to argue that there is no need to improve transport efficiency, energy use and emissions now because New Zealand will soon switch to low cost renewable solutions which will allow continuation of high rates of personal (electric) vehicle use, low use of public transport and low density

urban forms. That response would be more plausible if the strategy was articulated and plans were available for scrutiny. In the absence of those strategies and plans, there is a risk that New Zealand will find itself dependent on imported fossil fuels and facing damaging cost increases.

The third issue is what to do about hydrocarbon development options, especially those based on coal, lignite or oil. From a short-term economic perspective, expanding hydrocarbon production could improve the current account, reduce fuel supply risks and grow export revenues.

From a longer term and broader perspective the answer is very different. Growth of fossil fuel use is damaging the global environment and must be curtailed or the outlook for modern civilisation is grim. New Zealand is a relatively wealthy country already, a high contributor to global emissions on a per capita basis, has many renewable options and other ways to grow the economy. There is a precedent from deciding not to develop nuclear energy to avoid long-term risks.

Unfortunately fossil fuel investments have high initial capital costs which require long-term revenues so is not economically feasible to grow fossil fuel production now with the expectation that it will be curtailed later. If investment is made in fossil fuel energy there is some risk that aggressive climate protection policies could create stranded assets and leave New Zealand scrambling to expand renewable energy supplies.

A decision about whether to extract petroleum should take account of the direct economic gains, supply security benefits, emissions created, reputation effects on the clean and green brand, and local environment risks

Higher energy costs provide stronger incentives for more compact cities, for substituting public transport for cars and for switching from larger, fuel-inefficient cars to smaller and more fuel-efficient cars. Higher energy costs would encourage local production because transport cost penalties would become larger relative to the benefits from economies of scale. High energy costs would also increase New Zealand's distance penalty as an exporter, increasing the incentive to shift to exports that have higher value relative to their shipping cost.

High energy costs are already stressing household budgets and affecting transport choices. It would be prudent to plan for public transport, cycling, urban development and vehicle fleet evolution that will protect vulnerable people from further energy cost escalation.

The New Zealand Energy Strategy 2011-2021 sets out the Government's goal to make the most of New Zealand's abundant energy potential for the benefit of all New Zealanders. It identifies four priority areas: diverse resource development, environmental responsibility, efficient use of energy and secure and affordable energy. Within these priorities twelve areas of focus have been set that cover: developing renewable energy resources, petroleum and mineral fuel resources and new energy technologies; applying best practice in environmental management for energy projects, reducing energy-related greenhouse gas emissions; warm, dry, energy efficient homes, an energy efficient transport system, enhance business competitiveness through energy efficiency, better consumer information to inform energy choices; competitive energy markets, reliable electricity supply, oil security and transport (Ministry of Economic Development, 2011, pp.4-5).

Improving energy efficiency is very valuable because it contributes to reducing emissions and lowers energy costs. The New Zealand Energy Efficiency and Conservation Strategy 2011-2016 (NZEECS) is a companion strategy to the Energy Strategy that is specifically focused on the promotion of energy efficiency, energy conservation and renewable energy. It sets out six objectives for six sectors along with specific targets to be achieved (Ministry of Economic Development, 2011, p.18):

- A more energy efficient transport system, with a greater diversity of fuels and alternative energy technologies;
- Enhanced business growth and competitiveness from energy intensity improvements;
- Warm, dry and energy efficient homes with improved air quality to avoid ill-health and lost productivity;
- Greater business and consumer uptake of energy efficient products;
- An efficient, renewable electricity system supporting New Zealand's global competitiveness; and
- Greater value for money from the public sector through increased energy efficiency.

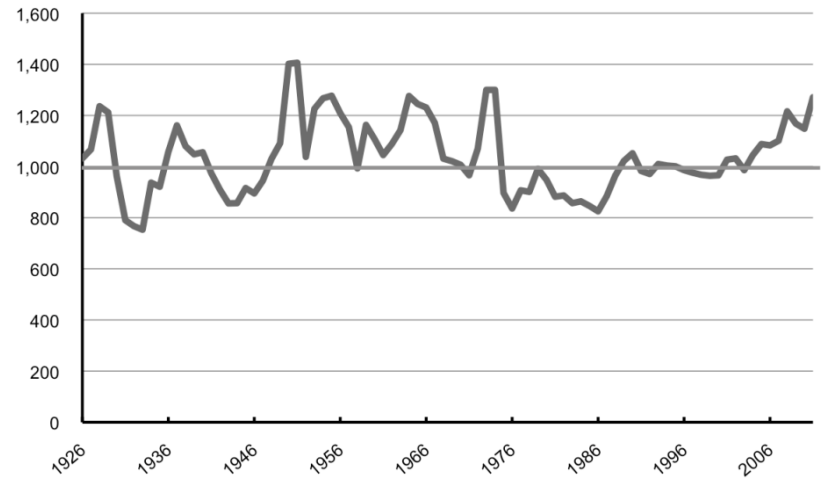
FOOD AND LAND

New Zealand has abundant land and water to provide for its own food needs and for export with current conditions. Climate change will force some adjustment of production mix and method but New Zealand seems to have the resource endowments and technological potential needed to change effectively.

Population growth and increasing affluence are driving increased protein consumption in rapidly developing economies. At the same time climate change and land degradation constrain supply growth. The result is likely to be further upward price pressure for food and other commodities.

Increasing real prices for food globally would lift New Zealand's export revenues and reduce the current account deficit, all other things equal. During the last ten years, New Zealand's terms of trade have improved materially and further food price rises would provide a material economic benefit.

FIGURE 19: TERMS OF TRADE, ANNUAL AT JUNE, 1926-2011



Note: June 2002 Quarter Base=1000
Source: Statistics New Zealand (2011).

Ideally, benefits from terms of trade improvement would be re-invested to increase the performance and resilience of the economy but in the present economic circumstances short-term benefits from higher prices are likely to be applied to reduce foreign debt as farmers and others pay down their borrowings and banks reduce wholesale international liabilities.

Despite those constraints, further increases of global food prices would improve New Zealand's economic position.

However, domestic prices for many foods would increase along with the export prices, increasing the pressure on household budgets, especially for those with low incomes.

New Zealand food prices increased 45% between Q1 2000 and Q1 2012, less than the global increase. Household energy prices increased 82% over the same period, also much less than the global price rise. In contrast, prices for audio-visual and computing equipment in Q1 2012 were only 30% of what they were in 2000 (Statistics New Zealand, 2012).

New Zealanders have been protected somewhat from the effects of increasing global food and energy costs by domestic production of foods, a high proportion of renewable energy and by reducing prices of manufactured goods as production has shifted to China and other lower labour cost countries.

With that shift of manufacturing to low cost countries partly completed and labour costs rising in many developing countries, it seems likely that future food and energy price increases will put more pressure on local consumers.

New Zealanders are also exposed to the indirect effects of food price increases in other countries. If food prices increase a lot, there will be more hungry people causing disruption in other parts of the world that might affect New Zealand in turn. For example, food price increases were a cause and trigger of recent civil unrest in Libya. That disrupted Libya's oil exports and contributed to global oil price increases that affected New Zealand's energy costs.

China is investing in Africa and building relationships with other countries including New Zealand to secure long-term supplies of important resources, including food. As food scarcities develop further, supply relationships are likely to shift from spot to long-term contracts and to vertical integration. Export protection is likely to become a more important trade policy issue and trade agreements are likely to include terms guaranteeing reciprocal supply of important commodities. As scarcities emerge, the policy agenda shifts from securing market access to securing supplies.

New Zealand's food strategy focuses on improving revenues by increasing the volume of commodities produced, adding more value before exporting, and investing downstream to get more of the margin.

There is debate about sales of agricultural land to foreigners; countries seeking supply security and individuals wanting a safe haven option. Ownership of food production matters. If New Zealand owns food production then it can choose to eat the food if circumstances become difficult. A foreign owner might choose to export instead to provide food for its own population. Currently New Zealand eats about half of the food it produces (Coriolis, 2012, p.11), but with expected population growth, threats to productivity from climate change and input supply security risks, it would be prudent to maintain control of food production resources.

That implies sales of food producing land to foreigners are acceptable at the margin, especially if the sale provides economic benefits beyond the sale proceeds, but that sufficient food producing land should be retained to protect New Zealanders' long-term economic and food supply interests.

Population growth in New Zealand is rapid and encouraged. New Zealand's rate of population growth between 1990 and 2010 was fifth fastest in the OECD, despite strong outward migration by New Zealand citizens (OECD, 2012).

Population growth has reduced the amount of agricultural land per capita and therefore the potential income per capita from food exports. In 1990, New Zealand had almost 5 hectares of agricultural land per person; by 2009 that had reduced to less than 3 hectares per person (The New Zealand Institute, 2011).

With current technologies and global conditions, the population growth trend is mainly an economic issue. However, if global conditions deteriorated materially then feeding the population might become a challenge, especially if supplies of tractors, hybrid seeds, imported fertilisers and agricultural chemicals were disrupted.

FRESH WATER

Population driven water demand growth, more droughts and floods, and water pollution are likely to make food production more of a challenge in many countries. The most important effect on New Zealand from global water trends may be further growth in demand for agricultural output.

Widespread and relatively reliable water availability is an important foundation for New Zealand's agriculture, forestry and hydroelectric generation. Water quality is an important contributor to tourism and recreation, providing fishing, swimming and other water-sport opportunities.

Some water supplies are under increasing pressure, especially in Canterbury as demand grows for irrigation to intensify agriculture. Runoff from farming has increased the nutrient loads in many rivers and lakes.

Despite these pressures, New Zealand is one of the least water-stressed countries, benefiting from the combination of high quality water supply, relatively low population density and few industrial plants.

Some observers of New Zealand's strengths in water have claimed that water provides current or potential competitive advantage. It is difficult to see how this view can be justified.

Competitive advantage reveals itself in the form of higher prices or a cost advantage that provides higher profitability than competitors achieve. People are unlikely to pay more for products that containing high quality New Zealand water than for products containing high quality water from other countries. The cost of water supply is very low as a proportion of total product costs so it is hard to see how water could confer a material cost advantage.

Abundant water allows New Zealand to participate in agriculture but does not provide material competitive advantage relative to other participants. Any small advantage in water cost is likely to be more than offset by higher energy costs for transportation of water-containing products to distant markets.

The most important priority for New Zealand's water management is to ensure sustainable reliable high quality supplies for agriculture, industry and human consumption. The second priority is to protect rivers and lakes from nutrient and other pollution so they can continue to contribute to high quality production, tourism, recreation and New Zealand's brand.

Expansion and intensification of dairy production has increased nutrient pressure on many streams, rivers and lakes. Public and official concern has risen sufficiently that efforts to reduce the pollution and clean up the rivers are increasing. There is a nutrient cap and trade system operating in the Taupo catchment, effluent management technologies and policies are being developed and deployed, and Fonterra is building water protection measures into milk supply contracts. There is likely to be on-going tension though, because water protection measures increase costs and reduce output.

Volumetric water pricing has been introduced by some local authorities to encourage less wasteful water use, promote adoption of water management technologies and reduce capital expenditure for water supply.

MINERALS AND MATERIALS

New Zealand's imports include minerals and other materials whose prices will rise further as scarcities develop.

For example, there is a particular issue with phosphate rock supplies, which are essential for New Zealand's agricultural productivity.

Phosphorus is an essential nutrient for plant growth and there is no substitute. Meat and dairy production require more phosphorus than cereal production. Phosphate rock is mined and transported to farms for application.

Ninety percent of the world's phosphate rock supply are located in or controlled by China, Morocco (Western Sahara reserves), Jordan, South Africa and the United States (Clabby, 2010, p.291). China has imposed a large export tariff to protect long-term availability, which has slowed exports. The United States is a net importer, getting supplies from Morocco. Western Europe and India are totally dependent on imports. Price rises since the mid-2000s prevent many poor farmers from using phosphate fertilisers.

Morocco has substantial world reserves and is a stable North African country, at present.

The Global Phosphorus Research Initiative estimates that peak phosphorus will be around 2034 (Cordell et al., 2009, p.298) when global population is still projected to be growing.

As for many other environmental issues, there are solutions but they require preparation, organisation and investment. There are undersea resources, including in New Zealand's Exclusive Economic Zone,

and human excreta can be recycled and returned in a safe form to fertilise agricultural land (Cordell, 2008). Decades would be required to establish effective large scale recycling systems.

Generic responses to secure long-term supplies of minerals and other materials are diversification of sources of supply and relationship development in the form of longer term supply contracts.

Mineral price rises and supply security concerns increase the incentive to exploit New Zealand's own mineral resources. Government has identified minerals and petroleum as a priority for development. It is reviewing the Crown Minerals Act to encourage more development, streamline the regime to deal with future developments and ensure better coordination among regulatory agencies.

Following a strenuously resisted and abandoned effort to allow mining in national parks it is now taking a more low key approach to encouraging exploitation, emphasising exploration as beneficial information gathering and signalling recognition of the need for protection of the environment.

Resource exploitation will be attractive if the resource quality and location provides competitive advantage, New Zealand itself gains a worthwhile economic or risk reduction benefit, and environmental effects are acceptable. Managing sustainably implies that mineral decisions should be influenced by the obligation to leave sufficient minerals to meet the expected supply needs of future generations.

ECOSYSTEMS

Ecosystems and biodiversity are mainly local issues, though they aggregate to form a huge global problem. Unless the decline in global ecosystems is halted, it will eventually affect New Zealand indirectly by reducing the carrying capacity of the Earth.

The New Zealand Department of Conservation has participated in the series of international, multi-stakeholder meetings developing the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

New Zealand's natural environment is a huge asset, worth protecting because of the many benefits it provides including for agriculture, tourism, film industry, recreational and culture.

New Zealand's reputation as an exporter of food and other primary products is enhanced by the perception of a healthy natural environment. It also contributes to New Zealand's broader reputation, helping establish New Zealand as a differentiated country with people who have good values and make good relationship partners.

If ecosystems continue to decline in other countries, New Zealand's ecosystem could become a more valuable differentiator but only if New Zealand manages both the physical environment and its international reputation well.

New Zealand's ecosystems are especially vulnerable to biosecurity risks. Long isolation means many pests are not present here and many local species are not adapted to compete effectively with invaders.

Indigenous ecosystems have been under pressure for a long time because of damage caused by possums, rodents, mustelids and cats. These mammals have been eating the native fauna and flora and left unchecked would cause further species extinctions and seriously disrupt indigenous ecosystems.

Other unintended imports threaten pastoral agriculture, forestry and horticulture, imposing costs for prevention and response. One estimate indicates the annual economic cost of pests is about NZ$3.3 billion, or almost 2% of GDP (MAF Biosecurity New Zealand, 2009, p.3).

New Zealand is recognised as one of a handful of countries that have invested in coordinated policies to manage invasive species. The Biosecurity Act of 1993, was a world first; a law specifically to support systematic protection of all our valued biological systems – introduced and indigenous – from the harmful effects of exotic pests and diseases (Biosecurity Council, 2003, p.5).

Around one-third of New Zealand's land is protected for scenic, scientific, recreational, historic or cultural reasons. Much of the protected land is mountainous. Very little indigenous lowland forest remains, because of conversion to economic uses, mainly farming.

There is a lot of effort to protect the remaining indigenous forest and other natural assets. Government has added more land to Schedule Four, the country's most valuable conservation land. The Department of Conservation, private sector and volunteer organisations are working to remove predators from many offshore islands and a few onshore predator-free sanctuaries are being developed.

Conversations on how to permanently remove invasive pests from the bush are underway and technologies are being developed. People are talking about restoring the dawn chorus and re-establishing populations of birds in the bush.

Environment damage is easy to see and understand in New Zealand and opportunities to help are readily available. Protecting bird species from extinction, saving stranded whales, cleaning up the Rena oil spill and native forest restoration are supported by many New Zealanders. Many businesses are contributing too, providing opportunities for staff to get involved. The New Zealand Trust for Conservation Volunteers provides information for environmental groups and facilitates matching of volunteers with projects.

OVERSHOOT

The risk from overshoot is much less tangible. It is not directly visible and requires knowledge and imagination to understand. Most of New Zealand's political, economic and business leaders use the dominant economic paradigm to understand and anticipate the future so many advocate maximising output growth to provide a future of continued progress.

Unfortunately, as argued above, established environment trends and response obstacles create a material risk that the Earth's return to sustainability may be forced, as resources and environment become insufficient to sustain growth. Rapid real resource price rises over the last decade may be a signal that the economic growth phase is ending.

A global overshoot crisis would result in widespread famine, failed states, forced migrations, conflict and a declining standard of living for many people. If that happens, New Zealand might be a relatively good place to be. It is remote, has relatively benign climate change predicted, might be able to be self-sufficient in food and has a relatively skilled population, potentially able to work well together.

Those advantages are already being recognised by people who are conscious of the risks so New Zealand is becoming recognised as a safe haven. If current trends persist, the safe haven status is likely to develop further, increasing attractiveness to both investors and migrants.

Despite these benefits, an overshoot crisis would disrupt trade and geopolitical relationships. New Zealand would have to adapt to severe supply chain issues, potentially harming local energy and food production systems. However, unless risks are identified, researched and managed, preparation will be inadequate and adaptation will be costly and disruptive.

Overshoot risk is not a current agenda item in New Zealand. In the dominant paradigm, the future unfolds as continuous growth and progress punctuated only by regular booms and recessions. There is no need to manage for the long-term because the long-term emerges from series of similar short terms.

The dominance of that belief system in New Zealand, combined with lack of widespread understanding among leaders of the global environmental status and trends, means there is little effort to understand or manage long-term future outcomes. In the dominant paradigm the future will be good if the economic growth trend of the last few decades is restored so that is the main priority. In that paradigm, futures management reduces to economic management.

An example of this on-going prioritisation of growth can be found in the paper *Building a Blue-Green Future*, released by the Environment Minister in March 2012. The paper notes that "This plan is about

bringing together policies that support a strong growing economy with sound stewardship of our natural environment" (Smith, 2012).

In the paper environment issues are presented as challenges to be managed individually, not as symptoms of the emergence of overshoot leading to important societal risks.

There are many policies presented and collectively they aim to improve environment outcomes in New Zealand but the question remains; is there a risk of overshoot and is New Zealand prepared to manage that risk?

There is no mention in *Building a Blue-Green Future* of New Zealand's exposure to climate change risks or to global resource scarcities. The incompatibility of global energy and climate policies is not mentioned nor the potential for further energy price rises in the section on transport. The implication is if New Zealand can implement policies that improve local environment outcomes while aggressively pursuing economic growth the long-term outcome will be good.

Without information that reveals global environment risks have been well-researched, there is little reassurance that poor outcomes feared by many will not occur.

For followers of the dominant economic paradigm the future will be an extension of the past, producing long-term economic growth and progress. Global environment risks do not need to be understood and managed because they cannot disrupt progress. It is an article of faith that technologies and policies will overcome any issues that might arise. There is no need to look at what the numbers are telling us.

POPULATION

An important current challenge is how to improve economic performance to turn New Zealand from a country many people want to leave into a country more skilled people want to stay in and come to. With growing recognition of the value of growing high value exports, and signs of mobilisation of effective effort, there is an increasing chance that will be achieved.

An important future issue will be for New Zealand to decide how many people should live here given the opportunities and risks from higher population, and which kinds of people should be attracted and accepted.

Modern societies and their populations depend on a highly sophisticated and globally integrated economic system. The food we purchase from the supermarket depends on seeds, fertilisers, agricultural chemicals, tractors, processing plant, electricity, the Internet, trucks, fuel and many other inputs. Computers are built from raw materials sourced in many countries, turned into components in highly sophisticated manufacturing plants and then assembled and shipped to us. These systems are only as strong as the weakest link and the redundancy and resilience build into them. They have been developed to provide the greatest customer value at the lowest cost, delivered at speed. They have not been designed for resilience.

If an overshoot crisis emerges, these long and complex supply chains will be disrupted and alternative methods to provide food, clothing and other goods and services will be required.

Low population density and a relatively good environment mean New Zealand is well positioned to support its population even if an overshoot crisis makes global circumstances much worse. However, New Zealand's environmental resources are not unlimited.

Many countries in the world have populations far too large to be able to cope if the effects of environmental constraints interrupt supply chains and force increased self-sufficiency. New Zealand does have choices and it would be unwise to take on unnecessary risk. It would be prudent to avoid growing the population beyond what could be supported in less favourable circumstances.

At present New Zealand's isolation protects it from unplanned arrivals of refugees. In future, many wealthy people may want to come to New Zealand because it is perceived to be a safe haven. More

refugees may want to come here too, leaving their homes because of water shortages, lack of arable land, inundation from sea level rise, and fleeing from other migrating people.

In New Zealand at present the major population concern is outward migration of New Zealanders. Inward migration of skilled people and population growth are welcomed to replace those departing, to stimulate the economy by increasing demand for houses and other infrastructure, and to provide agglomeration benefits. There is no active debate about population policy or the ideal population size taking account of all opportunities and risks.

This is in stark contrast to Australia where there has been an active and sometimes acrimonious debate covering environment impacts and optimal carrying capacity as well as the economic, demographic and immigration consequences of population policy.

TRANSFORMING THE ECONOMY

Emerging environmental constraints are triggering changes in demand, resource costs and availability, and policies. These changes create many business opportunities, for example:

- Strong demand for safe and healthy food leading to price increases for commodities, price premiums for traceability and quality assurance, and growth of value-added food product exports;
- Demand for products and services that will facilitate the transition to a low-emissions economy with less environment impact;
- International sale of technologies developed to adapt to environmental changes or for value-added products and services; and
- Using a green lens in all businesses to identify environment improvement opportunities that also provide commercial benefits.

Large scale economic shifts like the one to a low-carbon, resource constrained economy threaten businesses that are unable or slow to adapt. Other businesses emerge or gain advantages so the net effect on business as a whole may be positive. However, threatened incumbents should prefer to avoid change and may oppose environmental protection and economic transformation policies.

Many individual New Zealand businesses have been taking advantage of opportunities and responding to threats resulting from environment change. The New Zealand Business Council for Sustainable Development was established in 1999 to provide leadership in achieving social progress, ecological balance and economic growth.

Momentum for economic change is building rapidly.

The Green Growth Advisory Group, commissioned by Government, reported in December 2011 (Green Growth Advisory Group Secretariat). The Group focused on near-term opportunities for greener, faster growth. It concluded that greening of the economy is good for New Zealand. An ‘overwhelming majority’ of submissions supported growth as a concept. There was no discussion about the quality of growth although the Group did focus on the decoupling of emissions growth from economic growth.

There was a strong emphasis on greening the whole of the economy, rather than just on establishing new green businesses. The Group highlighted the need to increase the capability of SMEs especially to identify and take advantage of green growth opportunities. It recommended provision of information to inform public discourse on the benefits, costs and risks of petroleum and minerals extraction as well as provision of information to support sound decision-making in other sectors. It supported collaborative dialogue to develop consensus.

The Group was not asked to and did not provide guidance about how to handle situations where trade-offs are required between growth and environmental health. The report acknowledged, appropriately, that green growth is a narrower concept than sustainability.

The Group endorsed protecting, developing and taking advantage of New Zealand’s clean green brand, acknowledging more needs to be done to protect environmental attributes that support the brand.

The Advisory Group did not support development of a clean-tech or green sector as has been done in other countries, preferring to support innovation of all kinds.

The Pure Advantage organisation, founded by a group of business leaders, also wants to contribute to green growth. The first major report *New Zealand's Position in the Green Race* built its argument on the importance of environmental change for the world, the contribution that green growth could make, the progress being made in the leading countries and the observation that New Zealand is slipping in green performance relative to other countries.

Pure Advantage diverges from the Green Growth Advisory Group, proposing that developing green sectors of the economy offers large economic potential and is better than developing petroleum extractive industries with their associated emissions growth. Pure Advantage also argues to improve energy efficiency a lot and invest the proceeds in development of new green businesses.

The McGuinness Institute, previously the Sustainable Future Institute, is completing *Project 2058* which looks at how New Zealand can be successful long term. The approach is to develop scenarios describing possible futures and understand what choices could lead to the preferred outcomes. The intention is to encourage and contribute to building long-term capacity to manage risks and opportunities.

The Auckland Plan released by the Council in May 2012 acknowledges environmental challenges. The plan signals the need for policies to reduce greenhouse gas emissions, provide more and cleaner public transport, promote energy efficiency and green growth and increase the ability to cope with natural disasters and resource shortages.

INSTITUTIONS

There are many government agencies and NGOs that report on aspects of the environment or manage environment issues.

However New Zealand has few institutions that explicitly aim to anticipate, understand and manage long-term outcomes. There is the New Zealand Futures Trust, an NGO that promotes and facilitates futures thinking, and the McGuinness Institute (previously the Sustainable Future Institute), an NGO that does research and publishes analyses and proposals relevant to future management.

The Institute of Governance and Policy Studies, located in Wellington within Victoria University, focuses on current issues of domestic and foreign policy. Some of its research informs long-term environmentally informed thinking but that is not a primary focus.

There is no specialist futures institute staffed by government that anticipates the longer-term future and is a locus for central government thinking about how to develop and manage environmentally informed long-term strategy.

That makes New Zealand unusual among developed nations. Many other governments have established institutions and processes to develop views about the long-term future and build capability to respond to future trends and risks.

For example, in early 2010 Singapore's Government established a Centre for Strategic Futures to develop whole of government strategic thinking to guide long-term planning including how to respond to risks and opportunities. The aim is to improve the public service's capabilities to deal with 'strategic surprises' and involves a Strategic Futures Network of deputy secretaries from each government ministry to actively promote futures work within the civil service. The Centre is overseen by an advisory board chaired by the Head of the Civil Service.

In Australia, the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) offers advice and expert scientific opinion on policy challenges across the whole of government. Supported by the Australian Council of Learned Academies, it looks forward several decades using fore-sighting techniques.

New Zealand should have a whole of government capability to study and anticipate the future. The environmental, economic and social domains influence one another and success in one domain is only possible if the other domains are performing strongly too.

5. Ensuring New Zealand is well prepared

The last 60 years has been a period of relatively uninterrupted economic development for the world and for New Zealand. The data presented in chapter two indicates that the next 40 years are unlikely to be experienced as a continuation of that progress because the world's economy has become very large in relation to the size of the global environment that supports it. There are important environmental stresses already and those stresses will increase further given expected output growth, existing policies and the obstacles to change.

The issues raised in this paper are long-term with high stakes and high uncertainty. They are identified using an environmental lens but they are important economic issues too. Environmental change creates economic opportunities and threats too, and those must be well-managed. Global outcomes depend on what countries collectively choose to do. Each country decides, explicitly or implicitly, how it will contribute to managing or not managing important global economy-environment trade-offs.

A strategy is a plan to achieve a valued objective or to succeed in an important arena. When environmental strategy is referred to herein, we mean a strategy for the country that takes account of environmental issues and their economic consequences, not just a strategy that improves environment outcomes.

Given the high stakes and uncertainty about the future state of the economy-environment system, it would be prudent to think through what is likely to happen and what might happen during the next few decades and have a plan that positions New Zealand as well as possible for all eventualities.

In the recent past, the countries that have been most successful economically have been those with the skills and innovation capability to export high value differentiated goods and services. A few countries have become wealthy by exporting oil or minerals.

Countries with poor resource endowments have been able to import energy, food and materials to sustain their populations and economies and the major trade challenge has been to secure access to attractive markets for exports. A growing global economy has meant that development assistance, loans and aid have been available to relieve some hardships experienced by less well-endowed countries.

During the next few decades, resource scarcities will make access to energy, food and materials much more challenging so countries with strong resource endowments relative to the size of their populations will perform better. Climate change and ecosystem damage will exacerbate resource scarcity issues, especially in vulnerable less developed countries.

Environment-driven changes will alter the conditions for country success. When conditions for country success change some countries improve position relative to others. For example, the combination of technology availability, low labour costs and market access is allowing China and several other rapidly developing countries to improve their relative economic positions dramatically.

The options available to countries are partly determined by their starting positions and endowments but strategic choices and implementation effectiveness are important too.

New Zealand is relatively well-positioned to respond effectively to the direct effects of environment changes. There are numerous renewable energy options, abundant food, land, water and materials resources. The direct effects of climate change are expected to be less severe than those in many other countries. Ecosystems are vulnerable but remoteness, vigilance and biosecurity response capability provide some protection.

However, globalisation means New Zealand will have to respond to the consequences of environmental constraints in other countries.

The time horizon for a New Zealand environment strategy should be the next 40 years. That period is sufficiently long that it is very unlikely that current economy-environment conditions will persist, so the strategic thinkers will need to seriously consider what will be required to succeed in different potential future states of the world.

After 2050 things become much more uncertain. Population growth will have slowed as the demographic transition is completing in most developing countries. Forty years is long enough for resource scarcities to emerge and play out geopolitically, for some climate change and ecosystem effects to mature, and for unanticipated breakthrough technologies to be developed and deployed.

The alternative to developing an integrated local environment strategy is to continue on the current course, responding to local environmental issues as they become salient, participating in international forums and learning from the efforts of other countries.

The reasons to increase the planning effort are to:

- Have an integrated strategy suited to New Zealand's unique circumstances;
- Realise opportunities and reduce risk by taking action early rather than late;
- Guide business and individual behaviour on a day to day basis; and
- Help more people understand environmental issues so they will support risk reduction changes as they are proposed or required.

Given the global environment status and trends, New Zealand needs to acknowledge the possibility that continuing to maximise undifferentiated economic growth will increase the overshoot risk and eventually lead to a collapse of output and population.

However, if rigorous investigation reveals there is an acceptably small risk of the kinds of future outcomes that seem likely from the analysis in chapters two, three and four then New Zealanders should all understand that, breathe a collective sigh of relief, and get on with building competitive economic advantage to race other countries to grow incomes and wealth.

It seems much more likely that independent rigorous analysis will confirm the seriousness of the long-term risks. If there are important environmental risks then New Zealanders should understand those risks and manage the economy and environment to reduce them.

It would be unwise and irresponsible to assume without analysis that environment risks are unimportant or that enough is being done to manage them.

Developing an environmentally informed long-term strategy might seem futile given the amount of uncertainty about the future and the scale and scope of possible global changes. In response, the environment strategy can be developed within three themes:

- Progress **No Regrets strategies** that allow New Zealand to take advantage of or respond to expected changes in ways that realise benefits or have only low costs if changes do not occur as anticipated;
- Prepare **mini-max strategies** that protect against catastrophes by minimising the maximum loss; and
- Develop New Zealand's **capability** to manage and adapt to anticipated and uncertain environment futures.

Several directions for development are very likely to be beneficial despite uncertainty about the specifics of future global conditions.

No Regrets strategies are strategies chosen in uncertain situations which provide the benefit sought or some other net benefit regardless of how the uncertainty is resolved in the fullness of time. The No Regrets recommendations in this paper are not all strictly No Regrets because the analysis is not sufficiently detailed or robust to prove that. The idea is that they are directions for development that are likely to be beneficial whether environmental risks are low or very high.

Several of the No Regrets strategies are already being pursued. Those are included here for completeness, because we endorse them, and because inclusion enables long-term issues and opportunities from the strategies to be highlighted.

If serious environmental challenges will emerge then it is best to be wealthy, well-resourced and technologically capable as that will improve the potential to develop and implement solutions.

Earth's environment in aggregate coped well with the huge growth of output from 1900 to 1950 and less well with the much larger output growth from 1950 to today. It looks as if Earth will not cope well at all with the output growth expected by 2050.

There is a diversity of views about how serious potential environment outcomes might be. Some people believe the risks are exaggerated, others that technology will save us, others that we will soon change course and manage risks effectively, and others that our civilisation will collapse from overshoot. People who use the economic paradigm are usually more optimistic than those using the ecological paradigm.

No matter what is done to reduce environment damage and achieve a soft landing, some risk of overshoot leading to catastrophic outcomes is likely to remain. Failure to deploy technologies and policies to reduce damage, climate change, food shortages, ecosystem collapse, trade disruption and rising resource prices could operate separately or in combination to threaten economic progress and stability.

Mini-max is a strategic approach used when it is important to avoid catastrophic outcomes. Life insurance is an example of a mini-max strategy. A breadwinner may not expect to die and may understand that the expected value of insurance is less than the expected cost but insure anyway to avoid even a small probability of leaving his or her family in hardship.

The three mini-max recommendations are designed to limit the damage that would result if an overshoot crisis emerges. Ideally, mini-max strategies are not needed because the risk they protect against does not eventuate.

The analysis indicates that New Zealand is likely to need the mini-max strategies but timing remains uncertain. It might be in the near future or in several decades.

Many New Zealanders, including some of our leaders, remain unaware that ecological footprint, climate forecasts and other analyses indicate that the Earth is already deep in overshoot, creating the conditions for a future 'correction'. For those less well informed and more optimistic New Zealanders, mini-max strategies should be thought of as protecting against serious downside risks that are not expected but that, if they did occur, would lead to outcomes that would be so serious that we should be well-prepared, just in case.

In the 19th and 20th centuries, the economic paradigm maximised business profits and individual consumption and the environment could safely be ignored in most country-level strategy development. Twenty-first century societal management requires the economy to be managed within environmental constraints, which is much more complex. New capabilities are required to manage well in these new circumstances. Five recommendations follow to improve the capability to manage environment issues successfully.

The 16 recommendations in this chapter, if implemented, would help ensure New Zealand can take advantage of opportunities presented by environmental change and be prepared to manage environmental risks.

Some of the proposed strategic directions are broadly consistent with existing economic development efforts. More effort on these would position New Zealand well to respond when greater changes are required in the future.

NO REGRETS STRATEGIES

Recommendation 1: Grow high value agri-food based exports

New Zealand's low productivity economy has not earned enough to cover consumption spending so assets have been sold and debt has accumulated. A more successful economy would reduce the current account and fiscal deficits, repay debt and accumulate wealth.

An important reason for New Zealand's relatively low productivity is that exports are concentrated in low productivity agricultural commodities. New Zealand is a relatively efficient on-farm producer of

agricultural commodities but earns low average returns (Proudfoot, 2010, p.5), in part because of a poor overall competitive position.

Global food prices grew by more than 50% during the last decade. A further large increase of real food prices would lift export earnings and GDP but by itself would be insufficient to allow New Zealanders to re-join the highest income group of countries.

To lift productivity, New Zealand is adopting a strategy to establish and grow high value export businesses, in part by adding value to commodities already produced here. Building value-adding agri-food export businesses creates high value jobs that are anchored in New Zealand.

The idea of adding value to commodity exports has been around since at least the mid-1980s but progress has been disappointing. There is increased likelihood of success now because Government has recognised that it can and should contribute to successful industry growth, research effort is being refocused to support high value industry growth, and there is increased focus on developing the business capabilities needed to internationalise successfully.

There is nothing new or distinctive about this recommendation. What is distinctive is to include it in the environment management agenda. Many people think there is a conflict between economic and environmental goals but in the long-term they are mutually dependent. A wealthy economy will be much more able to transform itself to become sustainable and to adapt to expected and unexpected risks from environmental changes.

Recommendation 2: Include the goal of developing a technologically diversified advanced economy in economic development policy

The New Zealand Institute argued in 'A goal is not a strategy' (Boven et al., 2010) and previously, that New Zealand should create the conditions for success of exporters of high value differentiated goods and services.

Developing a workforce that is technologically capable with diverse skills can increase economic prosperity while also providing options and resilience to respond to future challenges that might not be recognised today.

Global supply chains and resource availability might be threatened by the consequences of environment change so New Zealand could need to adapt to disruption of critical supplies.

Industry development and skill development priority-setting should explicitly incorporate the goal of having a technologically capable population. To date, a cost-driven approach has been used, leading to losses of some technological capabilities. The implicit assumption of cost-driven approaches is that technologies and materials supply will always be readily available for import. That assumption may have been valid in the past but it is not for the future.

An environment risk management lens should be included in research prioritisation, industry policy and skills strategy development.

Recommendation 3: Encourage growth of the green economy

The third No Regrets priority should be to develop the green economy. A green economy is "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (Working definition of the United Nations Environment Programme Green Economy Initiative).

What is considered green is determined by the market alternatives. Gas is green relative to coal but wind is green relative to gas.

Growing the green economy includes pursuing green business opportunities and encouraging the greening of all businesses. When business leaders look at their businesses through a green lens they identify new opportunities that offer both business and environment benefits, 'win/win' opportunities.

Transforming to a low carbon economy is an important aspect of developing the green economy.

As argued in chapter two, the world will either make a lot more effort to reduce emissions than it has to date or will face very damaging climate change. If the world does form an effective emissions reduction agreement then New Zealand is very likely to participate. That implies a potential need to make an effort soon to reduce emissions quickly, in parallel with other countries.

It would be prudent to understand how a rapid transition to a low carbon economy would be achieved with minimum economic and social cost. Having businesses aware of the likely need to change would ensure they are better prepared and more effective if a global agreement causes the change process to be accelerated.

Efforts to reduce emissions are likely to combine with emerging scarcity of conventional liquid fuels to cause further increases in energy prices. High dependence on petrol and diesel and being distant from the world's large markets increases the risk that energy price increases will reduce industry competitiveness and impose cost increases on individuals. Infrastructure and other important investment analyses should include sensitivity analysis which includes energy price risks.

Recommendation 4: Establish a policy programme to rapidly improve resource use efficiency

The analysis of scarcities implies that the cost of energy and materials inputs has become much more important over the last decade and is likely to increase further. Ecological footprint analysis, output growth projections and the need to limit overshoot risks combine to imply that the materials intensity of economies will have to reduce a lot during the next few decades.

In the 20th century, when resources were plentiful and cheap, growing materials use was valuable. Export revenues were readily available to fund imports because New Zealand had a strong economy. More materials use meant more activity and higher revenues while contributing to job growth and higher GDP.

The world will have to change direction, reducing per capita materials use to sustainable levels. In part, that will be encouraged by signals from higher prices but customer preferences and government policy change will contribute too.

In a world where the quality of economic activity becomes more important and quantity less important, there are benefits from improving resource use efficiency. For example, more efficient vehicles or less wasteful packaging would reduce household costs and improve the current account balance, while contributing to better environment outcomes. Lower energy and materials inputs for the same customer benefit would improve international competitiveness.

Remoteness from input and output markets, a resource-intensive economy and high energy costs mean New Zealand can gain more benefits than most countries from improving resource use efficiency.

If New Zealand was an early mover in improving resource use efficiency then it might gain competitive advantages from developing valuable technologies. Germany used environment regulation strategically in the early 1990s to gain analogous benefits for its exporters of environmental technologies.

Recommendation 5: Lead national conversations to build consensus on important emissions issues

New Zealand faces four issues resulting from the likely need for rapid reduction of global greenhouse gas emissions:

- What should be the policy for agriculture emissions?
- What energy mix should be used for generation?
- What development of hydrocarbon energy sources should be progressed?
- How should urban form and transport development reconcile short term economic needs against long term energy cost and emissions risks?

These are all issues today but there are not yet widely agreed solutions, partly because the issues are inherently difficult to resolve. Any resolution developed today is likely to be modified in future as scientific understanding improves, international agreements are developed and new technologies are deployed but that is not a reason to defer planning and preparation.

The policy issues can be resolved individually but they need to be considered in an integrated way too, because collectively they will have a big impact on New Zealand's contribution to global emissions.

New Zealand's conditional commitment to reduce overall emissions by 10-20% by 2020 and by 50% by 2050 should be backed by a planned pathway to achieve those reductions. New Zealand has one of the highest per capita emissions in the world combined with limited effort to control agriculture emissions, plans to retain some thermal energy generation, preparations for large scale hydrocarbon development and a high emissions transport system.

Following an aggressive emissions reduction pathway would impose high costs for adjustment on agriculture, imply more effort to develop non-fossil fuel segments of the economy and a need to transform energy and transport systems to operate with low fossil fuel use.

There is disagreement between important segments of the population on these issues and policies have switched as governments have changed. National conversations leading to consensus are required because the issues are economically as well as environmentally important, and they are long-term, so stable policies are required to reduce uncertainty for investing businesses.

The debate so far has been characterised by contests between competing positions, sometimes based on pre-conceived beliefs and values rather than on high quality analysis taking all important factors into account and informed by a wide range of evidence. We can and should do better.

Recommendation 6: Lead preparation for adaptation to climate change

The climate is changing and climate change will continue. Change may be slowed by a strong management response or it may accelerate if the response is weak and positive feedbacks become important.

Despite uncertainty, many of the directions for climate change are well-understood.

Greater incidence and intensity of storms and flooding will require more infrastructure resilience and that should be built into engineering standards and planning processes.

Sea level rise will threaten coastal plains, cities and transport infrastructure so long-term plans should reflect the expected changes. New transport links and other developments should be built on higher ground. There are many obvious ways to prepare; for example building floating rather than fixed docks. Decisions should be made about where to invest in protecting existing capacity by building barriers and where to relocate.

Prioritisation for relevant infrastructure such as water storage and irrigation should take account of expected longer term changes in rainfall and river flows. Where increased incidence of droughts is expected, irrigation may increase resilience.

As the climate changes, the optimal agricultural production mix will change for many locations. Producers should understand likely local climate changes and implications for crop and livestock choices. Some information to inform these decisions is already available.

Our shared current understanding of the future is based on historical stability with widely recognised expectation of some unspecified disruptive changes at some time in the future. That should be updated, with a most likely course of future changes identified and communicated so New Zealanders can prepare for and begin the adaptation that will be required.

National response plans, including timing and investment requirements, should be prepared for a base case scenario, along with scenarios for accelerated and slowed climate change. Uncertainty is not a reason to be unprepared.

Long-term costs for retirement security and healthcare are included in strategic and financial planning. Costs for adapting to climate change should be included too.

Recommendation 7: Encourage more New Zealanders to be more engaged with environment protection and restoration

Vulnerability to invasive species is well-understood in New Zealand because of our experience of the consequences for agriculture, forestry and the natural environment of intentional and unintentional species imports. Biosecurity, preserving biodiversity and other conservation efforts are established because of recognition of economic risks and the high value New Zealanders put on continued enjoyment of a relatively unspoiled natural environment. Scientific research is mobilised to develop protective technologies. Environmental resource use and risk management policies and institutions are in place and there is a healthy tension between development opportunities and environment protection.

Material expenditure is required to limit the damage to forests now. Future efforts will focus on more permanent solutions that do not require on-going human efforts.

There is an opportunity is to gain greater commitment from people and businesses to support environment protection and restoration efforts. Many people are willing to help but leadership and organisation is required to mobilise and direct the effort. More engagement and restoration would help more New Zealanders appreciate the value of the environment and how important healthy ecosystems are to support life and the economy.

It seems wasteful that so many young New Zealanders are unemployed and not developing skills while insufficient effort allows the natural environment to continue to deteriorate. Government make-work schemes are unpalatable given the current fiscal challenges but there should be a way for civil society to develop solutions providing the environmental, social and economic benefits that seem to be available.

Recommendation 8: Lead development of an environmentally-informed long-term population and migration strategy

The implicit population policy currently seems to be that more is better to attract skills and capabilities, to replace outward migration losses, to gain agglomeration benefits and to stimulate the economy with investment in housing and infrastructure.

Countries seeking food supply and other resource security, such as China, and wealthy individuals seeking safe havens are already investing in New Zealand. It is likely that New Zealand's attractiveness to both labour and capital will increase as conditions become more difficult in other places.

More people are likely to want to come to New Zealand, including returning citizens, raising the question of how many and who should be accepted. Emergence of environmental risks that could alter climate, disrupt supply chains and reduce agricultural productivity make it prudent to avoid growing the population beyond what could be supported in less favourable circumstances.

New Zealand should develop a view about how big its population should be and introduce policies to achieve the desired outcome. Important influencers of population strategy include land availability and intensity of use, food for exports versus for consumption, demographic structure and agglomeration benefits, skills needs, expected migration patterns of citizens, the economic and social benefits and costs from citizen and non-citizen migration, and global risks from environment and other sources.

MINI-MAX STRATEGIES

Recommendation 9: Review long-term supply chain security to ensure availability of critical technology and economic inputs

Relatively low population density with abundant land and water means New Zealand does not face the same food security risks faced by many more populous countries and by poorly endowed countries.

However, as a small, isolated trading nation New Zealand is highly dependent on the rest of the world for supplies of important commodities and services. Without imports of agricultural chemicals, tractors, computers or spare parts for transmission networks or hydroelectric generation, life would become much more difficult.

For a long time, trade policy has been preoccupied with overcoming import protectionism. Export protectionism is an emerging new force. If established trends continue, there is likely to be a shift from spot purchasing of resource inputs to long-term contracts and vertical integration by customers securing supply. Supply chain risks can trigger wars and disrupt political leadership.

It is difficult for us to understand these concerns from New Zealand. Here, today, there is abundant food and no difficulty importing foods, liquid fuels, technologies and the equipment needed to operate the economy.

Relationships with important suppliers and trading partners should be managed carefully to ensure that New Zealand is a favoured customer. Reciprocity of supply security arrangements may become a feature of international partnerships and inter-government relationships.

The importance of global trade and the economic value of highly integrated supply chains mean it would be a mistake to stop trying to encourage stronger trade links and economic integration. However it would also be a mistake to continue to rely on persistence of uninterrupted supply of essential inputs while the risk of an overshoot crisis grows.

Just as effective event risk managers establish plans for disasters such as pandemics, earthquakes and volcanoes, there should be plans to prevent and respond to disruption of critical supply chains.

Recommendation 10: Develop self-sufficiency and skills

Europe and Japan have made domestic food supplies a foundation of agriculture policy since their experiences of food shortages in World War II. The United States has extended the use of fracking to expand supplies of domestic gas. As supply risk concerns increase there is increased effort to become more self-sufficient in important economic areas.

The net result is likely to be slowing or reversal of some globalisation trends with consequent loss of some of the gains from trade. Those economic losses will be partly offset by avoidance of higher transport costs as energy prices increase and by deployment of emerging manufacturing technologies such as 3D printing, which will improve the cost-competitiveness of smaller scale local manufacturing of a diverse range of products.

One response to supply chain and resource availability risk is to increase local self-sufficiency in essentials. There are already local examples of capacity establishment to protect against supply risks such as New Zealand's compliance from 2007 with the longstanding IEA requirement that countries hold 90 days of oil reserves from a combination of domestic commercial stocks or 'ticket' contracts to purchase stocks held in other IEA member countries in a declared emergency (Ministry of Economic Development, 2012c).

One risk that few people are aware of is the risk of lack of availability of seeds for cereals, and some fruit and vegetables. The production process for new hybrid seeds involves multiplying up for several generations prior to sale to a farmer or grower. If a farmer plants seeds grown from the first crop, the plant may be well formed and productive but later generations can be malformed with lower yields.

The arrangement suits the commercial needs of seed providers and increases yields but it puts food availability at risk if seed supply is interrupted.

An argument for developing towards a more technologically diverse and capable society was made earlier in recommendation two. Protecting against supply risk implies also taking that argument one step further and identifying the technologies and production capacities that should be available locally because the consequences of supply disruption would be unacceptable.

Note that this is not an argument for a return to the pre-reform situation where New Zealand aimed to produce many goods locally and protected local industries from import competition to manage the trade balance. It is an argument to insure against specific supply risks that could have seriously detrimental consequences.

Skills are an important element of preparedness. Many important skills are technological, involving competences like engineering that are required in the country in limited quantities. Others are skills that everyone needs such as literacy, computer skills and purchasing.

The skills that would be required in a disrupted society are different from those required today. Widespread understanding of basic construction, food production and preservation techniques, and how to work together in challenging circumstances would improve resilience if difficulties do emerge.

Recommendation 11: Review security and foreign policy to ensure preparedness for an overshoot crisis

For more than 60 years, humanity has grown populations and incomes without major disruptions from world wars, epidemics or famines. Given the challenges identified, it seems unlikely that growth will continue on the same course for another 40 years without a lot more effort to protect environmental assets and sustain environmental productivity.

It is possible that climate change, resource scarcities and ecosystems decline will combine to disrupt the economic development process people expect and rely on. Security may become far more important than currently expected. Contention for resources, spill-over consequences of environment events and failing states may create economic disruption, conflicts and migration flows that could threaten New Zealand's interests and security.

Many Pacific Islands with close links to New Zealand will be affected directly and indirectly by environmental changes.

A review of the implications of an abrupt climate change scenario for the United States Department of Defence concluded that energy, food, water and minerals shortages would lead to increased migration and conflict. The resulting violence and disruption would lead to different security challenges from those anticipated today (Schwartz & Randall, 2003).

Overall, the environment adds an important dimension to geopolitical evolution; one that is not yet fully understood. Foreign policy should be informed by the security, migration and other geopolitical implications of environment change.

Trade policies, including the Trans-Pacific Partnership, should be developed in ways that meet New Zealand's needs today while also protecting future interests in a more environmentally challenged world. Trade and security policies should be developed and assessed by environmentally informed strategists through a lens of risk protection alongside the traditional lens of economic opportunity.

BUILD CAPABILITY

Recommendation 12: Launch a futures-focused institution

The future is uncertain. What we can be sure of is that the powerful forces driving the environment overshoot process are unlikely to be reversed easily or quickly. Further, whatever future we might imagine, things are likely to turn out different.

One response would be to carry on as if the future is going to be a simple extension of the past few decades and be ready to respond to disasters. A better response would be to build understanding of likely outcomes, the risks and the opportunities from long-term trends and develop society and the economy to become better prepared.

New Zealand should develop stronger institutional capability to study the long-term future, to identify and disseminate tools for managing the long-term future, and to host and lead debates about long-term future issues. Understanding and managing future issues requires involvement by several government agencies. The capability should be a whole of government capability because environment, economic and social issues are all connected, especially long-term.

Recommendation 13: Systematically improve preparedness for environmentally driven changes (ANAR)

Having a central government institution like a futures institute cannot be a complete solution because many businesses and NGOs also need to anticipate and respond to environment changes. Just as government encourages and assists organisations to lift their innovation and management capability, it should also encourage building wider capability to manage environment change.

Four complementary capabilities, collectively labelled ANAR, should be developed for all organisations which may be affected by environment change:

- **A**cuity: Build an understanding of likely and possible futures, understanding trends, developing scenarios, identifying risks and opportunities;
- **N**avigation: Work out what to do to manage the risks and take advantage of opportunities;
- **A**gility: Be able to change effectively when change is required. Elements of preparation for agility include information provision, consensus-building, motivation and skills development; and
- **R**esilience: Be able to respond well when unexpected events or shocks occur. That will involve developing a combination of contingency plans, back-up supplies and systems, equipment and technology purchases, and skills development. Resilience can be thought of as having two layers; a spongy outer layer able to absorb shocks with a hard inner layer able to resist serious threats.

Without effective action, preparation is useless. So when the need arises it is important to be ready and able to be effective. Organisations such as businesses, sports teams and armies practice their disciplines to get really good at what they do. In the same way, the time may come when New Zealand's organisations have to adapt to major changes, expected or unexpected. Identifying and acting on current opportunities to improve environmentally relevant outcomes is a good way to get teams ready for the bigger challenges that are likely to emerge in the future.

Recommendation 14: Broaden economic performance metrics

What gets measured gets managed. Currently the most widely used societal performance measure is gross domestic product (GDP).

GDP measures the output or activity of an economy. GDP growth is generally good for businesses because private sector GDP is a reasonably valid measure of the quantity of contribution available for businesses. Business lobby groups usually promote GDP growth and smaller government because those development directions maximise the contribution opportunities for their private sector members.

GDP per capita is a summary measure of the amount of output available for consumption on average for each individual in an economy.

GDP was developed by economist Simon Kuznets in the 1930s when United States Presidents sought policies to combat the Great Depression. The growing role of government in the economy prompted demand for a comprehensive set of data to account for national economic activity (Wolverson, 2010).

In his first report to Congress in 1934 (p.7) Kuznets cautioned that the welfare of a nation cannot be inferred from a measure of national income and then in 1962 (p.29) added a further qualification, "Distinctions must be kept in mind between quantity and quality of growth, between costs and returns,

and between the short and long run. Goals for more growth should specify more growth of what and for what."

Despite measurement complexities, GDP is a crude measure that counts waste, crime and hospital stays as benefits and encourages the use of a large inefficient car in preference to a small efficient and less environmentally damaging one. GDP does not distinguish the output of efficient competitive export industries from the output of inefficient domestic production. GDP takes no account of debt accumulation, environmental damage or the resource depletion that results from economic activity. It measures current output only, taking no account of resulting changes to future output.

These drawbacks of GDP do not matter too much when resources are abundant and economies are growing. But the deficiencies of GDP have become much more important now that resource scarcity is increasing, many environmental assets are losing value, and growth is becoming more difficult to sustain in developed countries.

Efforts to improve metrics to encourage beneficial economic activity and reduce damaging activity take four directions. The first is to extend societal performance metrics to include other economic outcomes besides GDP and also non-economic outcomes such as social and environmental outcomes. Treasury's Living Standards Framework (Gleisner et al., 2011) and the New Zealand Institute's NZahead measures are examples.

The second direction is to use adjusted GDP measures like the Genuine Progress Indicator (GPI). "GPI adjusts for income distribution effects, the value of household and volunteer work, costs of mobility and pollution, and the depletion of social and natural capital" (Costanza et al., 2004).

From 1990 to 2006 New Zealand's average annual growth rate for GDP per capita was 1.9%, compared to 0.9% for GPI per capita (McDonald et al., 2009, p.9). In the United States since 1975 GDP per capita has grown strongly but GPI per capita has not increased (Jackson & McBride, 2005, p.34).

A third direction could be to complete separate national income statements and balance sheets for the economic, social and environmental domains.

We propose a fourth direction for New Zealand; adding new high level economic performance measures alongside GDP to highlight the quality of economic activity. Specifically, GDP should be supplemented by economic measures to encourage:

- *Growing the profit earned by the country's firms from exports*. Export profit is a much more valuable component of output than, for example, expenditure on unnecessary packaging. Metrics should encourage more rapid growth of valuable output like profitable exports and discourage damaging or wasteful output;
- *Lowering costs for delivery of the goods and services that are valued by the population*. Currently, if goods and services are delivered using wasteful processes GDP is higher than it would be if the waste was reduced. Money saved by reducing inefficiencies could be invested in productive export activities or spent on consumption of more highly valued goods and services;
- *Growing the value of environmental assets*. Currently, environmental assets are depleted by activities that provide current consumption benefits but the economic cost of depletion is not measured. Measuring changes in the environment balance sheet would improve management of trade-offs between current consumption and future consumption potential; and
- *Reducing ecological footprints*. Ecological footprints are estimated for countries, industries, firms, households and individuals. They can help focus environment improvement initiatives because media and popular attention is sometimes focused on what is most interesting or appealing, not what is most important.

Sound environment management requires high quality data. As the importance of environmental outcomes increases, better measures of the local environmental status are required too. Measuring environmental status and trends is difficult, partly because so many variables are important and there are complex interactions. But without good data there is a risk that decisions may be based on assumptions or values derived from paradigms that are no longer optimal.

Recommendation 15: Ensure that economy-environment trade-offs are managed explicitly, effectively and appropriately in Government's institution design

In the long run, a strong economy depends on a healthy environment and poor economic performance makes it difficult to protect the environment. But in the short run there are important trade-offs required between economic and environment outcomes and these trade-offs present difficult choices.

Ecologists may want fishing reduced to increase stocks and protect the marine environment for later generations whereas fishing companies may prefer more fishing to provide profits for shareholders now. Climate priorities argue for reducing greenhouse gas emissions but doing that quickly would impose economic costs. It is good to reduce damage to rivers and streams by restricting nutrient run-off but that may impose costs on farmers.

A common way to resolve these kinds of issues is to have the two sides define their preferred solutions, assemble evidence and support, and then exert power, lobby the minister or go to court to get their preferred solution adopted.

A better approach is to bring the parties together into dialogue to develop and explore options that best achieve the conflicting objectives. Creative breakthroughs, compromises and least-cost solutions are more likely when the parties work together. Innovative social technologies are being developed to help identify solutions to complex problems where many stakeholders have conflicting interests.

When decisions need to be made, the decision-making agency should have responsibility for, or at least concern about, both economic and environmental outcomes. In New Zealand there is one government agency responsible for energy and a different one concerned about emissions.

Denmark has a different institutional arrangement; one agency, the Ministry of Climate, Energy and Building, is responsible for national and international efforts to prevent climate change and reconcile that with energy policies. Denmark has a goal that by 2050 its energy and transport network will rely solely on renewable energy sources.

The Danish approach ensures that management of the trade-off is explicit and within a single institution but it does create another risk; that the single organisation becomes captured by a single viewpoint and that either economic or environmental issues are subordinated inappropriately.

Regardless of the mechanisms used, institutional arrangements should ensure there is analysis that examines how trade-offs should best be managed, not a conflict requiring a choice between divergent proposed solutions, nor a presumption that either economic goals or environmental goals are paramount.

Recommendation 16: Improve public understanding

An important argument made in this paper is that environmental issues are even more important than most people realise so the future will not be a simple extension of the recent past. Downplaying risks or leaving emerging issues for future generations to respond to would be unwise and irresponsible. Many young people have already concerned that uninformed older generations are wasting resources and borrowing from the future to maintain lifestyles that are unsustainable.

Governments and businesses can only play their part in managing adaptive change if the public provides leadership so it is in everyone's interests to ensure that the public is well-informed and motivated to lead. Unless that happens there will be insufficient change and the size of the overshoot will grow further.

If changes are required then it is best to be prepared, including by having the public understand what is happening and what needs to be done in response. Everyone can influence others and contribute to accelerating the change of public understanding.

If change is imposed as a surprise in difficult circumstances, then uninformed and unprepared people whose interests are threatened are unlikely to respond positively.

An illustration is provided by events in 2011 in Greece and Italy where dissatisfaction with outcomes, understandable lack of willingness to change, and dissatisfaction with leaders perceived to have failed combined to cause the temporary replacement of democratically elected incumbent governments by appointed ones. Tough times threaten democracy.

Unlike most OECD countries, New Zealand does not have a requirement to produce regular national reports on the state of the environment. Two national state of the Environment reports have been published. The latest, Environment New Zealand 2007, was released on 31 January 2008.

Efforts are being made to improve reporting with regular web-based report cards across ten domains. In August 2011 the Minister for the Environment proposed that the Parliamentary Commissioner for the Environment be responsible for producing an independent state of the environment report every five years (Ministry for the Environment, 2011a, p.4).

In recognition of the importance of the public understanding of environmental issues, the proposed reporting mandate should be widened to include lifting environmental literacy throughout New Zealand. Environmental information should be provided to the general public with regular measurement to assess understanding.

There is a difficult chicken-and-egg problem best resolved by information. Governments cannot introduce change policies unless there is public support and there will not be public support unless governments and others first provide credible information to the public. But we should all be engaged and concerned. Without more public understanding there will be insufficient change.

WHO DOES WHAT

Developing and implementing strategies to improve environmental outcomes is difficult because of the wide range of talents and resources that must be combined effectively. Science, policy and implementation competences are seldom found in one person or organisation so the knowledge, skills and power must be brought together to form one team or process.

As a result, environmental writing often contains great analysis proposing some desirable outcome that should result but offers no mechanism for getting that outcome. One simple way to help overcome that issue is to specify who needs to act, and how, to achieve the desired result. The recommendations earlier in this chapter have specified in each case who should act. The commentary below summarises what each participant should do to contribute to improving future outcomes and reducing risk.

Businesses

To play their part businesses should include use of a long-term environmental lens when developing their strategies. They should look for green business growth opportunities, look for resource use efficiency opportunities, review supply chain security, and align research and development programmes to support opportunities and reduce risks.

Businesses use many methods to develop their strategies including template driven form-filling, systematic assessment of the business environment, markets, competitors, technologies etc., SWOT and issues analysis. The implication of increasing importance of the environment is that strategy development processes should be revised to properly incorporate long-term environmental trends and issues.

Businesses can help achieve improved outcomes for New Zealand by their communications efforts. Helpful communications would include:

- Business understands the importance of long-term environmental outcomes for future business success;
- Emissions disconnects must be resolved in ways that reconcile environment and commercial interests; and
- Business requires integrated, stable long-term policies that reduce environmental risk; and
- Businesses are positively contributing to better outcomes via their discretionary activities.

Many businesses are already doing these things. Some businesses form and support organisations such as the Sustainable Business Council, Sustainable Business Network and Pure Advantage, which contribute by identifying and promoting opportunities to improve commercial and environment outcomes simultaneously.

Businesses can reduce risks by investing in their ability to respond to expected and unexpected environmentally-driven change. They should develop their ANAR capabilities – acuity, navigation, agility and resilience. These capabilities are useful beyond environmental risk management.

Government

At the highest level, governments, national and local, can consider institutional structures and processes to ensure sufficient attention is being paid to long-term outcomes and that institutional arrangements produce best-practice management of economy-environment trade-offs. A futures institution should be established to serve Government's own acuity and navigation advice needs.

Government is working to resolve the emissions disconnects but not yet in a way that fully integrates environment and economic goals in the context of a shared understanding of long-term environmental risks and opportunities.

Economic growth is the number one priority now and there are very good reasons to seek high quality economic growth. However, environmental risks and economic opportunities mean that maximising GDP or GDP per capita is no longer a suitable primary economic goal. The response should be to develop a suite of economic metrics alongside GDP to encourage focus on the quality of economic activity, not just the quantity, and on reducing the use of energy and materials.

Adaptation plans and downside contingency plans are required for many areas including responding to a robust and binding international emissions agreement, climate change, infrastructure, supply chains, self-sufficiency, technology development and skills. Environmental pressures could build over decades or appear suddenly. Central government, local governments and individual government agencies should have their own ANAR assurance.

Environmentally informed population, migration, trade and security policies should be in place.

Governments cannot move far in advance of public support. They face the challenge of how to promote actions that would be unpopular because of insufficient public understanding. In response, governments and leaders should invest in increasing public understanding.

If New Zealand can develop and implement a credible and effective economy-environment strategy along the lines proposed here, that will support promotion of environmental credentials as an element of the national brand. It will assist with marketing for exports and tourism, and with promotion of New Zealand as a great place to live and work. New Zealand might contribute to improved global outcomes by showing the way for others, doing so in a way that avoids high economic costs from being on the 'bleeding edge'.

Individuals

Individuals have the most important role because they care about long-term outcomes for themselves, their children and their communities and because businesses and governments will follow their leadership and change with their support.

Individuals who wish to contribute to reducing long-term environmental risk can become informed about environmental issues and review the implications of environmental change for their own behaviour and consumption choices. They can also consider the implications of their roles as leaders and their opportunities to influence their own organisations.

Most important, individuals can communicate the importance of environmental risks and opportunities to others to help increase public understanding. It is the lack of public understanding that is the root cause of slow responses to accumulating environmental risks.

Individuals also influence the behaviour of others via social norms. If people think environmentally damaging behaviour is acceptable they will continue to do it. Few people continue behaviour that is disapproved of by respected others.

NGOs and activists

Organisations and activists have their own widely varying purposes and agendas so their interactions with long-term environmental issues vary widely too.

Some may have opportunities to encourage or contribute to integrated long-term policy development or action in areas such as emissions disconnects, population and migration, supply chain, self-sufficiency and skills, or environmental protection.

Or they may be able to contribute to public understanding as an indirect means to influence businesses or policy. Environmental NGOs and activists should consider redirecting their effort away from trying to influence governments and businesses towards contributing to better public understanding. Governments and businesses are not responding fast enough and will not until there is more public pressure.

Many NGOs should develop ANAR capabilities as part of their own risk management.

PROPOSED AGENDA ITEMS

The table below summarises the proposed agenda to develop a long-term environmentally informed strategy for New Zealand.

Table 1: Recommendations	Widely recognised & agreed?	Sufficient work programme in place?	Who is responsible?
Grow high value agri-food based exports	Yes	No	Government, Industry, Businesses
Include goal of developing a technologically diversified advanced economy in economic development policy	Yes	Yes	Government
Encourage growth of the green economy	Yes	No	Government, Businesses
Establish a policy programme to rapidly improve resource use efficiency	No	No	Government
Lead national conversations to build consensus on important emissions issues	Yes	No	Government
Lead preparation for adaptation to climate change	Yes	No	Government
Encourage more New Zealanders to be more engaged with environment protection and restoration	Yes	Yes	Everyone
Lead development of an environmentally-informed long-term population and migration strategy	No	No	Government
Review long-term supply chain security to ensure availability of critical technology and economic inputs	No	No	Government
Develop self-sufficiency and skills	No	No	Everyone
Review security and foreign policy to ensure preparedness for an overshoot crisis	No	No	Government
Launch a futures-focused institution	No	No	Government
Systematically improve preparedness for environmentally driven changes (ANAR)	No	No	Government, Industry & Business leaders, other organisations
Broaden economic performance metrics	No	No	Government
Ensure that economy-environment trade-offs are managed explicitly, effectively and appropriately in Government's institution design	No	No	Government
Improve public understanding	No	No	Everyone

There are policies that affect all of the environmental strategy topics proposed, but 'No' in the column marked 'Sufficient work programme in place?' indicates there are not widely understood policies or actions that strongly target improved environmentally relevant outcomes.

6. Conclusion

Few people recognised the emerging economic risks from poor governance of performance incentives in investment banking, weak regulation and growing debt so when the Global Financial Crisis began it was a big surprise. The few warnings of the looming crisis were largely ignored. There was insufficient understanding, few incentives and limited ability to change course. That crisis developed quickly, and fiscal and monetary policies are now being used to limit the damage.

In a similar way, many people have been warning of environmental risks for a long time. Their arguments are supported by science and observations of global trends. But environmental damage accumulates slowly, most people have an incentive to delay change and there are many other priorities for governments, businesses and individuals.

What is at stake globally is not just economic growth and human economic well-being, as in the economic crisis. It is the stability of the biosphere that supports modern civilisation and other life on Earth.

Environmental effects on economies and well-being are not something theoretical that might be a problem in the future; the effects are being felt now. Future effects could be gradual or sudden. Growing the global economy so that it is more than two times the size that can be sustained, as is currently planned, does not seem a sound strategy in current circumstances.

Many people may dismiss concerns about risks from abrupt climate change, price spikes due to resource scarcity, disruption of supply chains and ecosystem damage, confident that economic growth and political stability will continue.

The merits of counter-arguments can be assessed by testing for understanding of the arguments raised here. High quality disagreement will counter the case made here that there is a risk, providing facts and reasoned rebuttal. Low quality disagreement will simply reassert the beliefs of the dominant economic paradigm that resource availability will continue indefinitely or claim that technology development will solve whichever difficulty is being discussed.

There are many reasons and motivations contributing to widespread lack of concern and response. Many people do not understand the evidence. Some who do understand the evidence have faith in future technology or in their leaders. Some believe the future is pre-ordained or is managed by a deity so there is nothing they can or should do. Some think an overshoot crisis will not occur for a long time so they will be safe. A few are content to anticipate the end of days.

Some people believe being optimistic is better than being realistic. Some may be concerned that if everyone understood how serious things are then our society would change direction and that would not be in their personal interests or would involve higher costs for all than continuing overshoot. Some may believe that their advantages of location, wealth or military strength will protect them from the effects of any crisis.

Unfortunately in human and environmental affairs there are no guarantees of homeostatic processes restoring equilibrium, of gradual change or of deistic protection. The numbers indicate that unless you are old or very sick, have no children or just don't care about outcomes then you should expect to face the consequences of environment overshoot personally.

When people understand this, it can seem a bit gloomy. But humans throughout the ages have had to deal with adversity, finding ways to work together to overcome challenges. The choice before us is to actively manage our future or become victims of circumstances.

New Zealand has been an innovator in emancipation, welfare and economic reform. It could set an example for the world in environmental management too, enhancing reputation, securing future economic performance and showing the way to better solutions for the whole world.

Long, happy and fulfilling lives can be achieved without depleting the environment if that is what we set out to do. Provided basic needs are met, there is not much correlation between income or wealth and happiness. If New Zealand set out to meet the needs of its population, live in harmony with the

natural world and build cohesive and resilient communities, it would reduce future risk, improve the prospects of future generations and set an example to the world. That seems a goal worth striving for.

Management will affect outcomes in many ways but one of the most fundamental is the choice of the societal performance metric. If maximisation of GDP remains the dominant societal goal then overshoot will be maximised. If risk management becomes the priority, overshoot is minimised.

If an economic manager signals that he or she wants to grow GDP as fast as possible but does not explain how environmental risks will be successfully managed that means one of three possibilities.

First, the economic manager has a different view of the future than the one offered in this paper and the manager is correct; growth can continue without limit because future technologies and policies will mitigate risks. Secondly, the economic manager does not understand the argument in this paper and is leading us to increasing overshoot and increasing risk. Thirdly, the economic manager recognises the risks from overshoot but chooses or is forced to trade-off those risks to secure short-term economic gains, leaving the issues to be resolved by future leaders.

The ecological footprint and other indicators tell us that the Earth is in an overshoot state already, the environment is deteriorating and economies are being harmed so the first possibility is very unlikely. Therefore, whether economic managers do not understand the large scale change processes and risks, or do understand and are forced by political circumstances to make undesirable trade-offs, the solution is to increase public understanding and engagement so the economic managers either change course to reduce risk or are replaced.

Successful adaptation to environmental change will depend on increased public understanding leading to widespread adoption of an ecologically informed paradigm so governments and businesses incorporate environmental risks and opportunities into their strategy development.

The strategy development process could include four phases, ideally led by government, businesses and civil society working together:

- Build widespread understanding of the status of the global and New Zealand environment, the processes that are changing the environment, and the opportunities and risks resulting;
- Identify the environment topics requiring agreed directions and the issues to be resolved
- Facilitate public debate about each of the topics/issues; and
- Agree strategies and actions to take advantage of opportunities and reduce risks.

The danger from paradigms that prevent confrontation of important risks was highlighted by the report on the Fukushima nuclear incident. It seems that the plant operators were not prepared to deal with the disaster because in their paradigm such a disaster would not occur. The interim report of the investigation is explicit (Investigation Committee, 2011, pp.21-22):

> "The nuclear disaster prevention program had serious shortfalls. It cannot be excused that the nuclear accidents could not be managed because of an extraordinary situation that the tsunamis exceeded the assumption.
>
> The Investigation Committee is convinced of the need of paradigm shift in the basic principles of disaster prevention programs for such a huge system, which may result in serious damage once it has an accident."

It is very hard to think about life in a world that could be fundamentally different from our world today. It would be a shame to succeed short-term in the economic growth race but fail to prevent or respond effectively to an environmentally-driven crisis because of a collective failure to imagine a future that could be very different from what we now expect. Future generations will judge us harshly if we fail to manage well as the Earth moves from an age of abundance to an age of scarcity.

It is interesting to observe as the proportion of the population concerned about the environment rises over the years. Extrapolating from observations of changes in public opinions, those who ignore or downplay the environmental risks today are likely to be fine supporters of the need for change later. But by then it might be too late to avoid the worst effects.

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