National Science Strategy Committee for Climate Change

Climate Change Research Strategy 2002

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CLIMATE CHANGE RESEARCH STRATEGY 2002

Goal
The goal underpinning this strategy is to enable better climate change policy decisions and responses from society, through responsive climate change science.

Rationale
A climate change research portfolio that is fit for purpose is essential to assure government's delivery of policy commitments, initially arising from ratification of the Kyoto Protocol and then subsequently from later "commitment periods". At the same time, the portfolio must deliver knowledge and tools to understand and cope with the effects of climate change and its fundamental drivers.

Introduction

The purpose of this Climate Change Research Strategy is to provide a high level framework to guide science funders and providers to identify priority areas of research, while maintaining a balanced portfolio that will achieve both short- and long-term outcomes.

The National Science Strategy Committee for Climate Change has reviewed its 2000 strategy in light of the Government's decision to ratify the Kyoto Protocol and the announcement of its preferred policy package. The Committee has also considered the government's Sustainable Development Strategy, and in this context, the Growth and Innovation Framework. These recent government decisions and frameworks provide a more certain environment in which to identify priorities for climate change research than existed in 1999/2000 when the last review took place.

No single research approach can address all the problems, solutions and opportunities that climate change represents, but rather, different outcomes are required to satisfy different needs of society. The Committee has identified eight Outcome Statements for research to address these needs. Each of those outcomes is driven by a particular high-level commitment or value judgement, corresponding to the needs of different parts of the society and economy to address climate change in the short and long term.

The balance of efforts between those outcome areas cannot be based exclusively on scientific information and international agreements, but is ultimately based on value judgements regarding the expected outcomes. The balance between those high-level outcomes is therefore a question of governance, which needs to be exercised by government. In preparing this strategy, the Committee therefore did not presume any priorities between those Outcome Statements.

Outcome Statements and priorities across all outcomes

Outcome Statements

The Outcome Statements which define broad sets of research needs are as follows:

1. Kyoto commitments are met and a downward path in gross emissions established by 2012.
2. New Zealand protects its medium to long-term interests by participating in political and scientific networks and negotiations, informed by sound scientific information.
3. New Zealand is able to reduce substantially its greenhouse gas emissions beyond 2012 while sustaining a growing and vibrant economy and society.
4. New Zealand understands and adapts to the effects of climate change on its natural, managed and built environments.
5. The health of all New Zealanders is improved and social inequalities in health are being reduced.
6. Science foresight and the capacity to deal with surprises is maintained.
7. New Zealand society engages in responding to climate change.
8. New Zealand proactively engages with domestic and global business opportunities and risks arising from a carbon-constrained world.

While the assigning of priorities *between* those Outcome Statements is a question of governance, research priorities can be defined broadly, based on collective expert judgement, *within* each Outcome Statement. The Appendix lists, for each Outcome Statement, the key research priorities, timing for results, synergies, co-benefits and dependencies on other research and policy areas, the risks associated with achieving them, the infrastructural needs to underpin them and the key groups with a stake in the achievement of the outcomes.

The research priorities identified by the Committee are by necessity only broadly defined. Project-specific funding decisions must be made by funders who have access to the detailed information at a project specific level and the ability to judge the quality of proposals. The role of this strategy is to provide a framework against which specific proposals can be evaluated.

Research priorities across all Outcome Statements

The following table lists those areas of research which are seen, in the Committee's judgement, as critical to achieving the outcomes described in the eight Outcome Statements. It focuses on those areas of research that are critical because:

- they are necessary to achieve the desired high-level outcome
- research results are required by a given time
- there are critical capacity thresholds in the science system
- they critically underpin other outcomes, other areas of research or explicit policy goals.

Based on this set of decision criteria, some research priorities described under several of the Outcome Statements do not appear in this list. It is important to recognise that this is not because that research is not necessary or relevant to achieving the desired outcome, but because it cannot be defined as absolutely necessary, has no definite timelines for delivery of results, there are no critical capacity issues in the science system, or it is not critical to achieving other outcomes or to support other research areas or policy goals.

Nonetheless, lack of support for those areas of research that are listed in the detailed Appendix, that do not appear in the Table below, would in the longer term result in the desired outcomes not being achieved, or the research portfolio devoted to these outcomes being unbalanced and likely to be less effective and responsive to end-user needs.

Table 1. Priority Research across all Outcome Statements

Research area	Rationale/Risk	Timing	Current capacity and research effort
Context: Outcome 1 – Kyoto			
Carbon accounting system consistent with "Good Practice"	Underpins government's policy package to meeting Kyoto obligations; failure to meet standards risks ability to trade sink credits	now until 2007 and beyond	Effort insufficient to meet obligations; capacity at risk
Reduce uncertainty of greenhouse gas inventory	Necessary to ensure ability to trade sink credits under UNFCCC/Kyoto Protocol	now until 2007 and beyond	Sufficient if current effort is continued
Reduce gross emissions and set on permanent downward trend by 2012	Corresponds to explicit government policy	now until 2012	Effort insufficient to achieve target
Context: Outcome 2 – Protecting New Zealand's interests and participating in networks and negotiations			
Reliable projections of future GHG emissions, removals and trends, and increased understanding of carbon cycle in NZ ecosystems	Driven by timelines and requirements for negotiations on future commitments under the Kyoto Protocol and UNFCCC	now to 2005-2007, depending on progress of negotiations	Currently insufficient knowledge on carbon cycle, and on emission projections and mitigation options beyond 2012
Develop and increase social and economic modelling capability related to climate change policies	Planning for future commitments and development of policies will require independent assessment of the impact of a range of policies	now to 2010 to allow policy decisions for future commitment periods	Very limited pool of expertise; currently need to contract overseas expertise
Context: Outcome 3 – Long-term emission reductions beyond 2012			
Market and socio-economic barriers to energy efficiency and demand management	Essential to enable implementation of domestic and international technological solutions to mitigate CO_2 emissions	long lead time, results required by 2012	Limited effort on demand management and social and market barriers; very limited social science capacity

Planning for efficient urban form and transport systems	Research specific to NZ conditions needed since overseas research will not be able to provide readily applicable solutions; high pressure from population growth in urban centres	long lead time, needed to underpin emission reductions post 2012	Limited capacity and effort in social science aspects
Long-term mitigation of agricultural non-CO_2 emissions	Essential to allow major reductions in NZ's total GHG emissions due to the high fraction of non-CO_2 GHGs in the inventory	long lead time, essential after 2012	Growing engagement from industry; some critical capacity thresholds in science sector
Outcome 4 – Adaptation			
Improved projections of regional climate and El Niño variability, and reduced uncertainty of changes in extreme events	Essential to increase engagement and improve planning by local government and key industry sectors	long lead time; fractional improvements of knowledge	Limited to one main science provider, limited by research funding from central government only
Interaction of climate variability and change with ecosystem services, biosecurity, and pests and diseases	Current biosecurity threats and costly eradication measures would provide high co-benefit of improved management of invasive species	current pressures	Limited links between climate studies and biosecurity
Research for the development of integrated adaptation strategies	Infrastructure investments lock in decisions for many decades creating risks to communities	Research needed now to avert future risks	No cross-disciplinary research going on that can underpin local authority decisions that create climate change resilience in communities
Outcome 5 – Health			
Understand and quantify co-benefits and risks from GHG mitigation and climate change effects	Key component to increase public awareness and engagement for community-based solutions	start now to support emission reductions by 2012	Climate change needs to be factored into health research; limited capacity for economic valuation
Outcome 6 – Future Watch			
Systematic observations of key climate parameters and ecosystem changes	Long time-series high-quality baseline data are essential to determine changes and attribute causes	on-going	Monitoring systems lack overview; funding often by commercial or other policy imperatives and hence insecure or not long-term.
Fundamental knowledge about regional climate system (air/water/sea/ice) and ecosystems	Underpins shorter term mitigation and adaptation research, deals surprises, links to international projects, gives ability to assess implications of new science	On-going. Significant input building to IPCC 2007 assessment	Adequate, but critical mass needs to be monitored.
Outcome 7 – Societal engagement			

Research into community attitudes and underlying value systems	Vital to target future awareness programmes that achieve participation	now	Very limited research capacity
Research into barriers to translating knowledge into action	Vital to design of policies and supporting measures, and link between technological and social solutions	now, on-going	Very limited research capacity, limited interaction between traditional social science and climate change research community
Integrate existing social science research into climate change decisions	Vital to increase cross-disciplinary research capacity	now	Very limited research capacity, limited interaction between social science and climate change research communities
Outcome 8 – Business Opportunities			
Realisation of domestic no-regrets options	Vital to achieving emission reductions and adaptation to climate change effects beyond those provided for by specific policies	now, on-going	Limited links between business and science sector

Cross-cutting issues

There are significant cross-cutting issues that reach across several of the Outcome Statements. These are the need to decouple economic growth from growth in greenhouse gas emissions, responsiveness to Maori stakeholders, and the capacity of the science sector of a small country to respond to current and emerging research needs.

There is also a key issue around the need for all levels of government and the private sector to engage in practical research that can be used when making decisions that might lock in increased greenhouse gas emissions.

Decoupling growth from greenhouse gas emissions
The focus for many developed societies is increasingly to decouple economic growth from energy consumption and greenhouse gas emissions.

In the short term, this decoupling is most likely to be advanced through a combination of policy support for implementing known technological solutions, and research to exploit well-described potential technological and social solutions. Relevant research is described in Outcome Statement 1 – Kyoto.

For longer term outcomes, the focus needs to shift more towards blue-skies research, innovative adaptation of globally emerging solutions for emissions reduction, and integrated and sustainable adaptations in our natural, managed and built environments. New Zealand faces particular challenges and opportunities in this area, due to its large primary production sector, distribution of natural and human resources, and low population density. The arising research opportunities

are described in Outcome Statement 3 – Long-term emission reductions, 7 – Societal engagement, and 8 – Business opportunities.

The Treaty of Waitangi

There are real risks to the Maori Treaty Partner if the proposed research does not respond to their specific needs. These risks include:

- Lost opportunities for Maori to benefit from business growth and opportunities
- Lost opportunities for the government to minimise further costs to Maori communities
- Additional costs in the implementation of the government's climate change policies
- Lost opportunities for Maori scientists, or scientists with particular knowledge of Kaupapa Maori, to develop and participate in climate change research

In designing programmes that are responsive to Maori, researchers may be guided by the following framework (source: Foundation for Research, Science and Technology, 2002):

- *Maori-centred research*: The research addresses a distinct issue of importance for Maori and contributes to improvements in outcomes for Maori. Maori are significant participants and senior members of the research team e.g. a Maori perspective on impacts of climate change on coastal resources.
- *Kaupapa Maori research*: Research that responds to a culturally distinct issue of importance using and producing Maori knowledge that meets Maori expectations and quality standards of Maori. Maori are significant participants and the primary researchers e.g. a compilation of Maori traditional knowledge of climate and climate variability
- *Research specifically relevant to Maori*: Research whose results are specifically relevant to Maori. Low level of Maori involvement e.g. targeted technology transfer from research may provide an opportunity to improve outcomes for Maori-carbon trading relating to indigenous forests.
- *Research involving Maori*: Research that responds to an issue of importance to Maori and contributes to improvements in outcomes for Maori. Maori are participants in the research and possibly members of the research team e.g. research on changes to ecosystems or taonga species of importance to Maori associated with climate changes and variation.
- *Research not involving or not specifically relevant to Maori*: Research with no specific impact on Maori beyond general benefit to New Zealand and Maori participation has not been sought e.g. research to enhance the mitigation of greenhouse gas emissions due to energy use in the residential sector.

Capacity of the Science Sector

The capacity of the science sector to respond to this strategy is a significant issue for a small but independent country such as New Zealand. There are a number of specific problems:

- The age structure of scientists in some key areas
- The low numbers of scientists being attracted in at the longer ages groups
- The retention of scientists when they are attracted
- The lack of cross disciplinary science capacity
- The lack of critical mass in the social sciences to work on climate change related issues
- Ongoing capital investment in essential infrastructure to support research
- Participation of scientists and those using science in international dialogues
- The lack of good science communicators

Currently NZ has good research teams in most climate change research areas, but many of the lead scientists are nearing the end of their careers and are starting to retire. This will increase over the decade. The age cohort that would normally replace them is small or almost non-existent. The labour market internationally has become very mobile and, while scientists can be attracted here for short periods, they do not stay. It has also been difficult to attract bright young people into science due to poor understanding of career prospects, salary, opportunities and the pull offshore by better science infrastructure.

Retention and recruitment of key science staff is urgent for building productive teams. Cross-disciplinary research capacity is not sufficiently connected to climate change research. As new economic activity flows from invention of new infrastructure and management systems cross-disciplinary capacity will be needed to ensure its uptake. There is an urgent need to identify and develop such capacity including social, economic, design knowledge and skills to ensure that the integrative thinking is done and available for decision-makers especially at the local and regional levels. They also need to tie into central government agencies which make funding decisions that lock in infrastructure that can increase GHG emissions or reduce adaptive capacity, e.g. roading, wastewater and water reticulation, housing location and urban design decisions.

Associated with this is the need for a critical mass of social scientists, including economists, located in both universities and research institutes with close links with the scientists generating the understanding of the possible impacts and adaptation approaches. Neither can work in isolation if New Zealand is to avoid costly mitigation and adaptive responses.

The essential infrastructure to support the research effort needs to be maintained through ongoing capital investment, e.g. research vessels, computers, observing systems and field equipment to enable NZ with its surrounding EEZ and interests in the SW Pacific, Southern Ocean and Antarctica to adequately participate in the research.

The ability of NZ scientists and those using science for climate change decision-making need to participate in appropriate international projects, their planning meetings and cross-disciplinary meetings, e.g. key research programmes; bilateral and multilateral arrangements between countries; institution to institution linkages and travel exchanges (including local government, government agencies and research institutions). These links and collaboration are essential if NZ is to capture New Knowledge for application to NZ, new cross-disciplinary approaches to using the research, and to ensure the application of science knowledge from the Southern Hemisphere is considered in the international policy/science discussions and negotiations such as IPCC and SBSTA meetings and reports. Such policy-relevant activity needs funding support in a clear and accountable way that is not reliant on “public good” research funding.

Finally, the science sector needs to be engaged more in communicating scientific understanding of climate change, its challenges and solutions to the general public working closely with the different audiences. This would help provide publicly accessible information, greater public support for climate change policies and would also ensure that policies are seen to be fully consistent with the available scientific information.

The risks associated with the limited capacity of the science sector are as follows:

- Loss of critical mass/capability in established science teams
- Lack of credibility in international climate negotiations
- Limited distribution of scientific information by respected and credible scientists who are able to understand and engage with communities
- Limited integration of separate fields of knowledge that need to be combined to achieve climate change-relevant outcomes
- Costly infrastructure decisions and investments that lock in vulnerability to increased emissions and reduced adaptive capacity
- Poor decision-making and adaptation responses because decisions especially at a local government level are not based on the most up to date and complete science knowledge
- Loss of credibility with SW Pacific Island States
- Inability to detect and measure trends in climate, sea-level, terrestrial ecosystems and other long-term changes around NZ leading to risky investments, poor planning and subsequent risks to property and people.

Research collaboration at all levels of government and with the private sector
Climate change research relies upon a high degree of collaboration between government, industry, local and regional government. To date the majority of the funding stream has come from government. The government has recently signalled the need for greater private sector contribution to climate change research especially from the primary production sector, given the opportunities for both productivity and direct economic gains from technology and good practice developments. The available funding and venture capital programmes need to be used for developing partnerships in climate change research.

The role of local and regional government in research on climate change mitigation and adaptation will be critical in reducing consumption patterns that generate fossil fuel use and to assist in making infrastructure decisions that lock in urban form and infrastructure for a very long time. Arrangements to build up the level of research of interest to local government are urgently needed.

Outcome 1: Kyoto commitments

Outcome: Kyoto commitments are met and a downward path in gross emissions established by 2012.

Research is needed to address the following main areas:

1) the "sinks" approach to meeting commitments together with ability to trade;
2) emissions reductions;
3) business opportunities;
4) reduce uncertainties in greenhouse gas inventories.

Rationale for research areas:

Ratification of the Kyoto Protocol places certain obligations and fiscal responsibilities on government. Areas 1 and 4 are a necessity created by government's liabilities under the Kyoto Protocol. Areas 2 and 3 have a high priority as they correspond directly to stated government policy goals.

Area 1: The government's policy package for meeting its obligations under the Kyoto Protocol is underpinned by sink credits outweighing projected excess emissions, and the ability to trade the sink credits on the international market.
Area 2: Government has set itself the goal of gross emissions being on a permanent downward trend by 2012, for which emission reductions beyond those currently projected under the National Energy Efficiency and Conservation Strategy (NEECS) and the Waste Strategy will be required.
Area 3: Emission reductions beyond those already envisaged will most likely be achieved by clearly linking emission reduction options with business opportunities and practical adaptive response options that maximise benefits and minimise private sector and local government adjustment costs to a carbon-constrained world.
Area 4: Reducing uncertainties in the national greenhouse gas inventory is a fundamental part of meeting commitments under the Kyoto Protocol, underpinning area 1, with the inventory providing the means by which "success" will be measured internationally and domestically.

Key users of research results:

Central government (MED, MAF, MfE/EECA, Treasury, Transfund), local government (local infrastructure funding decisions and regional development), private sector (agriculture, energy users, managers and suppliers, transport users and operators, environmental consulting services).

Priority research needs for each area:

1) the "sinks" approach to meeting commitments and the ability to trade

a) Develop a comprehensive "sinks" inventory including implementation of a carbon accounting system that covers planted and indigenous forests, shrubland and soils
b) Inventory of carbon stored in planted forests: Coordination and compliance with "Good Practice", including publication of scientific research and reduction of uncertainties, maintenance and extension of relevant databases, verification of models; determine

priorities to ensure NZ can meet "Good Practice" inventory standards once guidelines are finalised

c) Landcover database: Determination of 1990 baseline for "Kyoto" forests, consistent with inventory reporting requirements under "Good Practice"
d) Improve understanding and reduce uncertainties related to shrubland regeneration and reforestation, and soil carbon changes, and choice of baseline year, for NZ's overall carbon credits

Synergies, co-benefits with, and dependence on other research/policy areas:

- Landcover Database (LCDB) underpins cost-effective accounting for planted and indigenous forests and shrubland (but needs supplementary data and supporting research to be used consistent with "Good Practice"). LCDB and the Carbon Monitoring System also form vital information tools for areas outside Land-use, Land-use change and Forestry (LULUCF) carbon accounting. Other outputs include biodiversity, soil quality, erosion control, and potential future use in accounting for forest management under Article 3.4 of the Kyoto Protocol. Local government is an important user of this additional information.
- Most inventory accounting relies on a range of databases and other inventories that were established and are being funded for non-climate purposes, including Agricultural Statistics, NEFD (National Exotic Forests Description), NVS (National Vegetation Survey), Energy Datafile. There is a risk that databases could be run down if the provider of the database is not aware of their vital importance for Kyoto accounting.
- A robust inventory of agricultural non-CO_2 gases underpins the development of agricultural mitigation options, and is necessary for research funders to determine the cost-benefits of different elements of a mitigation research strategy.

Relevant funding agencies:

FRST, MAF, MfE, MED.

Adequacy of current research effort, capacity, and funding levels:

- Compliance with good practice may require the initiation of a range of additional research and implementation activities (particularly on soil carbon, and reducing uncertainties in growth rates in planted forests) that will need to be started in 2003.
- Full implementation of the Carbon Monitoring System for indigenous forests and shrublands, and for soils is urgent, since it is necessary to ensure an acceptable inventory. The funding for this programme is currently highly uncertain.
- Funding uncertainty is currently leading to a loss in human capacity from some key research providers. Both a moderate increase in overall underpinning funding, and better coordination of funding and outcomes will be necessary to ensure New Zealand meets its primary obligations under the Protocol.
- Research contributing to area 1 (carbon sinks) is funded by several different agencies with limited coordination. Most of this research is no longer optional but a necessity for government under Kyoto. Government may wish to review whether its current funding mechanisms are adequate to meet its new obligations.
- New Zealand scientific experts need to be included in, and available for, the development and acceptance of "Good Practice" guidelines by the IPCC and SBSTA/COP, and their implementation in New Zealand systems. This requires clarity of funding arrangements, and sufficient funding levels/duration and human capacity for research providers in relevant areas.

Risk of short-term underfunding:

- There is a very tight timeframe to allow New Zealand to bring its reporting and accounting systems up to "Good Practice" guidelines. Delays in working towards meeting criteria could put New Zealand's eligibility to trade at risk.
- Recent funding changes and uncertainty are risking a serious loss of human capacity in carbon monitoring in planted forests, indigenous forests, shrubland and soils. The human capacity and function of systems, including development and verification of models, would be difficult to replace within timeframes mandated by Kyoto Protocol reporting commitments.

2) Emissions reductions

The priority research areas discussed here are those that are most likely to provide short-term emission reductions (i.e. by 2012), while other solutions with longer lead-times are discussed under *Outcome Statement 2 – Future Commitments*. Developing and implementing new emission reducing technologies in the energy, transport and agriculture sectors has long lead times, and it is likely that most research effort invested in the near future will achieve its most significant pay off after 2012.

To achieve short-term emission reductions, before or by 2012, it is essential to establish the capacity in New Zealand to take local technological initiatives required to meet NEECS targets, as well as to maintain the capacity to rapidly adopt new and emerging energy technologies and adapt international developments where necessary, so that potential solutions fit New Zealand conditions.

a) *Energy systems in general (efficiency, demand management, and renewables):* Increase capacity to adapt, transfer and implement new and emerging technologies, and modify international developments as required to suit New Zealand-specific conditions.
b) *Energy Efficiency:* Establish an understanding of how to create the necessary market and regulatory environments for efficiency improvements. Priority sectors: large-scale industries, households, commercial buildings including small-to-medium-scale businesses, and local government.
c) *Renewable Energy:* Develop new solutions specific to New Zealand conditions, mainly in the areas of bioenergy, windpower, and small hydropower.
d) *Transport:* Ensure technological capacity remains matched to international developments (both in vehicle and road user charging technology and behavioural measures) and improve uptake in New Zealand. Establish a clear and robust understanding of the effects of mandatory vehicle performance requirements and fleet management standards. Increase research on transport behaviour patterns and appropriate policy tools to influence travel behaviour and transport choices.
e) *Agricultural CH_4 and N_2O emissions:* Undertake research into options, including fundamental "blue skies" research, a large component of well-defined and practical solutions with perhaps lesser impact but higher chance of success, and a clear focus on implementation consistent with farming practices. Requires strong engagement from private sector to be successful. Potential solutions also need to avoid concurrent increases in CO_2 and competition between reductions in CH_4 or N_2O emissions, and to maintain international competitiveness of the sector. Development of proven technologies to verify emissions reduction is an essential component of this research.

Apart from technological solutions, increased attention to human dimensions will be needed to ensure technological solutions achieve actual emission reductions. This includes identifying social, market and structural barriers to making use of existing solutions, and integration of social and marketing science into the development of new solutions from the outset (see also *Outcome Statement 7 – Increased Societal Engagement*).

In addition to solutions provided by research and new knowledge, implementation of policy mechanisms will be needed to ensure the uptake of knowledge and technologies and achieve NEECS target emission reductions by or before 2012.

Synergies, co-benefits with, and dependence on other research/policy areas:

- Research into ruminant CH_4 mitigation forms an important part of NZ's overall mitigation challenges and opportunities. Reducing ruminant CH_4 offers New Zealand a unique opportunity to reduce substantially its total greenhouse gas emissions, adding to reductions in CO_2 from energy and transport. This may be highly relevant for the negotiation of future commitment targets since it determines the total emission reduction that New Zealand can achieve across CO_2 and non-CO_2 gases. Marketing of commercially viable tools and techniques for ruminant CH_4 mitigation would also provide a significant business opportunity and provide a marketing tool for agricultural products based on New Zealand's clean green image.
- Improving demand-side management, energy efficiency and renewable energy supply would increase reliability of energy supply with wide business co-benefits. Greater security of supply would also reduce the risk of dry-year shortages in the hydro-power supply system, and associated CO_2 emission peaks in dry years. This would increase certainty of the Crown's fiscal position related to New Zealand's total greenhouse gas emissions during the Kyoto Protocol's first commitment period.
- Many energy efficiency and transport measures could provide co-benefits for human health (e.g. from improved housing insulation, reduced air pollution, or increased physical activity), improved economic and transport efficiency, and would strengthen New Zealand's "clean green" international market reputation.

Relevant funding agencies:

FRST, NERF, TechNZ, IndustryNZ, private sector, government departments and agencies (EECA, TransitNZ, Transfund, MoT, MED).

Adequacy of current research effort, capacity, and funding levels:

- Current emissions of CO_2 are on a steep upward trend, and non-CO_2 emissions are also likely to increase until the first commitment period. The Government policy goal, that gross emissions should be on a permanent downward trend by 2012, is therefore unlikely to be achieved unless research into ruminant CH_4 mitigation shows very early success, and research and policy support for energy efficiency, renewable energy generation and transport management is substantially increased in the very near future.
- Success of the National Energy Efficiency and Conservation Strategy (NEECS) will require a substantial increase in research into energy demand-side management, and public acceptance and implementation of both available and emerging solutions in energy efficiency, renewable energy generation, and transport management.

- A comprehensive NPV analysis of different emission reduction strategies would increase certainty around what size of emission reduction, and at what cost, is manageable across the entire spectrum of options from energy efficiency and demand management, renewable energy generation, and transport management. This would improve the ability to compare options and opportunities and assess their cost-benefit from a GHG perspective.

Risk of short-term underfunding:

- If research that supports CO_2 emission reductions (energy supply and demand system and transport) and reduction of agricultural non-CO_2 emissions is not increased substantially in the very near future, including research into implementation by end-users, New Zealand is unlikely to meet government's policy goal of setting gross emissions on a permanent downward trend by 2012.
- Negotiations on future commitments under the Kyoto Protocol (or alternative international regimes) are due to begin formally in 2005. Lack of certainty about future emission reduction options beyond 2012, caused by limited efforts in research and implementation from now until 2012, would make it difficult for New Zealand to accept much more stringent future emission targets (such as are already being promoted by the European Union). See also *Outcome Statement 2 – Future Commitments*.

3) Business opportunities

These business opportunities refer specifically to opportunities arising from the Kyoto Protocol's first commitment period, 2008 to 2012. Wider and longer term opportunities and risks are described under *Outcome Statement 8 – Business Opportunities arising from climate change*.

a) Tools and techniques for ruminant CH_4 mitigation and verification, and their export.
b) Energy Management Systems that accelerate the deployment of energy efficient products and services through effective and efficient market processes.
c) Renewable energy supply and energy efficient end-use technologies that have a specific New Zealand role, and technologies in which NZ businesses can expect to become a significant supplier in international markets (e.g. bioenergy, wind power, micro-hydro power).
d) Emissions profiling and foot-printing: Standardise and refine emissions footprinting tools for small to medium-size companies and individual products. This offers both an opportunity to provide a service domestically and internationally, and also a "green" marketing opportunity for companies in triple-bottom-line reporting and advertising.
e) Consumer behaviour and "green" product branding and marketing: Social science research on product acceptance and preferences in New Zealand and overseas, increase awareness of such opportunities in New Zealand.
f) Research on generic opportunities, risks, and procedures for private sector involvement in the Clean Development Mechanism (CDM) and Joint Implementation (JI) mechanism, including generation of forest sinks overseas.

Synergies, co-benefits with, and dependence on other research/policy areas:

- Reducing agricultural non-CO_2 emissions is likely to lead to an increase in feed conversion efficiency of animals (for ruminant CH_4), but current policies provide no other domestic business opportunity arising from reducing agricultural non-CO_2 emissions. Hence business opportunities linked with agricultural emission reductions are currently largely limited to

export markets. If potential solutions are developed before 2012, government may wish to consider policies that would enhance implementation in New Zealand through additional business opportunities.

- New Zealand's capacity to create permanent forest sinks on marginal agricultural land offers its companies the opportunity to develop and enhance their international clean-green image by offsetting GHG emissions through native forest plantations. However the increasing liability this places on future generations needs to be factored into national cost-benefit analyses even if there is a clear short-term benefit for industries.
- The increased awareness of climate change not just in New Zealand, but particularly Europe, offers both a risk and opportunity for New Zealand businesses to capture new market segments or re-brand and enhance their access to existing markets, provided that GHG emissions associated with products are lower than those of competitors.

Relevant funding agencies:
FRST, TechNZ, NERF, Industry NZ, private sector, government departments (EECA, MED).

Adequacy of current research effort, capacity, and funding levels:

- Most research that creates business opportunities will be driven by the private sector based on commercial opportunities. However business opportunities arising from the Kyoto Protocol are currently poorly understood. Government will need to increase public and private sector awareness of the implications and opportunities of the Protocol including the flexibility mechanisms of emissions trading, CDM and JI, facilitate collaboration and public/private sector partnerships, and provide leadership in setting standards for GHG accounting, labelling, and international promotion of a coordinated NZ Inc. position with regard to responding to climate change.

Risk of short-term underfunding:

- Many countries, in particular the EU, but also USA and Australia, are investing heavily in low emission technologies, energy efficiency and renewables. There are likely to be significant gains by early positioning and assuming leadership positions associated with branding, access to emerging markets, and capturing consumer attitudes. New Zealand risks losing out on those opportunities if it is not able to develop and market its own solutions in tandem with international trends.
- Key sectors of the economy risk becoming captive to overseas technology providers in a technology market that favours suppliers. It is important that New Zealand develops its own solutions and products where those are likely to be very specific to New Zealand's situation, for example, energy efficiency in wood and dairy processing, bioenergy production, housing design and building service technologies, and our energy supply and distribution systems. There are risks to New Zealand should it become more dependent on external technology providers to meet its own domestic standards.
- Developing countries have an increasing need to participate in clean technology transfer, sustainable forestry, climate forecasting, impacts assessment and adaptation services. New Zealand has a high degree of expertise in many of these areas, but the private sector has not always the necessary information about domestic and international policies and measures to proactively pursue emerging opportunities, which may depend on early positioning by companies offering useful services and products.

4) Reduce uncertainties in greenhouse gas inventories

In New Zealand's greenhouse gas inventory, emissions from the agriculture sector are more uncertain than for other parts of the inventory. In part this is the result of dealing with naturally higher uncertainties in biological systems (rather than the combustion of fossil fuels). The other contributing factor is that specific emission factors and models representing New Zealand agricultural systems are still under development.

Beginning in 2003, Annex I Parties are to be applying *Good Practice*[1] in the preparation of their national greenhouse gas inventories. Applying G*ood Practice* to New Zealand's greenhouse gas inventory results in both CH_4 from ruminants and N_2O from agricultural soils being categorised as key sources. Under *Good Practice*, countries should use tier 2 (i.e. more complex) methods for estimating emissions from key sources, rather than default methods, as these tier 2 methods will better characterise the emissions and hence reduce the uncertainties in the estimates.

a) Research to reduce uncertainty in CH_4 emissions from ruminants: Emissions from animal species and stages of maturity that have not yet been measured explicitly (e.g. deer, heifers). Continue to refine existing inventory data to obtain more robust estimates of uncertainties due to measurement or calculation methods.
b) Research to reduce uncertainty of N_2O emissions: Animal excreta management, influence of different soil types and effect of irrigation/rainfall, indirect emissions.
c) Both CH_4 and N_2O: Develop techniques to upscale emission estimates from individual animals or urine patches to farm scale (for verification and trials) and landscape scale (for inventory verification).

Synergies, co-benefits with, and dependence on other research/policy areas:

- With area 1 above: A robust and internationally recognised inventory is required for New Zealand to be able to trade its sink credits
- With area 2 and 3 above: Tools and techniques to measure agricultural non-CO_2 emissions accurately are a prerequisite to verify the effect of any emission reductions on the GHG inventory
- With *Outcome Statement 2 – Future Commitments*: A good understanding of agricultural non-CO_2 emissions will be necessary to encourage widespread implementation of emission-reducing technologies and practices that will allow New Zealand to meet more stringent future emission targets
- With *Outcome Statement 8 – Business Opportunities*: Business opportunities generated by the ability to reduce agricultural non-CO_2 emissions will depend on the ability to verify those reductions at a cost less than the price of the emission units avoided.

Relevant funding agencies

MAF, MfE, FRST. Partnership with private sector efforts to reduce ruminant CH_4 emissions.

[1] *Good practice* is a set of procedures intended to ensure that greenhouse gas inventories are accurate in the sense that they are systematically neither over- nor underestimated as far as can be judged, and that uncertainties are reduced as far as possible. *Good practice* covers choice of estimation methods appropriate to national circumstances, quality assurance and quality control at the national level, quantification of uncertainties, and data archiving and reporting to promote transparency.

Adequacy of current research effort, capacity and funding levels

- New Zealand has already begun the task of moving from tier 1 to tier 2 methods for greenhouse gas emissions from the agricultural sector. The aim is to begin reporting estimates obtained from tier 2 methods in the greenhouse gas inventory report due in April 2003. MAF is currently funded for this work through to FY 04/05. Ongoing maintenance funding post FY 04/05 will be required.

Risk of short-term underfunding

- If aspects of New Zealand's greenhouse gas inventory are found to be inadequate to meet the requirements of Kyoto Protocol reporting, the risk is that either the inventory will receive an adjustment (resulting in less assigned amount for the base year or higher emissions in the commitment period), or that New Zealand will be ruled ineligible to participate in international emissions trading (and hence will not be able to benefit from "sink credits").

Outcome 2: Protecting New Zealand's long-term interests

Outcome: New Zealand protects its medium to long-term interests by participating in political and scientific networks and negotiations, informed by sound scientific information.

Research is needed to address the following main areas:

1) reliable projections of future greenhouse gas emissions, removals and trends;
2) knowledge to support a full carbon accounting regime;
3) technical, economic and social analysis of different emission targets and policy options.

Rationale for research areas:

Under the Kyoto Protocol, governments will begin negotiations for targets and accounting rules for the second commitment period of the Kyoto Protocol as early as 2005. If New Zealand wishes to participate in those negotiations in an informed and proactive way, and wants to engage in possibly much more ambitious emission targets, it needs:
Area 1: reliable projections of future emissions that take current energy, transport and agricultural mitigation research into account,
Areas 2: to be well informed about its technical and scientific ability to meet more stringent and comprehensive accounting rules for the land-use, land-use change and forestry sector,
Area 3: to understand how technological and scientific options could be implemented through policy, and what the economic, social and environmental effects of those policies would be.

Key users of research results:

Central government (MFAT, MoT, MED, MAF, MfE, Treasury). As far as social, environmental and economic effects and ability to implement potential future policies is concerned, central government (DoC, DIA, MSP, DOL), local government, and private sector bodies.

Priority research needs for each area:

1) Reliable projections of future GHG emissions, removals and trends:

a) Maintenance of research towards an inventory of agricultural non-CO_2 emissions, and continued refinement of databases and industry/stock number projections; this should include a regular review of the effectiveness of CH_4 and N_2O mitigation research and monitoring of overseas developments.
b) Improve understanding of effects of management on agricultural systems (e.g. individual farmer decisions such as grazing policy, fertiliser use, irrigation)
c) Improved projections of forest plantation and deforestation rates, and associated carbon storage using methodologies consistent with likely future best practice requirements, including early assessments of international market effects.
d) Population/energy/transport scenario development extending to at least 2020, including emerging technologies, supporting policies, and regional details where possible.

Synergies, co-benefits with, and dependence on other research/policy areas:

- Review of the effectiveness of agricultural non-CO_2 mitigation research is required to allow government to decide whether agricultural non-CO_2 emissions continue to be exempted from an emissions charge post-2012.
- Projections of forest plantation rates are key to long-term planning of infrastructure requirements associated with wood processing.
- Medium-term scenarios of population, transport and energy demand underpin research for sustainable communities and practical long-term planning in metropolitan and regional rural centres.

Relevant funding agencies:

FRST, MAF, MfE, EECA, DIA

Adequacy of current research effort, capacity, and funding levels:

- Research into agricultural non-CO_2 emission inventories is currently adequate but needs funding to continue in the long-term to ensure mitigation options can be assessed for their likely effectiveness.
- Projections of forest plantation rates will be driven largely by requirements associated with regional economic development, and meeting obligations under the first commitment period of the Kyoto Protocol. An increase in funding will be required to meet those obligations.
- Little funding and effort is currently available for population and long-term energy and transport scenario development, and how long-term technological solutions could be supported by policy. This requires an active engagement of the research community in long-term policy development.

Risk of short-term underfunding:

- The degree of success of agricultural mitigation will determine the size of future emission reduction targets that New Zealand can accept. A good understanding of options as early as possible is necessary to achieve this.
- Forest sinks will continue to play a role in New Zealand's approach to reducing net GHG emissions beyond 2012, and clear projections of net sequestration rates are important to determine whether it is practicable to devolve ownership and liability for sink credits in future commitment periods, and to what extent gross emissions can be offset by sink credits beyond 2012.

2) Knowledge to support a full carbon accounting regime:

a) Quantification of the effects of forest management and resulting carbon changes above and below ground in planted and indigenous forests
b) Better methodologies and good practice inventories for shrubland, and forest revegetation and degradation, including the effect of pest control
c) Quantification of the effects of erosion and associated volatisation of carbon

Synergies, co-benefits with, and dependence on other research/policy areas:

- Erosion is a major issue for sustainable land management and conservation of indigenous forests generally; it may therefore represent opportunities for integrating climate change dimensions in other research programmes.
- Improved understanding of carbon flows through ecosystems may represent an important international business opportunity through eco-system management consultancy.

Relevant funding agencies:
FRST, MAF, DoC, MfE, some co-funding by local government.

Adequacy of current research effort, capacity, and funding levels:
Increased funding is needed to bring New Zealand up to international best practice required for the first commitment period (see *Outcome Statement 1 – Kyoto*). This increased funding will need to be maintained in future years as international reporting and accounting requirements become more comprehensive and require more extensive supporting research and data after 2012.

Risk of short-term underfunding:
This type of research has a long lead time, and implementation of new forest management techniques needs to be consistent with other drivers outside of climate change. Given that full carbon accounting is likely to be increasingly required of developed countries, these research areas need to be progressed now to ensure that relevant and practicable knowledge is available in 10 years from now.

3) Economic and social analysis of different emission targets and policy options:

a) on-going refinement of economic modelling of energy policy options, including the development of a New Zealand-specific modelling capability that could replace use of the ABARE (Australian Bureau of Agricultural and Resource Economics) model,
b) validate assumptions about price elasticities in a post-Kyoto world that may see the growing availability of energy-saving technology
c) improve understanding of the social impact of a carbon charge on different sectors of society
d) improve energy supply and demand modelling beyond 2012 that incorporates the impacts of the increasing availability of energy saving technology and supporting policies

Synergies, co-benefits with, and dependence on other research/policy areas:
- Social effects of policies have a strong link with *Outcome 7 – Societal engagement* since their impact depends on choices made by different sectors of society.

Relevant funding agencies:
FRST, MED, Treasury, MfE, DIA

Adequacy of current research effort, capacity, and funding levels:
There is only a very small base of independent economic researchers in New Zealand; this can polarise the debate and does not allow for a good process of scientific peer review. This basis needs to be expanded. It could be linked with the need to increase the capacity for social science research, as described in *Outcome 7 – Societal engagement*.

Risk of short-term underfunding:
There is a lead time of several years to add significant new capacity to economic and social research. There is likely to be a renewed debate about economic impacts of a carbon charge in 2007, and at the same time government needs to define its domestic policy in response to future emissions targets. For this reason, efforts to increase the independent economic and social research capacity should occur within the next few years.

Outcome 3: Reducing emissions in the long term

Outcome: New Zealand is able to reduce substantially its greenhouse gas emissions beyond 2012 while sustaining a growing and vibrant economy and society.

Research and information are needed to address the following main areas:
1. Improved energy efficiency and waste minimisation
2. Replacement of fossil fuels with renewable energy sources
3. Planning for efficient urban form, work and transport systems
4. Continuing reduction of non-CO_2 greenhouse gas emissions and enhancement of greenhouse gas sinks after the first Kyoto Protocol commitment period.

Rationale for Research Areas

It is very likely that emission reductions in the order of 50-70% will be required over the next 50 to 100 years. While current technologies can deliver some of those reductions if supported by adequate policies, they would require a major change in society and economy. It is likely that a large part of required future emission reductions will also come from new technologies.

Many of these research areas contain an element of fundamental research, and they are part of a global research effort. New Zealand may want to limit its research efforts in those areas where there is a global effort going on and where new technologies could be readily imported and implemented, and concentrate on those areas where New Zealand-specific solutions can be found, or where New Zealand has a natural advantage in developing new solutions that can be exported. The research priorities outlined below focus on this latter group of research areas.

Together, these research areas underpin sustainable development and improvement of New Zealand's economic and social long-term well-being while maintaining and improving its sustainable use of natural resources.

Key Users of Research Results

Central Government (MFE, MED, MCDEM, EECA, MAF, MFish, DOC, MOT), Regional and Local Government (Regional and local development, hazard mitigation, economic development), private sector (farmers, energy users, energy suppliers, manufacturers, consultancies).

Priority Research Needs for Each Area

1) Improved energy efficiency, energy management and waste minimisation

a) Identifying where significant savings and gains can be made most effectively and efficiently.
b) Socio-economic barriers and drivers to uptake of energy technology and efficiency measures; measures to overcome these.
c) Development of baseline understanding: Household and business energy efficiency databases, baseline transport data.

d) Energy markets: Understanding the elasticity of energy demand and its drivers; incentives to guide energy markets towards achieving energy efficiency improvement.
e) Building design and technology for NZ climate and social conditions.
f) Energy efficiency technology: developments in energy efficiency technology applicable to New Zealand's energy supply, distribution and end-use systems.
g) Energy demand management: developments in energy demand management technologies and systems, particularly in the electricity sector.

2) Replacement of fossil fuels with renewable energy sources

a) Biofuels: Relevant and appropriate biofuels technology, producing bioenergy products and conversion to biofuels.
b) Hydrogen production from New Zealand's renewable energy resources.
c) Technology: Evaluating, designing or modifying renewable energy systems for NZ conditions. Distributed energy generation in support of renewable energy
d) Climatic resources and technologies for renewable energy generation (water, waves, wind, solar), spatial and year to year variability, impacts on them of climate change.

3) Planning for efficient urban form, work and transport systems

a) *Social drivers of transport behaviour:* achieving attitudinal change.
b) *Influence on transport & energy use of structure of human settlements* and regional development.
c) *Vehicle and transport mode efficiency:* Cost-benefit analysis of different policy options including urban planning, mandatory vehicle performance requirements, fleet management standards, time scales for change, and organisational responsibilities.

4) Post Kyoto sink enhancement and non-CO_2 emission reductions

a) Reducing non-CO_2 greenhouse gas emissions from agriculture: Continued work on methane, nitrous oxide reductions and implementation in partnership between government and the agriculture sector.
b) Sustainable land management practices which enhance CO_2 sinks (including sustainable forestry) – Carbon cycle understanding / budgets to guide and defend such practices.

Synergies, co-benefits with, and dependence on other research/policy areas

- Many of the research and information needs identified under this heading are also required for other national, regional and local strategies which foster innovation and growth and improve economic and social well-being. Priorities identified in the Government's approach to sustainable development[2] include creating more innovation, skills and wealth, and reducing our negative impact on the environment and understanding our natural resources. The mitigation research identified contributes to these outcomes as well as to a whole range of other government strategies, policies and legislative requirements. These include Agenda 21, the pending Local Government Bill, the Resource Management Act, the New Zealand Transport Strategy, and the Growth and Innovation Framework, the National Energy Efficiency and Conservation Strategy (NEECS), the New Zealand Waste Strategy.

[2] New Zealand Government, 2002: The Government's Approach to Sustainable Development. http://www.beehive.govt.nz/hobbs/med-sustainable-development-govt-approach.pdf

- A lot of the contributory work to achieving climate change goals will be done by local authorities as they work on general sustainable development issues around urban policy, land use management, alternative transport forms, energy end-use management, potential alternative energy generation and new infrastructure management mechanisms.
- Maximum benefit will be gained by designing research to inform and support these broader sustainable development needs, rather than by focusing only on climate change.
- Research on implementation and barriers to implementation should be integrated into research into new technologies from an early stage to ensure that solutions are practicable, can be readily integrated, and supporting policies have sufficiently long lead-times to ensure uptake of solutions.

Relevant funding agencies:

Because of the wide scope of climate change adaptation and mitigation research aimed at sustainable development, its funding should be of interest to a range of institutions, including: FRST (PGS&T), Marsden, MAF, Agriculture sector, MFE, MED, MOT, EECA, Vote Education, MFish, Regional and Local Councils.

Adequacy of current research effort, capacity and funding levels

- Current investment into mitigation of agricultural non-CO_2 emissions is a good start, but unlikely to be adequate to achieve major and sustainable reductions across the sector. Funding will need to increase, and be sustained over at least the next decade, to ensure both comprehensive exploration of opportunities and their implementation consistent with farming practices.
- Research into human dimensions and implementation of technological solutions in the energy and transport sector is currently limited and often done in an ad-hoc add-on manner. A long-term transformation of New Zealand's emissions profile is unlikely unless greater attention is paid to the social dimensions of the challenge of climate change. See also *Outcome Statement 7 – Societal participation*.
- There has been a loss of critical capacity particularly in the area of accounting for Kyoto forest sinks. This needs to be rebuilt and extended to ensure New Zealand can extend its systems to a comprehensive accounting of all carbon stocks and sinks across managed and indigenous ecosystems.
- Research into renewable energy sources and technologies to exploit them is currently limited by low market demand and commercial opportunities due to higher cost of renewable energy. Policy intervention consistent with the NEECS strategy may be needed to increase commercial research interest in this area.

Risk of short-term underfunding:

- It is critical to recognise that the changes required in the future will involve the reversal of many long-term historical trends. Decisions are continually being made which affect our ability to reduce greenhouse gas emissions, adapt to future climate, and foster sustainable innovation and growth. It would be counterproductive and costly in the long term to delay research which will help our agricultural industry develop productive systems with lower greenhouse gas emissions, and our cities develop energy-efficient and publicly acceptable transport processes and systems.

Outcome 4: Adaptation

Outcome: New Zealanders adapt well to current and future climate (including variability, extremes and changes), minimise negative impacts and maximise climate-related opportunities.

Research and information are needed to address the following areas:

1. Local government decision-making, regional development and emergency management plans which minimise the impacts of climate hazards and climatic extremes in both urban and rural locations.
2. Fostering uses of land, freshwater and ocean resources (business, agriculture, fishing, aquaculture, service industries, tourism, energy generation, water usage) that are well matched to and take advantage of current and future climate[3].
3. Maintaining biosecurity and biodiversity under a changing climate.
4. Contributing to the ability of small island nations in the South-West Pacific to build adaptive capacity to cope with climate variation and change.

Rationale for Research Areas

Adaptation research will provide information and tools to help local government plan for the effects of climate change, an important responsibility noted in the Government's confirmed climate change policy[4]. Three of the priorities identified in the Government's approach to sustainable development[5] are: creating more innovation, skills and wealth; improving the well-being of our children; improving participation by Maori and Pacific peoples. The adaptation research areas outlined above contribute to these priorities and to a range of other government strategies, policies and legislative requirements. These include the pending Local Government Bill, the Resource Management Act, the Civil Defence and Emergency Management Bill, the Growth and Innovation Framework, the Biosecurity Act and the National Biodiversity Strategy.

Key Users of Research Results

Central Government (MfE, MED, MCDEM, MAF, MFish, DOC), District and Regional Councils (Regional and local development, hazard mitigation, economic development), private sector (farmers, energy users, energy suppliers), community groups focused on conservation, NZAID, Pacific Island countries.

Priority Research Needs for Each Area

1) Minimising the impacts of climate hazards and climatic extremes

Better information on likely future changes is required to enable local government and key industries to plan for changes in natural hazards and climate extremes, and to allow communities to proactively engage with the challenges a change in climate will present. The research findings should be provided in ways that can be integrated into standard risk assessment processes.

[3] There are links to needs under Outcome Statement 6 (Business opportunities) through development of new land uses, crops etc.

[4] Media Briefing: Confirmed Climate Change Policy. New Zealand Climate Change Project, 17 October 2002. http://www.climatechange.govt.nz/whats_new/policy-background.htm

[5] New Zealand Government, 2002: The Government's Approach to Sustainable Development. http://www.beehive.govt.nz/hobbs/med-sustainable-development-govt-approach.pdf

a) Improved regional climate scenarios. Improve regional characteristics and better quantify uncertainty and assumptions of regional climate scenarios, particularly for precipitation, wind strength and direction, and likely changes to ENSO regimes.
b) Climate extremes and their impacts (e.g. drought, flood, coastal erosion, strong winds, frosts): Better quantify likely changes in intensity and frequency of extremes and characterise regional differences, and link projection of changes with assessment of current climate variability.
c) Understanding perceptions of climate risk, improve communication of scientific findings to general public and local decision-makers, identify barriers to adaptation, incentives for action, decision-making tools to enable risk assessment.
d) Assessment of the cost of extreme climatic events and associated damages to existing and future infrastructure and developments, the monetary and non-monetary cost of various adaptation options, and their effectiveness in avoiding damages.

2) Matching activities of the primary production sector to current and future climate

Research results on climate change and variability, soils, future agricultural technology needs and economics should be integrated into management support and land-owner decision-making systems.

a) Research to improve seasonal climate outlooks and development of ENSO patterns, and links to agricultural production models and decision support tools.
b) Climate guidance for sustainable management of land and water: Understanding the effect of spatial and temporal variations in climate, climate extremes, and projected changes in CO_2 and UV-B on potential land-uses, aquaculture and fisheries, and water availability.
c) Identification of technologies to allow the primary sector to adapt to climate change (e.g. new plant, crop and livestock types, new biocontrol methods, new land management techniques).

3) Biosecurity, biodiversity and maintenance of ecosystem services under a changing climate

a) Understanding impacts of climate variability, climate, atmospheric composition and land-use change on ecosystems. Includes interactions of climate change impacts with other environmental stresses.
b) Development of conservation strategies for natural biological systems (terrestrial and aqueous).
c) Monitoring for invasive species and pests: Developing systems to monitor changes in distribution, manage and eliminate pests, diseases and weeds.

4) Pacific Island adaptation

a) *Regional and local climate:* Cooperate with Pacific Island countries to identify, understand and predict seasonal climate variability, climate extremes and climate change. This includes capacity building, contribution to monitoring programmes, regional collaboration in seasonal climate prediction and climate change scenario development.

b) *Impacts:* Cooperate with Pacific Island countries to identify the likely impacts of climate variability, extremes and changes, including effects of sea-level changes.
c) *Adaptation and resilience:* Participatory collaborative studies of impacts of past climate and weather events on vulnerable communities and identification of successful adaptation techniques. Assistance in identifying future adaptation options.

Synergies, co-benefits with, and dependence on other research / policy areas

- Adaptation to climate is fundamental to much of the work and many of the responsibilities of central and local government for sustainable development and for emergency management. A large part of the work on adapting to climate change will be done by local authorities as they address sustainable development issues including urban development, land use management, potential alternative energy generation, sustainable water supplies, civil defence and emergency management plans, and new infrastructure management mechanisms.
- Transformation of how New Zealand society deals with natural risks and hazards is likely to require long lead times from the development of a science-based understanding to decision-making tools and "mainstreaming" a proactive risk management approach in everyday planning decisions. This will require a combination of science, engineering and policy support.
- Land and water based industries will also benefit from improved future planning of infrastructure and land and water usage taking account of climate change and altered climate variability.
- Maximum benefit will be gained by designing research to inform and support these broader sustainable development and hazards management needs, rather than by focusing on climate change in isolation. In addition, research which helps people adapt to current climate and its extremes forms a useful first step in understanding the role of climate in our well-being, building resilience to future climate changes, and encouraging communities and organizations to identify and plan for such changes.

Relevant funding agencies:

Because of the wide scope of climate change adaptation research aimed at sustainable development, funding should be contributed by a range of institutions, including: FRST (PGS&T), Marsden, MAF, Agriculture sector, MFE, MED, Vote Education, MCDEM, DOC, MFish, Regional and Local Councils, NZAID.

Adequacy of current research effort, capacity and funding levels

- Proactive adaptation measures are currently limited by large uncertainty of regionally specific climate projections, particularly changes in climatic extremes over catchment areas. Greater engagement with climate change impacts at the local government level will in part depend on the ability to reduce uncertainties and provide more region-specific projections.
- Funding for adaptation is currently coming predominantly from central government PGS&T fund administered by FRST, with some regional scoping studies carried out by Regional Councils. Increased funding support and involvement is desirable from industries and sectors that will particularly benefit from improved adaptation to climate, and government departments, to provide information and solutions to natural hazards, tailored to policy and regional development needs.
- Research on matching land-use to current and future climate is currently adequate, given the long lead-time for climate change knowledge and practices to develop. The focus should be increased on whole-system approaches involving the human dimension.

- Research into specific needs of Maori should increase in the short term to ensure research needs can be better characterised and addressed.
- Research into Pacific Island climate monitoring, and assessment of impacts and adaptation, could be funded through a reprioritisation of NZAID funds which should include capacity building in the local research and government planning community and support of climate monitoring activities.

Risk of short-term under funding:

- Information is required on changes in climate hazards and extremes, since infrastructure and housing designed today, or the establishment of long term land uses such as forestry and croplands requiring irrigation or drought protection, will have a sufficiently long life-time to experience major changes in climate conditions. Delays in producing more specific information may mean that more infrastructure will be designed that is not well matched to future climate conditions, which could have major cost and liability implications.
- Research on regional climate change and its impacts has relatively long lead times and information cannot easily be generated through short-term investment. Since New Zealand cannot expect to import New Zealand-specific knowledge from overseas, it is important to at least maintain existing capacity into the foreseeable future.

Outcome 5: Health

Outcome: The health of all New Zealanders is being improved and social inequalities in health are being reduced.

Research is needed to address the following main areas:

1. studies related to disasters (storms and floods especially);
2. factors vital to control of vector-borne disease;
3. understand and quantify health co-benefits and risks arising from climate change effects and from reducing greenhouse gas emissions.

Health research takes place in a complex environment that sees significant pressures on the health system from many non-climate sources. While the specific contribution of climate *change* to public health may be generally small, linking of climate-specific research with other on-going research programmes can ensure that relevant research needs are addressed without creating significant additional funding demands.

Rationale for research areas:

Area 1: Natural hazards already pose health challenges and cause death, and could become exacerbated with climate change. Improved resilience to current health risks from natural hazards would result in greater resilience to future climate change.
Area 2: This causes few impacts at present, but is of high concern (eg incursions of exotic mosquitoes), and is likely to increase due to global and domestic climate change as well as other global pressures.
Area 3: A range of actions either to adapt to the effects of climate change or to reduce greenhouse gas emissions could have significant co-benefits for public health. A better and quantitative understanding of those co-benefits is important to allow a full assessment of the costs and benefits of those actions and to increase public awareness of their desirability.
All areas: Health impacts related to all three areas would be likely to increase inequalities in health status.

Key users of research results:

Central government (Health, Housing, Civil Defence and Emergency Management, Agriculture and Forestry, Biosecurity, Immigration, Foreign Affairs), local government (community services, Regional Councils), District Health Boards.

Priority research needs for each area:

1) Studies related to disasters (esp. storms and floods)

a) Early warning systems of extreme climatic events: Map areas of vulnerability, further improve short-term forecasting and dissemination and uptake of relevant information in disaster management and prevention

b) Factors influencing the vulnerability of NZ populations to injury and disease from extreme weather events: Improve understanding of attitudes, awareness of disaster mitigation options and long-term cost-benefit balance
c) Health system responses to disasters: Improve understanding of regional economic and social effects of disasters such as floods, droughts and storms, flow-on effects and persistence of effects, balance of prevention and recovery.

Synergies, co-benefits with, and dependence on other research/policy areas:

- Early warning of extreme events (floods, droughts, storms, storm surges and coastal flooding) and building of regional capacity to respond to such events is helped by the development of regional climate models capable of simulating likely changes in extremes, further improvements in seasonal and short-term climate and weather prediction services, and timely communication of warnings relevant to the community and appropriate agencies.
- Vulnerability of NZ populations to injury and disease is closely linked with local government planning generally taking climate change effects into account (with regard to housing development, water supply, storm- and waste-water services, regional and local transport infrastructure). Policies should support the general consideration of climate change effects in planning for natural resources and hazards by all relevant stakeholders.
- The Civil Defence Emergency Management Act 2002 requires a more proactive approach to hazard management and prevention. There is an opportunity over the next few years to integrate climate change effects into the assessment of natural hazards and hazard mitigation, which needs to be supported by sound data and quantitative analysis to decide on priorities in hazard mitigation and prevention.

Relevant funding agencies:

FRST, HRC, MoH, MCDEM, local government.

Adequacy of current research effort, capacity, and funding levels:

- Little is currently know about the long-term and flow-on effects of disasters (including drought) on communities and impacts on the health system including mental health.
- In the health area, there is very little research currently underway in these areas. No quantitative studies of future risks of injury and death due to natural disasters has been conducted. Other kinds of natural disasters (especially earthquakes) have been studied more closely – some of the findings from this work (e.g. related to health service responsiveness) may be extrapolated.

Risk of short-term underfunding:

- If no additional work is done in the area, the management of civil defence situations may be based on the assumption that climate-related hazards will not change over time, which is likely to be incorrect. Opportunities to reinforce climate change messages in the implementation of the Civil Defence Emergency Management Act 2002 may be lost and climate change scenarios may be more difficult to be integrated later.

2) Factors vital to control vector-borne diseases

a) Current distributions of potential vectors
b) Factors influencing the introduction, establishment and spread of new vectors: Carriers, short-term spread, establishment, efficient eradication options, to inform targeted surveillance and control/eradication actions

c) Susceptibility of the New Zealand population to these diseases: Socio-economic differences, role of preventative health care access
d) Systems research: Design of more responsive information systems that combine clinical, environmental and laboratory data

Synergies, co-benefits with, and dependence on other research/policy areas:
- Distribution modelling dependent on the availability of regional climate change scenarios and the availability of spatial climate mapping tools.
- Surveillance of current vector distribution and establishment risks closely interface with current biosecurity work by MAF and would help inform this work with regard to "high-risk" years caused by interannual climate variability. See also *Outcome Statement 4 – Adaptation to climate change effects*.

Relevant funding agencies:
FRST, HRC, MoH, MAF. Regional co-funding by local government where related to current biosecurity surveillance and eradication efforts.

Adequacy of current research effort, capacity, and funding levels:
- The HRC has funded several projects examining the potential for exotic mosquito vectors to become established in New Zealand, using the CLIMPACTS spatial climate impacts modelling technology. Capacity to carry out further work is limited to only a few individuals in New Zealand, but current funding is adequate to continue work in this area.

Risk of short-term underfunding:
- The relevant modelling work is currently carried out by only one group (IGCI, University of Waikato in collaboration with Wellington School of Medicine), and relies on the availability of spatial climate mapping tools. Loss of the underpinning modelling capability would take several years to regenerate.

3) Health co-benefits and risks arising from climate change effects and from reducing greenhouse gas emissions

a) Quantify health effects of air pollution to enable comprehensive cost-benefit analysis of technological, traffic management and policy options that would simultaneously reduce air pollution and reduce greenhouse gas emissions
b) Improve understanding and quantify relationship between housing insulation and public health to incorporate health benefits in cost-benefit analysis of improved building and insulation standards; this should include the likely influence of future climate change
c) Better understand and quantify health benefits and risks of alternative transport modes such as public transport, walking and cycling

Synergies, co-benefits with, and dependence on other research/policy areas:
- Housing is an important service provided by central government and provides an opportunity to positively influence market standards. There are also important synergies between health outcomes, and mitigation through improved energy efficiency and insulation standards.
- Transport management and the role of urban form is of critical importance to the well-being and future development of New Zealand communities.
- There are obvious links and synergies with research in *Outcome Statement 8 – Societal engagement* since complex urban environments are driven by human choices that cannot easily be influenced by simple policy or technological solutions; hence a good understanding

of societal preferences and choices is vital to ensure that research outcomes are relevant to real-world decision-making problems.

Relevant funding agencies:
FRST, HRC, MoH, Housing NZ, Transit NZ, local government.

Adequacy of current research effort, capacity, and funding levels:
- Research to quantify health benefits of reduced air pollution is beginning to be applied to New Zealand specific assumptions and is mainly driven by air pollution concerns. It would be important to ensure that linkages with greenhouse gas emissions are not overlooked to make use of the obvious research synergies.
- Quantitative research into health benefits and risks from alternative transport modes is very limited at present.
- The HRC has funded a programme of research on housing and health, including studies of insulation and energy use. This work could be assisted and expanded by better integration through a central agency to collect and maintain relevant databases and research results.

Risk of short-term underfunding: Transforming New Zealand's urban communities to become more energy efficient and less polluting is a key task for decades to come. Sound and comprehensive research results are likely to have long lead times and hence need to be initiated several years before practical results are expected. While immediate benefits of this research are therefore likely to be small, delays in additional work mean that even preliminary cost-benefit analyses of different urban form and policy options are likely to underestimate mitigation co-benefits since they exclude health co-benefits, or be open to criticism because they are not based on sound data.

Outcome 6: Future watch and capacity to deal with surprises

Outcome: New scientific knowledge and observations are generated to improve local, national and international actions and policies to mitigate and adapt to climate change and maintain the capacity to deal with scientific surprises.

Some of this knowledge will come from research undertaken overseas. Nevertheless New Zealand needs scientific capability and international scientific links to:

- keep well informed about new scientific international developments, including scientific surprises about Earth systems,
- understand their implications and the opportunities they create for New Zealand,
- lead or influence and participate in research and observing programmes where New Zealand has a particular need or obligation, i.e. the NZ territory, the SW Pacific, Southern Ocean and Ross Dependency.

Research, information and capacity are needed in the following areas:

1. New knowledge about the global and regional climate system, and the sensitivity of our natural and managed ecosystems and social systems to climate changes, to reduce uncertainties and identify any important new factors ("surprises").
2. Science teams and leaders with credibility, capability and resources to plan and participate in relevant international programmes, develop appropriate New Zealand research, participate in IPCC assessments, and advise policymakers and planners.
3. Capabilities for downscaling global and regional-scale climate projections to improve predictions for climatic change in New Zealand.
4. Long term programmes of systematic observations required to advance scientific knowledge and verify / improve regional and local predictions of changes and impacts. These include: atmospheric constituents, atmosphere and ocean climate, rivers, glaciers and snow cover, and biological responses by sensitive natural and managed ecological systems.

Rationale for Research Areas

The IPCC's Third Assessment Report notes there is a wide band of uncertainty in the amount of warming that could result from any stabilized greenhouse gas concentration[6]. It lists important uncertainties in the science including[7]: factors in modelling the carbon cycle, the likelihood of large-scale abrupt climate changes, uncertainties in projections of local or regional detail – especially climate extremes, assessing and predicting the response of ecological, social and economic systems to the combined effect of climate change and other stresses.

The UNFCCC states that lack of full scientific certainty should not be used as a reason for postponing precautionary action where there are threats of serious damage. Nevertheless, policies and actions for mitigating and / or adapting to climate change can be made more effective as new knowledge reduces the uncertainties, identifies new impacts, and identifies new mitigation opportunities. There are still significant uncertainties in the emission rates of various non-CO_2 greenhouse gases from agricultural activities, an area of particular importance to New Zealand.

[6] Climate Change 2001: Synthesis Report, Summary for Policymakers, Question 6.
[7] Climate Change 2001: Synthesis Report, Summary for Policymakers, TableSPM-3.

To track local changes in climate and their impacts we need to maintain a national programme of systematic observations of climate parameters as well as changes in our unique ecosystems, linked in to relevant international observing programmes. This will enable us to check predictions, and modify adaptation activities accordingly. Observations from our region make an important contribution to the global observing system needed to detect global and regional anthropogenic climatic changes and improve understanding and modelling of these.

Under the UNFCCC and the Kyoto Protocol we have internationally agreed obligations to support and develop international programmes for research and systematic observation. But even without these commitments we would need to undertake research and monitoring in our region, since other countries are not going to do this for us. By participating in international programmes and science assessment activities we can leverage our own efforts by ensuring scientific issues of importance to New Zealand and the Pacific Islands are addressed, There are important co-benefits, for example improved understanding of El Niño / La Niña processes and improved global climate models will also help us better forecast seasonal climate hazards (such as drought).

Key Users of Research Results

Central Government (NZ Climate Change Programme, MFE, MED, MAF, MFish, DOC), Local Government (Regional development, hazard mitigation), private sector (farmers, energy users, energy suppliers). International (UNFCCC, IPCC, GCOS, IGBP, WCRP, IHDP, DIVERSITAS).

Priority Research Needs for Each Area

1) New Knowledge and capacity to deal with surprises

a) *Potential nonlinearities and abrupt changes* – Atmospheric chemistry, atmosphere and ocean circulation, non-linear effects on ecosystems, thresholds leading to abrupt changes in ecosystems and shifts to new ecosystem states.
b) *South Pacific atmospheric circulation, ocean processes and ocean-atmosphere interactions* – Includes dynamics & circulation including El Niño/ La Niña; biology / chemistry of CO_2 uptake in the Southern Ocean; Production of aerosols (e.g. through dimethylsulfide (DMS) production) and their effect on clouds and radiation balance; palaeoclimate studies, and regional climate modelling of palaeoclimates).
c) *Quantifying the entire carbon cycle for the NZ region*: Atmosphere / terrestrial / aquatic / marine.
d) *Antarctica / Ross Dependency* including palaeoclimate, ecosystems, sea-ice properties / break-up.
e) *Interactions* between climate change and ozone depletion/UV damage in effects on ecosystems and atmospheric chemistry and dynamics.

2) New Zealand climate impacts and adaptation

a) *Increase basic understanding and models of the sensitivity of NZ ecosystems* to climate variability and change, elevated CO2 and UV-B levels due to ozone depletion (terrestrial, aquatic and marine, including Ross Dependency).

b) Germplasm resources and collections of genetic resources suited to future climates, including biological control agents for future pests. Preparing for future biological opportunities and threats associated with climate change.

3) Systematic observations

a) *Maintaining and continuing to automate* an adequate atmospheric climate, chemistry, hydrology and (natural and managed) ecosystem biology observation network that contributes to international observation programmes and databases.
b) *Sea level network:* Supporting an appropriate network of open-coast gauges with associated GPS measurements of underlying geological movement with long-term funding certainty for its "public good" component.
c) *Exploiting satellite technology* to monitor greenhouse gas emissions and concentrations, climate change impacts on ecosystems and other large-scale changes in natural and managed ecosystems, LULUCF, traffic density

Synergies, co-benefits with, and dependence on other research / policy areas:

- Ocean and atmosphere dynamics research and regional modelling also support improved seasonal climate predictions.
- Research on ecosystem sensitivity, and systematic observations of climate and ecosystems also supports sustainable development and biodiversity goals.
- Systematic climate, river and sea level observations are important for assessing risks of natural hazards and planning to minimise their impacts, independent of the specific effects of climate change.

Relevant funding agencies:

- *New Knowledge:* PGS&T, Marsden, Vote Education;
- *Science Teams and International Collaboration:* CRIs, Universities, MoRST, FRST, Marsden.
- *New Zealand Climate and Impacts Prediction:* PGS&T, MFE, MAF, MFish;
  Systematic Observations: PGS&T, MFE (Indicators Programme), LINZ, Regional Councils, MOT (through MetService Contract).

Adequacy of current research effort, capacity and funding levels:

Capacity to deal with surprises depends on skilled individuals, systematic human capacity across institutions, and scientific infrastructure (laboratories, monitoring networks, research vessels, computers). New Zealand currently has strong teams working on underpinning science of importance to New Zealand, which also bring international credibility to our participation in the IPCC and SBSTA. The available research funding for this effort should have critical mass and its adequacy monitored.

Risk of short-term underfunding:

See introduction - Science Capacity.

Outcome 7: Societal engagement

Outcome: New Zealand society engages in responding to climate change.

Research is needed to address the following areas:

1) community understanding of climate change processes (including causes, effects, and responses)
2) barriers to translating understanding into action
3) integrated participatory studies
4) informed individual and community (including local government) decision making
5) Review of existing social science research issues, and further methodological development.

Rationale for research areas:

At its most basic climate change may be seen as a social problem. It is caused by human actions and for the most part we are concerned because it will have adverse effects upon people. As scientific certainty about the "bio-physical" processes increases, it is becoming increasingly clear that a major stumbling block lies in our understanding of the social processes.

From a policy perspective, such knowledge is equally critical if we are to adequately respond to climate change and its effects, either through reducing net greenhouse gas emissions, as we are committed under the Kyoto Protocol, or adequately positioning the population of New Zealand to effectively adapt to changes that might arise.

Three key areas emerge in relation to community engagement. These are a) facilitating "buy in" to response policies and b) encouraging community and individual action where policy intervention is inappropriate or insufficient to achieve the desired engagement and c) encouraging community initiatives as part of joint or government programmes.

Area 1: People's understanding of problems does not necessarily result in them taking ameliorative action. However, it is likely to increase support for policy developed in response to such problems. There is a very limited body of research into people's understanding of climate change and of their motivations to respond to the challenges it poses. It is likely that there is considerable confusion about climate change among the general public and the media (e.g. ozone depletion and the greenhouse effects are consistently conflated). There is a need for research to determine if much of the resistance to mitigation is because there is limited understanding of the likely impacts and costs of adaptation, or the possibilities for no-regrets mitigation actions and their long-term costs and benefits to society. There is also a need for research that ensures the work of the science sector is made accessible to the general public and other decision-makers.
Area 2: We also need to know why, despite understanding of the issues, there is often antipathy towards adopting response measures, even where they may be win-win or no-regrets options. This research will need to address individual and community environmental values, the role of the larger political-economy in constraining individual and other actions, and other social and economic factors that act as impediments to change.
Area 3: Integrated, longitudinal, participatory studies undertaken in certain key sectors are likely to yield the most fruitful results. They will enable social, climate and other scientists to work

with communities to help build understanding of climate change and develop, or support, appropriate response strategies. It will also enable in-depth impacts and adaptation research to be carried out (see *Outcome Statements 1, 3* and *4*).

Area 4: Much of the response to climate change, both mitigation and adaptation, will be conducted outside of the central government sector. The issues outlined in the statements for the two preceding research areas need also to be investigated in relation to local government and include development of tools for local governments to incorporate climate change into their planning activities and to examine constraints to local government adoption of climate change responses.

Area 5: The incorporation of generic social science into climate change research has been relatively weak. This reflects a general lack of interest among some social scientists and a number of factors that have constrained the effective collaboration between social scientists who are interested and other researchers in climate change. These include the concentration of climate change-relevant funding into CRI and other institutions that do not have a social science background, and differences in research paradigms, and funding strongly skewed towards the non-social sciences. This has resulted in a significant barrier to incorporation of standard social science expertise into solutions aimed at climate change problems and limits the advancement of our full understanding of climate change processes and the identification of effective societal response options. This research and capacity building area is of direct relevance to other outcomes, especially those related to adaptation, but also those concerned with health and mitigation.

Key users of research results:

Central government (e.g. MED, MAF, MfE/EECA, Treasury, Civil Defence and Emergency Management), local government (Regional and District/City Councils, emergency management), private sector (agriculture, energy users, managers and suppliers, transport users and operators, ecological consulting services, developers) and non-governmental organisations (e.g. land care and coast/dune care groups, environmental groups).

Priority research needs for each area:

1) Determining levels of understanding of climate change and possible response options among individuals, local governments, voluntary organisations, businesses and other organisations, and in different sectors of society and the economy:

a) Nationwide survey of popular understanding of climate change: this would enable areas (both in terms of demographic groups, sectors, community groups, regions, etc., and of aspects of climate change knowledge) to be identified where more intensive research efforts might be focussed.

b) Concentrated research including intensive interviewing, focus groups, etc., with groups likely to have key roles in terms of response to climate change. Some examples may include:
   - Transport providers and users.
   - Energy providers and users.
   - Agriculture

- Coastal communities
- Maori communities
- Local and Regional governments

c) Research into communication of scientific information on climate change and other environmental issues that ensures that a public awareness is increased (both in terms of quality of information and numbers of people informed).

2) Identifying barriers to translating knowledge into action:

a) Identification of environmental values amongst New Zealanders including dominant environmental discourses
b) Sophisticated research into the variance between stated intentions and behavioural outcomes.
c) Identification of institutional and structural aspects of New Zealand society, politics and economy that impede climate change response.
d) Case studies of no-regret or win-win response options and identification of factors that restrict their dissemination and uptake.

3) Development of resources to enable informed decision-making by individuals, local governments, voluntary organisations and businesses:

a) Based on findings of the studies outlined above (areas 1 to 3), a range of methods for building understanding and enabling informed decision-making by different target stakeholders may be developed. These methods should be tested and evaluated for effectiveness through a range of social science methodologies including participatory research.

4) Integrated participatory studies:

It is likely that the most useful research will be that which is longitudinal, integrates social and natural/physical science, works with stakeholder groups in a participatory manner and builds from developing understanding of the issues through to the instigation of responses. Some examples include:

a) Integrated studies of farmer understanding of climate change processes including the role of agriculture as a contributor of greenhouse gases, the likely effects of climate change on farming activities, and the range of responses that may be considered. Such research could include local/regional scenario development and involve natural/physical and social scientists.
b) Integrated studies on sustainable settlements working with local government and community groups as well as members of the energy, transport and construction sectors.
c) Specific integrated studies with groups that may be significantly impacted by climate change effects. These could include communities based on winter sports such as skiing, coastal communities, and Maori communities.

5) Review of existing social science research issues, and further methodological development:

Research on the social aspects of climate change is relatively poorly developed. There are important methodological issues that remain unresolved, particularly in the area of integrating

the physical and natural science research with social research. On the other hand there is a considerable body of existing generic social science research that is likely to be highly relevant. This includes research on societal response to environmental extremes as well as many studies of individual and community response to a range of non-environmental changes, and on the perception of risk and responses to perceived risks.

a) Review and synthesis of existing work on human dimensions of environmental variability and other relevant social science research that will inform our understanding of the societal aspects of climate change.
b) Methodology development for human dimensions of climate change research, incorporating both mitigation and adaptation responses, and associated requirements for scenario development.
c) Development of new, and refinement of existing, tools and methods for integrating social science and natural/physical science.

Synergies, co-benefits with, and dependence on other research/policy areas:

- Much of the research outlined for Outcome 7 will have close relationships to policy development at both central and local/regional government levels.
- Universities have a strong research capacity in this area, but are not always well connected with natural science research in CRIs. There is currently no major research institute in New Zealand with a solely social science research focus, although the International Global Change Institute at Waikato University focuses on the human dimensions of global change. To foster greater cross-disciplinary research capacity, there is a need to increase the capacity of social science research and the social science capacity of climate change-related research institutions, as well as achieving greater collaboration between the University and CRI sectors.
- For participatory research to be successful it will need to have strong linkages to local governments and community organisations.

Relevant funding agencies:

FRST, MAF, MfE, Civil Defence and Emergency Management, EECA, Ministry of Transport, local government. Private sector groups, especially those involved in agriculture, energy and transport.

Adequacy of current research effort, capacity, and funding levels:

- This area of research is the most neglected in terms of funding and research outputs.
- There is ongoing relevant research in a number of these areas (much of it as policy development at both central and local government levels) but little of it is related to climate change. While the majority of social scientists tend to neglect environment related issues, there is a group who are engaged and are encouraged by FRST attention to the need for this research.
- There are differences in research paradigms, where some of the new exciting developments in social science do not "fit" easily with traditional scientific methods. Rather than being seen as a problem, however, there is great potential for work that succeeds in integrating these approaches.

Risk of short-term underfunding:

Inadequacy of societal response to climate change. This would result in failure to meet emissions targets (and international obligations) or disruption from adaptive failure.

Outcome 8: Business opportunities

Outcome: New Zealand proactively engages with domestic and global business opportunities and risks arising from a carbon-constrained world.

The best results for NZ will be achieved by encouraging a dialogue between the business community and the various science providers in the field, to better exploit existing, and identify emerging, business opportunities. This will require the further development of commercial arrangements between science providers and investors to manage governance and intellectual property issues.

Research is needed to address the following areas:

1. realisation of domestic no-regrets options;
2. planning for, and development of global business opportunities;
3. mitigation of global business risks

Research in these areas is most likely to be effective if it is carried out in partnership arrangements between government at its various levels, private sector, and research providers. The balance of funding will depend on risk, the distance of the research from commercialisation, and the potential to deliver benefits to the country as a whole. Effective engagement between business and research is essential for achieving the Government's Target Outcomes for research and contributes to the Growth and Innovation Framework and the National Energy Efficiency and Conservation Strategy.

The research described in this outcome statement focuses on long-term opportunities and risks arising from an increasingly carbon-constrained world, and from climate change itself. Opportunities arising specifically from the Kyoto Protocol's first commitment period are described under *Outcome Statement 1 – Kyoto*.

A key to investment is relative certainty. Investors will want to understand Government's long term policy framework for managing climate change and how it views and wishes to utilise its own investment in science.

Rationale for research areas:

Area 1: Emission reductions beyond those already envisaged will most likely be achieved by linking emission reduction options with business opportunities that maximise benefits and minimise private sector adjustment costs to a carbon-constrained world.
Area 2: Creating more innovation, skills and wealth is a key priority identified in the Government's approach to sustainable development[8]. New Zealand needs to ensure it can efficiently access the energy production and consumption technologies that will be required by its main economic sectors in the future, through strategic investment in selected technology developments.

[8] New Zealand Government, 2002: The Government's Approach to Sustainable Development. http://www.beehive.govt.nz/hobbs/med-sustainable-development-govt-approach.pdf

Area 3: New Zealand needs to protect its economic interests as global market expectations change in a carbon-constrained world.

Key users of research results

Private sector, professional bodies, Industry NZ, MED, Tech NZ, FRST PGS&T.

Priority research needs for each area:

1. Realisation of domestic no-regrets options to reduce emissions

a) Energy Efficiency – developing the capacity to adapt, transfer and implement new and emerging technology developments in energy efficiency applicable to New Zealand's energy supply, distribution and end-use systems, including domestic and commercial buildings. This also requires simple methods for cost-benefit calculations of improved energy efficiency for individuals or companies, and a better understanding of acceptable market and regulatory environments for ongoing efficiency improvements in the long term.
b) Renewable energy supply and energy efficient end-use technologies that have a specific New Zealand role (e.g. bioenergy, wind power, micro-hydro power, distributed power generation and storage, urban peak demand management).
c) Reduction of ruminant CH_4 emissions, consistent with the need to avoid concurrent increases in CO_2 and N_2O emissions and to maintain international competitiveness

2. Planning for, and development of global business opportunities

a) Best practice in sustainable business applications.
b) Tools and techniques for ruminant CH_4 mitigation and verification of emissions and emission reductions.
c) Energy Management Systems that accelerate the deployment of energy efficient products and services through the effective and efficient market processes.
d) Renewable energy supply and energy efficient end-use technologies in which NZ businesses can expect to become a significant supplier in international markets (e.g. bioenergy, wind power, micro-hydro power, distributed power generation and storage in remote and rural areas, urban peak demand management).
e) Creation of market advantages for New Zealand products through development of production technologies with lower environmental impacts, and appropriate marketing techniques for overseas markets.
f) Environmental consulting: Services related to climate monitoring and prediction, matching land-use and crop species to climatic conditions. The high degree of expertise and experience in NZ in this area has export potential for both developed and developing countries.

3. Mitigation of business risks

a) Development of new and efficient production technologies for key processing functions in New Zealand primary industries. This is to ensure they are not forced to adopt cheap but high emission technologies produced in countries that face lesser incentives to reduce emissions.

b) Early identification of climatic changes that could threaten key primary production activities in New Zealand, and where adaptation to changes may take a significant amount of time. Examples are water shortages in dry eastern areas, and spread of subtropical pests and diseases in pastures and forestry systems.
c) Monitoring of consumer attitudes in key trading partners. The long distance of New Zealand from its export partners could trigger negative reactions because of the energy required to transport products, and adequate marketing mechanisms need to be developed to counter such risks.
d) Early identification of changes in land-use in key competitor countries driven by climate change. While in most instances climate change will be only a minor driver for production changes in key exporting countries, early reaction to a likely long-term change would allow New Zealand businesses to retain or expand their market share.

Synergies, co-benefits with, and dependence on other research/policy areas:

- Most technological solutions in energy demand management, energy efficiency and renewable energy will achieve higher rates of implementation if they are supported by appropriate policies that are being developed in tandem with technological solutions.
- Retrofitting of housing stock and energy efficiency assessments are likely to have significant co-benefits with regard to the sustainability of buildings and their effect on community health (see also *Outcome Statement 5 – Health*).
- There needs to be greater awareness by business of the potential global opportunities created specifically by the Kyoto framework. This will occur over time when the Protocol comes into force, political resistance reduces, more information on CDM, JI becomes available, and international project schemes with opportunities for collaboration develop. Government could play a role with some strategic workshops bringing together international policy experts and business leaders.
- Current low standards of energy efficiency in New Zealand mean that it is difficult for NZ companies to use the domestic market to develop products with export potential. This applies to devices that could improve the energy efficiency of appliances, housing stock, and enterprise-wide energy demand management systems.

Relevant funding agencies:

Private sector, FRST, NERF, TechNZ, IndustryNZ, MAF, MfE.

Adequacy of current research effort, capacity, and funding levels:

- Investment by the private sector in energy efficiency and energy demand management solutions is still limited, partly due to the lack of a regulatory and pricing framework that specifically encourages the uptake of energy efficiency by large users.

Risk of short-term underfunding:

Investment in research and subsequent commercialisation of research outcomes requires long-term investment and commitment. Delays in the creation and fostering of business opportunities will make achievement of the policy goal, that gross emissions should be on a permanent downward trend by 2012, increasingly difficult to achieve.

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