

Involving the public in science and technology decision-making

A review of national and international initiatives

Working Paper produced by the Cross Case Study Learning Group

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Introduction

This working paper introduces the science community in New Zealand to the society-science dialogue initiatives funded by the Ministry for Science, Research and Technology (MoRST), and provides an international and national context for these initiatives. This review also illustrates why there are calls for change within our science institutions that impact on the work of scientists in New Zealand. MoRST and other government-related agencies (e.g. the Parliamentary Commissioner for the Environment, P.C.E., and the Foundation for Research, Science and Technology, FRST) recognise the need for learning in relation to useful dialogue in New Zealand, especially around science and technology issues that are the source of tensions between different groups in society. The *Science and Technology Dialogue Fund* programme offers opportunities to pilot new initiatives, and to feed the learning gained from the four MoRST-funded projects back to the science and technology community.

The criteria for funding the dialogue fund projects were developed in 2002 in consultation with a Dialogue Fund Strategy Group. In March 2003, \$450,000 was dispersed to four projects, two led by Crown Research Institutes (Landcare Research and NIWA) and two by universities (Victoria University of Wellington and University of Waikato). The science themes include: biotechnology relating to medicine development and food; genetic modification; the use of 1080 and biological methods to control animal and plant pests; and improved wastewater management systems that address Maori cultural and spiritual values. The projects are trialling a number of different dialogue initiatives. These include one-on-one interviews, focus groups and hui, and structured processes for multi-stakeholder communication and dialogue through to experiential on-site visits by local stakeholders. Significantly, each project identifies the need to include Maori participants, raising challenges as to how different world-views and different kinds of knowledge can be usefully discussed, understood, and incorporated into finding solutions to complex problems. Further information about these projects can be accessed through the MoRST website. (See <http://www.morst.govt.nz>)

The need for science-society dialogue in New Zealand has not arisen in a vacuum, but is an international trend, impacting upon the ways in which scientific research is funded, carried out, and implemented. Science communities, governments using science to inform policy-making, and industries that use science to develop new products and technologies are increasingly subject to questioning by the public (Breckenridge and Hoepfel, 2003; Commission of the European Communities, 2003; Dierkes and von Grote, 2000; EUROPTA, 2000; Phillips and Orsini, 2002; Wynberg, 1993). Globalisation and information technology mean that science questions and outcomes in one country – or international collaborations - are likely to impact on other countries. Much of today's science touches people in their everyday life, whether through television or through the food products on our supermarket shelves.

A concurrent international movement contributing to science-society dialogue initiatives is the call for more participatory democratic participation in political decision-making, and the need for a 'civic' society (Adams and Balfour, 1998; Dryzek, 2000; Forgie, Cheyne and McDermott, 1999). Scepticism and/or distrust of political systems or regimes has meant that governments have had to promote a more participatory and open style of governing which has included devolution of central state control and regulatory functions to regional or local governing bodies. In New Zealand, these changes are represented by the move to MMP (Mixed Member Proportional Representation), and more recently changes to the Local Government Act (2003) which make it mandatory for local governments to consult more widely with the communities they serve when making decisions that impact on those communities (Boston et al 1996).

The global resurgence of ethnic rights and sovereignty issues for indigenous peoples are part of these changes. There is a growing recognition that different kinds of cultural knowledge and world views have a number of implications for the ways in which countries are governed, both nationally and regionally, as well as challenges to the dominance of western science as

the legitimate way of understanding the natural world (Smith, 1998). Internationally, the *Human Genome Project* has brought ethnic issues to the fore, given the legacy of eugenic-based arguments for discrimination and/or annihilation of certain ethnic groups. New Zealand is unique in terms of its Treaty-based partnership with Maori through which governments and science communities need to negotiate with appropriate Maori communities, usually iwi, about how decisions around science and policy are made and implemented; what science is carried out, and who should be involved in carrying out that science (Cram, 2001; Dickinson, 1996).

Cutting across the above trends is the call for better practices to achieve global and local environmental sustainability. In New Zealand, the Ministry for the Environment (MfE) have endorsed the *triple bottom line* approach, whereby social, economic and environmental outcomes are equally important and the need to integrate these outcomes, rather than make trade-offs between them, informs a whole-of-government approach to national, regional and local policy, as well as directives for science research carried out in New Zealand.

The significant areas covered in this working paper include:

- Science and policy
- Science and Maori
- Sustainability science

The science and policy section discusses trends and initiatives in a number of western countries, ranging from government-led policy changes through to methods of facilitating public participation in debate and decision-making about new science and emerging technologies. In this context, we can appreciate the efforts made by MoRST, other government departments, and funding agencies within New Zealand, in promoting different ways of carrying out research which necessarily engage with a wide range of communities of interest. These initiatives are aimed at developing participatory methods of scientific research and policy formulation that are not only relevant to scientific research and development, but take heed of New Zealand's cultural context and unique partnership with Maori, based on the Treaty of Waitangi.

The history of change within New Zealand in relation to the interface between science and Maori is the focus of the second section. This change, based on a Treaty-based partnership model, reflects the importance of determining appropriate processes for engaging Maori experience, knowledge and cultural and spiritual values when discussing or engaging in scientific research. While past and present problems and issues for Maori are highlighted, there are also initiatives that can be celebrated, especially in comparison to other western countries. International and national practices of community engagement, especially with Maori, are related to the rising importance given to the sustainable management of the environment and how this intersects with the productive sector.

The 'sustainable science' section illustrates how past practices of a linear transfer of scientific knowledge to managing the environment has not always been effective. Firstly, research findings often lag behind the need to develop and implement policy, and a division of roles between experts and managers means there has been little dialogue between researchers and end-users. It is also recognised that the contexts in which land users and those that make policy interact is complex and variable. This needs to be taken into account when developing research agendas. Incorporating people, in all their complexity, into the ways in which scientific research is designed and carried out presents a challenge to science and decision-making institutions as well as to those in other disciplines who are charged with facilitating this experiential learning.

It is hoped that the science community will find this working paper useful in describing and explaining the reasons for international and New Zealand initiatives for developing a dialogue approach to scientific research and the application of new technologies. This working paper will be complemented by a further report on completion of the Dialogue Fund projects funded by MoRST.

Science and Policy

Introduction

In the last decade the governments of western social democracies have intensified their efforts to encourage innovation in science and technology and to minimize negative social and environmental impacts. Attention to the social and cultural impacts of new technologies has prompted a range of initiatives to involve citizens in policy making and regulation of new science (See, for example, Advisory Group to the Office of Science and Technology, 1999; House of Lords Select Committee, 2000; EUROPTA, 2000; Royal Commission on Genetic Modification, 2001; Human Genetics Commission, 2003; Canadian Biotechnology Advisory Committee). This is consistent with international strategies to involve citizens in a range of processes that legitimize policy decisions (Adams and Balfour, 1998, Dryzek, 2000).

Action by government agencies to encourage public engagement with science has been complemented by the work of quasi-governmental organisations and scientific associations. These initiatives are often directly or indirectly funded by governments and are directed at informing public policy. In the past, decisions relating to technological risk were seen as a matter for expert decision-making; now there is greater acknowledgement of uncertainty, more public involvement, and attention to a wider range of factors when assessing new technologies (Barnes et al, 1996, Dierkes and Von Grote, 2000, Willis and Wilsdon, 2003).

As indicated in the section on “Maori and Science”, indigenous people in New Zealand and elsewhere have been prominent among those involved in political debate about the relationship between indigenous knowledges and western science. Key concerns have been issues associated with intellectual property and indigenous flora and fauna. While indigenous people have organised around a range of intellectual property issues, the Human Genome Project and genetic modification, government attention to public participation has also been driven by the growth of international and local environmental movements, patients’ rights groups, community health movements and activism associated with food and water consumption (Petersen and Bunton, 2002).

In some respects, New Zealand has pioneered strategies for public engagement with science and technology (See, for example, the Royal Commission on Genetic Modification 2000 – 2001 and the incorporation of attention to the Treaty of Waitangi into the Hazardous Substances and New Organisms Act). In other respects, it has built on developments elsewhere (See, for example, the House of Lords Science and Society Report, 2000, and use of the Danish Consensus Conference model by the NZ Consumers’ Institute in 1996 and 1999, Consumers’ Institute; Goven, forthcoming).

The following discussion considers a variety of international and New Zealand initiatives that support the ideal of dialogue between diverse participants in discussion and decision-making about scientific work and its application. These initiatives by government agencies, quasi-governmental institutions and science organisations reflect the insight that good decision-making increasingly requires participatory strategies and interaction between scientists, technologists, policy makers and other citizens.

International developments – A discussion of selected initiatives

Danish Consensus Conferences

Scandinavian countries have been most active in initiating strategies directed at public engagement with science and technology and opportunities for public input into parliamentary decision-making in this field. The Danish Board of Technology was set up by the Danish Government in 1995 to inform the public about technology and to involve them in assessments of new technologies. One of these strategies has been the consensus conference, a model for citizen engagement that recognizes ‘social intelligence’ or the local knowledge of citizens and their interest in public debates about technology. (See the Danish Board of Technology website http://www.tekno.dk/uk_about_us.htm?language=uk).

Advocates of consensus conferences argue that technologically literate citizens are more likely to effectively participate in democratic decision making. Decisions that lack this involvement can be rejected as “illegitimate” and “antidemocratic”. For this reason, governments need to both inform and engage people in discussion about science and technology (See discussion about this on the website of the National Academy of Engineering, <http://www.nae.edu/nae/techlohome.nsf/weblinks/>)

Consensus conferences entail the selection of a panel of 14-16 citizens from a random sample of 1,000 adults. Further information about potential panellists is used to select a panel that is diverse with respect to jobs, age, gender, education and location and who have different positions on the technologies to be discussed. They cannot have professional expertise or commercial interest in these technologies. The panel is brought together over two weekends to give them access to information relevant to the technology they will be discussing. An expert panel is also constituted to participate with the panellists in the consensus conference that runs over four days. These events combine “experts’ knowledge” and “people’s common sense and popular will”. Panel members do not fight it out; rather, they are facilitated to “creatively move through their differences” (<http://www.co-intelligence.org/P-ConsensusConference1.html>). In the Danish context, consensus conferences are often organised to coincide with parliamentary discussion of science and technology issues so that they can inform decisions by parliamentarians.

Consensus conferences have been used in a variety of different contexts including many European states, Canada, Australia, New Zealand and Korea to engage ‘ordinary citizens’ in deliberation about the impacts of new technologies. They have demonstrated that those with little previous knowledge of a particular field of science can question experts and formulate recommendations that draw on their own ethical commitments, life experience and belief systems as well as information about the technologies (Joss, 1995; Joss, 1998).

United Kingdom initiatives

GM nation? The public debate

A large-scale public debate in Britain about genetic medication is currently underway. The need for this debate was identified the report, *Crops on Trial*, published by the UK Agriculture and Environment Biotechnology Commission (AEBC) in September 2001. The government accepted this recommendation. (See GM Nation? The public debate website, <http://www.gmpublicdebate.org>).

This government-funded intervention is being conducted by a Steering Board (which will report in September 2003), and is evaluated by an independent academic team funded by the Leverhulme Trust. This programme began with a series of discussion workshops in different parts of the country that were used to frame the issues and to develop the focus for the debate. Public meetings at national and regional levels have been held, and County Councils have taken on responsibility for running meetings using a ‘toolkit’ supplied by the Steering Board. Local networks and voluntary associations have also been involved in these processes. An interactive online GM Nation? Public Debate website, a CD-ROM for use in public meetings, as well as videos and hard copy material are being used. The goal is to stimulate “deliberative debate” and a series of “deliberative focus groups” were used to inform the structure for the debate. These focus groups will be used again at the conclusion of this experiment in policy-focused public participation. The government has undertaken to respond to the debate and demonstrate in government policy that it has taken into account views expressed by the public during the debate.

Human Genetics Commission

The UK government also set up a Human Genetics Commission in 1999 to provide advice to government, professional and regulatory bodies. The Commission has particular responsibility for publishing the Code of Practice and Guidance on Human Genetic Testing Services and recently conducted a review of genetic services supplied to the public. This included consultation with a variety of different stakeholders (Human Genetics Commission <http://www.hgc.gov.uk/genesdirect/>).

A written consultation document and a formal submission process was combined with evidence gathering meetings with key groups and individuals, consumer organisations and “the wider public” to produce *Genes Direct* in March 2003. Public involvement included:

- Public meetings
- Focus groups
- An Internet based survey
- The Democs process. http://www.neweconomics.org/gen/participation_democs.aspx

This consultation process is complemented by the Royal Society National Forum for Science 2003 which focused on Genetic Testing – Which Way Forward? – The People’s Science Summit (<http://www.royalsoc.ac.uk/templates/scienceinsociety/>). The UK government has also recently released the white paper for discussion entitled, *Our Inheritance, Our Future: Realising the potential of genetics in the NHS* (Department of Health, 2003). All these initiatives indicate that governments and science organisations are recognizing the need for public engagement with health applications of genetics, and not just the production of genetically modified food and fibre. However, these documents often display a high level of advocacy for genetic science relative to open-ended discussion of alternative positions on the implications of genetic science.

British Association for the Advancement of Science Proposals

Challenges of assessing how science is meeting the needs of the public have also been addressed by the British Association for the Advancement of Science in their recent *Science in Society* paper for the UK Office of Science and Technology. The British Association were invited to propose how the government could monitor what scientific activities were taking place, whether they were meeting the needs of the public, and how best to coordinate the efforts of scientists. They consulted “a wide range of people” using a web-based questionnaire and half-day meetings. Recommendations included:

- Establishing an activities database that mapped science activities.
 - Regular national public surveys to establish an understanding of public interest and needs.
 - A needs analysis to identify needs and gaps.
 - An evaluation of activities.
 - Special group research to look at disadvantaged groups with the aim of understanding how best to engage them in science related activities.
 - Media monitoring.
 - A providers’ forum where organizers and funders can meet to collaborate.
 - A networking fund that facilitates networking between funders and providers.
- (British Association for the Advancement of Science, 2000 <http://www.britassoc.org.uk>).

European initiatives

The Commission of the European Communities has argued that to date there has been an “unspoken contract” between institutions responsible for science, such as governments, universities and industry and the public, but that now, because of the increased impact of science in socio-political life, new relationships are needed. It has identified the need to “implement research policy around the real aims of society and fully involve society in seeing through the research agenda” (Commission of the European Communities, 2000: 5). The Commission argues that questions about the relationship between science, society and the public are among the most complex facing society because of their technical nature, the uncertainties involved, and the “know-how” needed to deal with them and their diffuse features. Questions raised include:

- How to manage risks
- The implications of the precautionary principle
- Ethical issues and consequences
- What is needed for dialogue between science and society.

Science, society and the citizen in Europe advocates the need for a consistent approach by European countries and the possibilities of fruitful dialogue between European nations and those in other parts of the world. The *Science and Society Action Plan* of the European Communities (European Commission, 2002) sets out a series of strategies that European states can use to engage people with science and technology issues. It articulates the goal of active citizenship “so that it is society itself that governs which scientific choices are made and controls their impact” (European Commission, 2002: 6). This work has been extended by the development of specific strategies relating to life sciences and biotechnology that includes providing “an adequate forum for promoting an open and transparent dialogue between all the stakeholders concerned” (Commission of the European Communities, 2003: 19). The Commission recognizes that the economic stakeholders and interests involved in the production of GM-crops extend beyond national frontiers and that governing innovation in this field requires attention to global rules and principles.

The European Commission Action plan refers to the Eurobarometer Survey of European Attitudes to Science that provided evidence that Europeans were both hopeful about the power of science to cure cancer and AIDS, but were also concerned about the negative impact on people's lives of scientific and technological innovation (Eurobarometer, 2001). The Action Plan argues that it is necessary to “strengthen the ethical basis of scientific and technological practices, to detect and assess the risks inherent in progress, and to manage them responsibly on the basis of past experience (European Commission, 2002: 8).

The European Participatory Technology Assessment project (EUROPTA) was carried out between 1998 and 1999 in six partner countries – Denmark, Germany, the United Kingdom, Holland, Austria and Switzerland (EUROPTA, 2000). The purpose was the development of participatory technology assessment practices that could be used to support public involvement in discussion and decision-making about science and technology. While the focus was on detailed cross-national comparison of sixteen different attempts at participatory technology assessment, the project also involved holding two international conferences directed at furthering information about this form of technology assessment. The EUROPTA study was funded by the European Commission and coordinated by the Danish Board of Technology.

While there had been some experimentation with participatory technology assessment before this study was done, there was a lack of theoretical and empirical work and a need to establish some frameworks to underpin action. The key aim of technology assessment strategies is to involve a range of members of the public, key stakeholders, policy makers, scientists, and others with relevant expertise in the process of assessing the impacts of particular technologies. It is seen as part of a wider move across a range of different sectors towards more interactive policy processes.

Canadian Initiatives

The Canadian Federal Government, like many contemporary nation states, has committed itself to making Canada “a responsible world leader in biotechnology” (Ontario Public Health Association, 2001: 7). It has also recognized its responsibility to monitor the purpose, use and regulation of biotechnologies and created the Canadian Biotechnology Advisory Committee (CBAC) to enhance public participation in the decision-making processes associated with regulation of biotechnology and its commercialization.

The CBAC has particular responsibility to explore the social, ethical, economic, health and environmental issues associated with new biotechnologies. It conducts public fora directed at ensuring that interested Canadians can share their views on current and emerging issues. Topics that have been explored in these fora are genetically modified foods, ethics, patents, genetic privacy. This governmental advisory committee interacts with the non-governmental organisations active in this area such as Greenpeace, Friends of the Earth, the Council of Canadians and the Canadian Institute of Environmental Law and Policy (CIELAP). Some of these NGOs have questioned the advisory committee's independence, while it remains located in Industry Canada with its links to the commercial biotechnology sector (Breckenridge and Hoepfel, 2003: 37).

Australian initiatives

The Australian Government set up the Australian Biotechnology Advisory Council (ABAC) in 2001, following the launching of its National Biotechnology Strategy in July 2000 (National Biotechnology Strategy for Australia, 2000). This Council is charged with consultation with a variety of organisations and with developing public consultation processes. These initiatives were preceded by the First Australian Consensus Conference on Gene Technology in the Food Chain held in Canberra by the Australian Consumers' Association (McKay, 1999). This consensus conference followed the Scandinavian model of the selection of 14 "lay" panel members, briefings on the issues, question posing, interaction with "experts" and then deliberation. In this case the panel was supported by a "Steering Committee" who chose an "interactive" rather than "neutral" facilitator for interactions between the panel and the experts who answered their questions. The website Gene Technology in Australia is an excellent source of information about these initiatives. (See <http://www.genetech.csiro.au/>)

Australia has also used the Café Scientifique model pioneered in Europe to engage the public in discussions with scientists. (See <http://www.cafescientific.com.au/home.htm>) Those involved in this initiative hold public fora in a variety of settings in which scientists and other members of the public discuss scientific issues. It is associated with a website providing linkages to other European and UK based sites. This is complemented by the work of the NGO, Science Now, which holds a four-day national forum in Science Week, combining the media, scientists and members of the public in debate about science. They run a competition to identify "exciting" new scientists and support organisations that want to stage sessions during the forum.

New Zealand initiatives

The Royal Commission on Genetic Modification (RCGM), which reported in 2001, was the most significant effort in recent years to involve diverse stakeholders in the process of shaping science and technology policy. In 2000 the Commission conducted scoping meetings as well as public meetings in different parts of the country (15 cities or regional towns), and provided an online participation mechanism. It also received written submissions and conducted formal hearings with individuals and organisations granted Interested Person status (RCGM, 2001, Appendix 1: 109-55; RCGM, 2001, Appendix 2: 13 – 23). Hui were held throughout the North and South Islands to facilitate Maori participation in the Commission process, and a public opinion survey was also conducted (RGGM, 2001, Appendix 3). While there has been debate about the extent to which the findings of the Commission were shaped by public submissions, this consultation process was in itself a significant experiment in participatory strategies in relation to science and technology policy development. It attracted international as well as local media attention.

The Royal Commission concluded that New Zealand should "keep its options open" with respect to genetic modification - the major theme of the report was "preserving opportunities" and advocacy for the coexistence of all forms of agriculture (Report of the RCGM, 2001: 2-3). The Commission recognized that debate about GM in the New Zealand context is unique in the international context because of the partnership between tangata whenua and the Crown articulated in the Treaty of Waitangi. The RCGM recognised that current regulatory agencies were not equipped to address ethical and cultural objections to GM, including Maori concerns about GM, and recommended the setting up of the Bioethics Council – Toi te Taiao – to address the ethical, cultural and spiritual issues associated with new biotechnologies. Toi te Taiao has now been established, and is currently developing a work programme that will create a variety of opportunities for public engagement with controversial science and technology issues (Ministry for the Environment, 2003; Bioethics Council - Toi te Taiao, 2003). Toi te Taiao has stated that: "Governments, academics and other commentators in New Zealand and internationally have recognized that a country's citizens have a role to play in decision-making about whether to implement certain technologies. Such decisions cannot be left to governments, business, scientists and technologists alone" (Bioethics Council, 2003).

The Royal Commission on Genetic Modification also recommended that the Ministry of Research, Science & Technology “develop on a consultative basis a medium- and long-term biotechnology strategy for New Zealand” (Report of the Royal Commission on Genetic Modification, 2001: 360). This has led to the production of the *New Zealand Biotechnology Strategy Public Discussion Paper* (MoRST, 2002c) and the *New Zealand Biotechnology Strategy: A Foundation for Development with Care* (MoRST, 2003). The discussion document was distributed as hard copy in October 2002 and was available on the MoRST website. There were opportunities for both online and hardcopy submission on the discussion paper, and focus groups were also conducted with people experiencing different life stages, ethnicities, locations and social circumstances. The development of this strategy has in some respects continued forms of consultation with the public that were a component of the RCGM.

The final version of the New Zealand Biotechnology Strategy has a major focus on community engagement with biotechnology, future watch and consideration of cultural, ethical and spiritual issues (MoRST, 2003: 10 – 14). Discussion includes attention to amendments to the Hazardous Substances and New Organisms Act that support consideration of cultural, ethical and spiritual matters and extends the Ministerial call-in powers to include these matters. It highlights amendments to the HSNO Act that attend to the Treaty of Waitangi and recognise the value of Treaty and tikanga knowledge when appointing members to the Environmental Risk Management Authority Board.

One of the objectives of the Biotechnology Strategy is to “promote active engagement and dialogue between researchers and developers and different groups in the community, to enable New Zealanders to contribute to biotechnology directions in New Zealand” (MoRST, 2003: 10). The Science and Technology Dialogue Fund administered by MoRST funds four projects explicitly directed at meeting this goal. It is consistent with the international initiatives identified above (MoRST, 2002b).

A key issue identified in a number of recent publications on biotechnology strategy is the tension between encouraging innovation and the uptake of new science and technology and the requirements of regulation and community participation in decision-making. The New Zealand Biotechnology Strategy has three goals:

- Building understanding about biotechnology and constructive engagement between people in the community and the biotechnology sector.
- Growing New Zealand’s biotechnology sector to enhance economic and community benefits.
- Managing the development and introduction of new biotechnologies with a regulatory system that provides robust safeguards and allows innovation.

The Biotechnology Task Force report, *Growing the Biotechnology Sector in New Zealand* identifies the compliance costs and delays associated with public consultation and the prescriptive and time consuming aspects of the current regulatory system (Biotechnology Task Force, 2003: 7). This suggests that there will be a need for ongoing negotiation about the ways in which innovation, consultation and regulation can be combined.

The Ministry of Research, Science and Technology (MoRST) has coordinated the development of the New Zealand Biotechnology Strategy and the consultative processes associated with its development. It has increasingly demonstrated a commitment to initiatives associated with public understanding of science (MoRST, 2001, 2002a, 2002b). One of these initiatives was commissioning the *Commonsense, Trust and Science* project – an inquiry into public perceptions of science by the New Zealand Council for Educational Research (NZCER) in association with ACNeilson. This research combined a social survey and analysis of in-depth discussion in small focus groups. It builds on similar research carried out in the UK and describes similar categories of public responses to science. The survey participants were variously categorized as: “Confident Science Believers”, “Educated Cynics”, “Concerned Science Supporters”, “Confused and Suspicious”, “Uninformed Individualists” and “Left Behind” (Hipkins et al, 2001: 1-2). The characterization of these categories of responses to science may be challenged, but what they illustrate is the different responses of New

Zealanders to science and technology issues. They also suggest the need for diverse initiatives, if members of the public are to be engaged in debates about science.

A recent New Zealand contribution to public discussion about science and technology is *Illuminated or blinded by science? A discussion paper on the role of science in environmental policy and decision-making* produced by the Office of the Parliamentary Commissioner for the Environment (2003). The aim of this discussion paper is to enhance government policy on environmental issues and reflect on the role of science-derived knowledge. It recognizes that scientific developments can have both negative and positive impacts. Negative impacts that are listed include developments that have impacted on climate change, ozone depletion, threats to biodiversity and resource depletion. Positive impacts listed include science that has assisted in managing the marine environment, controlling possums and managing biosecurity risks to the environment. It recognizes that policy is often made under time constraints and that decisions can potentially have irreversible consequences. It seeks feedback from those in the public with an interest and background in enhancing the interface between science and policy/decision-making (Office of the Parliamentary Commissioner for the Environment, 2003).

Many of the initiatives by government to involve the public in discussion of new technologies have involved the preparation of written submissions either via hard copy or websites. Often, as in the case of the Royal Commission on Genetic Modification, public participation involves a formal hearing in which presenters are subject to cross-examination. The current dialogue initiatives funded through the Science and Technology Dialogue Fund provide alternative ways for members of the public to talk with a range of stakeholders about their positive and critical responses to the use of new technologies. These projects focus on dialogue, listening and synergy, rather than formal presentation and challenges to argument and evidence. They contribute to the widening of a range of potential forms of public engagement with science that are now being pioneered internationally. Assessment of the outcomes of these experiments in engagement with science will be available to a range of stakeholders in the next few years as they meet to talk about the overlapping and different interests in these forms of innovation.

Maori and Science

Introduction

Discussions about the Maori–science interface over the last few decades have touched on a broad array of issues and, whilst they have been heated and controversial at times, positive outcomes and initiatives have often been achieved. An understanding of the Maori-science interface requires attention to Maori and other indigenous peoples' experiences of colonisation. This is necessary to gain full understanding and appreciation of the relevance and importance of factors such as Treaty of Waitangi responsibilities and philosophical debates around the nature of science itself and mātāuranga Maori (Augustine, 1997; Dickinson, 1996; Posey, 1995).

It is equally imperative to recognise the influence of a global indigenous renaissance that has demanded more accountability from scientific institutions and researchers. Indigenous peoples now promote zero tolerance of the abuse of indigenous languages, cultures and resources that happened in the past. Notwithstanding that these past experiences resulted in poor outcomes, or no outcomes at all, for Maori, progress has been made through the work of numerous dedicated individuals in the science sector within Aotearoa New Zealand, both Maori and non-Maori.

Also impacting on relationships between Maori and science are current political and social trends and policy directives. Such directives have increased over recent times with moves from science research funders, government and international players for science, researchers and institutions to be more responsive to Maori needs. Understanding these broader issues and influences and how they impact on the science Maori interface will greatly assist Maori and scientists alike to engage in more effective and fruitful dialogue.

Key issues and influences

Knowledge of the diverse influences, pressures, and trends impacting on the Maori -science interface is vital for understanding and effectively addressing issues which may hinder good dialogue. These include:

- Increasing global awareness of the importance of indigenous languages and cultures for complementing science in the conservation and utilisation of biodiversity.
- Increased awareness of the Treaty, and its status as a founding document for NZ Society, including an increased awareness in the science sector and at the very least an acceptance that Maori and the Treaty can not be ignored.
- Increased capacity and willingness by iwi Maori to engage with scientific institutions at multiple levels.
- Increased willingness and capacity of iwi Maori in moving to develop linkages and research collaborations with scientists and to lead research themselves.
- Policy directives and commitments to increase Maori participation in science by government, scientists, institutions, and committed Maori and non-Maori.
- Maori and other indigenous peoples have been over consulted and researched and are therefore wary of science institutions and researchers as a result of a long history of gaining little or no benefits from engaging in science research projects.
- Maori are wary and suspicious of consultation processes as their views have often been dismissed as irrelevant or outweighed by the “public interest” in the past.
- Continued debate and diversity of views over the relationship between Mātāuranga Maori and science i.e. are these two knowledge systems reconcilable?
- Increasing numbers of Maori Scientists and non-Maori scientists interested and committed to working with Maori to improve science responsiveness.
- Continued struggles by many science institutions to come to grips with Treaty of Waitangi obligations and other complex issues such as Maori community and iwi dynamics.

- Science research funders and regulators demand that science institutions and individuals be more accountable to Maori and the Treaty.
- Maori and other indigenous peoples globally becoming more aware and active in the area of protecting their cultural heritage and awareness of the inability of intellectual property rights to protect their interests in biodiversity.
- The significant impact of the debates around genetic modification and the Royal Commission and ERMA processes on the science-Maori interface.

Whilst there are other key influences impacting on the Maori-science interface, it is beyond the scope of this paper to provide an in depth coverage of all the issues. Instead the above provides valuable insights into the context in which relationships between Maori and science develop. However, genetic engineering (GE) biotechnology is worthy of closer scrutiny, as it is one of the most significant issues that has impacted on these relationships and has often forced scientists to interface with Maori where they may not have done so in the past.

For over a decade Maori, and other indigenous peoples, have raised concerns about the misappropriation of indigenous knowledge and biological genetic resources by biotechnology companies. In 1991, such concerns culminated in the lodging of the well known WAI262 indigenous flora and fauna claim which argues that the Crown failed to protect the rangatiratanga of Maori over both their cultural heritage, including genetic resources and the cultural knowledge linked to those resources. The concerns Maori have are often globally reflected in those of indigenous peoples, and generally relate to:

- The use of indigenous knowledge by researchers to access flora and fauna that may be useful for developing biotechnological inventions.
- The lack of consultation with Maori over the development of these inventions.
- The lack of benefits for Maori as a result of these inventions (e.g. monetary benefits, transfer of technology and skills).
- The inability of intellectual property laws to protect Maori knowledge in indigenous flora and fauna, whilst the same laws provide foreign corporations with the tools to increase their profits and exploit indigenous peoples' heritage.
- The potential loss of control over indigenous knowledge, genetic resources, and the future well-being of Maori to transnationals.
- Objections to Western market based approaches that promote the commodification of biodiversity resulting in the loss of genetic diversity.
- Objections to genetic engineering as breaching tikanga Maori, causing moral or spiritual offence (Tipene-Matua, 2000).

Maori have called for clear information and time to debate these issues so informed decisions about GE can be made. The establishment of ERMA and the increased profile of GE as a national issue meant that Maori had to be informed and formulate responses to either specific applications to develop GMOs or to GE generally. Whilst these issues have meant that Maori have to come up to speed on often complex science, it has also meant that scientists have had to come to grips with equally complex Maori issues and processes. Important lessons from the GE experience can be learned about doing good dialogue regardless of the fact that the debate is polarised and often dominated by anti-science sentiments.

Some indigenous people have articulated their concerns about the impact of western science and technology in this way:

Since the beginnings of the technological juggernaut the only consistent opposition has come from land based native peoples. Rooted in an alternative view of the planet Indians, Islanders, and peoples of the north remain our most clear minded critics. They are also our most direct victims... (Mander, 1991:195).

Scientific and technological advances this century place the plight of indigenous peoples and other marginalised and oppressed groups at extreme risk in the next century....The mix of science, cultural arrogance, and political power continues to present a serious threat for indigenous peoples (Smith, 1998: 15).

These statements reflect the often negative views and perceptions that Maori and other indigenous peoples have of modern science and technology. Such views might be rooted in Maori concerns about GE or they may be influenced by past experiences of being ignored or deemed irrelevant to the science sector. Whatever the motivations, it is clear that these issues will continue to have a significant impact on the Maori-science interface. However, there are also numerous positive developments and relationships between Maori and scientific institutions around the country which should be celebrated, particularly in light of some of the polarised perspectives around the impact of science, technology and economics on Maori and other indigenous peoples globally.

At present there is only one Crown Research Institute that has not established a position within their organisation (usually in management) dealing specifically with increasing responsiveness to Maori. The recent emergence of a group consisting of Maori working across CRIs (MACRI) has the potential to influence the Maori-science interface and is likely to impact significantly on this sector in future.

Similarly, the resurgence of NAMMSAT (National Association of Maori Mathematicians, Scientists & Technologists) is also a potentially significant development. NAMMSAT is a collective of Maori who support increased participation and achievement by Maori in the fields of mathematics, science, technology and engineering. The organisation was established in 1994, with the majority of members themselves being Maori who specialized in these fields. Successful past achievements include national conferences, science camps and a network of Maori practitioners within all fields of mathematics, science and technology. The NAMMSAT ki Waitaha (Canterbury Division of NAMMSAT) have elected a regional co-ordinator and are planning a Maori Research Symposium – Language Culture and People - in October 2004 at the Christchurch Polytechnic Institute of Technology.

NAMMSAT has identified key priorities for the advancement of Maori and Maori values in the contemporary scientific arena:

- To reconsider the definition of science, particularly when considering Maori science and the science of other indigenous peoples.
- The value of Maori contributions to New Zealand Science.
- Increased Maori participation to ensure Maori have control over their own resources and development.
- The importance of Maori scientists who are able to work alongside and understand whanau, hapu, and iwi needs and aspirations (Office of the Parliamentary Commissioner for the Environment, 1998).

NAMMSAT has focussed on science education in the past and stressed the need to make science more accessible to Maori students. An inclusive curriculum in science provides opportunities for Maori students to:

- Learn science that they, their peers, their teachers, their whānau, and the wider community value.
- Learn science through the medium of te reo Maori.
- Learn science which acknowledges and values Maori scientific knowledge.
- Develop scientific concepts within Maori contexts.
- Use their preferred learning and communication styles, such as co-operative learning and holistic approaches; and have oral contributions recognised for both learning and assessment purposes.
- Interact in an environment where the language and resource materials used are non-racist.
- Use a wide range of resources in te reo Maori.
- Have access to positive Maori role models, including Maori teachers, in their science programme (http://www.tki.org.nz/r/science/curriculum/p14_e.php)

Regulators and funders of science research (such as FRST, HRC, and ERMA) are now demanding that the science community be more responsive to Maori at multiple levels. For example, the Maori Development portfolio at the Foundation for Research Science and Technology promotes an increased focus on delivery of outcomes for Maori and increasing research by Maori and the development of Maori research provider capability (FRST Website, 2003).

Increased demands for science to be responsive to Maori developmental needs are likely to continue to be made by government decision makers, research funders and regulators as well as Maori themselves. This provides incentives for scientists and technologists to embark on serious and meaningful dialogue with Maori and investigate better ways of having these discussions. If there is a serious will to include Maori in science decisions and develop mutually beneficial projects and initiatives, effective dialogue will follow.

Sustainability and 'sustainability science'

Towards dialogue from "development"

The need for new approaches to environmental policy and natural resource management has emerged in line with the evolving concept of 'sustainable development'. Over the past three decades, "development theorizing has progressed beyond economic parameters based on gross domestic product (GDP) per capita growth, and even the conventional social indicators of literacy, life expectancy and caloric intake ... interventionist frameworks now regularly include such dimensions as sustainable environmental practices, gender equity, respect for human rights and participatory governance (Beemans, 1996). Similarly, while conventional approaches to support industry have in the past tended to employ narrow economic or productivity criteria to measure their success, today the questions have been broadened to simultaneously evaluate the health of relevant systems in terms of ecology, ethics and equity (e.g. Dahlberg, 1991).

These major changes in the way the issues of economic growth, human development and environmental protection are approached can be highlighted through the outcomes of two major United Nations conferences. The Conference on the Human Environment, held in Stockholm in 1972, provided the first major discussion of environmental issues at international level. The subsequent increase in public awareness and understanding of the fragility of the environment was one of the most successful outcomes from Stockholm. However, while it succeeded in placing environmental concerns on the international political agenda, the environment still remained a marginal issue. In particular, little was done to give practical effect to the integration of environment and development in economic policy and decision-making, and the health of the planet continued to deteriorate at an unprecedented rate (Wynberg, 1993:1).

The second major discussion of environmental issues at international level occurred at the United Nations Conference on Environment and Development (UNCED), held at Rio de Janeiro in 1992. Where Stockholm adopted an issue-oriented approach to pollution and non-renewable resource depletion, Rio emphasised integrated strategies to promote human development through economic growth based on sustainable management of the natural resource base (Report of the Secretary-General, United Nations, 1997). It is true that given its ambitious agenda, UNCED may not have achieved all that was hoped for, but among its successes is the recognition of mutual interdependence of North and South, as well as the clear acknowledgement that the causes of environmental decay are more significant than the effects (Wynberg, 1993:4). New pathways were opened for public participation in intergovernmental communications, allowing for increased communication and cooperation between governmental and non-governmental organisations. Indeed, Rio provided clear roles and responsibilities for all sections of society, with the recurring message that "real change is most likely to come with the involvement of ordinary people" (Wynberg, 1993: 1).

Agenda 21, the action plan emerging from the UNCED process, represents a statement of willingness to strive for a form of development that recognises the linkages between economic growth, social equity and protection of the environment. This agenda clearly identifies 'information', 'integration', and 'participation' as key building blocks to help countries achieve development that recognises these interacting factors. It emphasises that in sustainable development everyone is a user and provider of information. It stresses the need to change from old sector-centred ways of doing business to new approaches that involve cross-sectoral coordination and the integration of environmental concerns into all development processes. Furthermore, Agenda 21 emphasises that broad public participation in decision making is a fundamental prerequisite for achieving sustainable development.

Towards changing extension practices (agricultural science)

For most of this century, the related concepts of extension and technology/information transfer in relation to land and water management have been used to refer to a straightforward process of reaching out to users with new knowledge or products developed through science. Success was measured largely in terms of increased production or productivity. The dominant metaphors are those of information transfer, technology transfer, channels of communication, and education.

This approach is highly successful where a problem has a clearly identifiable end-user (be it an individual enterprise, agency, or industry sector) who acknowledges ownership of the problem, has the capability to fit the research findings/products into their wider organisational management system, and the resources and mandate to act on the solution. In these cases, the findings and products developed from scientific research are readily adopted by end-users, and can be clearly seen to 'make a difference' to their management system. Often too, the required research innovation can be regarded as commercial (i.e. its application will improve productivity or cost-effectiveness in the short-term), and the end-user will have a clear idea of the value of the innovation to their management system.

This approach to extending the results of science underpinned the rural economy until 1984. Prior to 1984, the agricultural extension service, formerly known as the Farm Advisory Division and latterly, the Advisory Services Division, saw its role as the provision of technical and farm management advice to all farmers and growers. This was achieved through discussion groups, seminars, articles, radio talks, field trials, field days, as well as direct one-to-one interactions – all provided on a non-chargeable basis. This service was largely based on extending knowledge and technologies available to enhance production and economic gain.

Over the past two decades, the challenges facing landowners and resource managers have multiplied. Where once rural agricultural and horticultural environments were viewed as single-sector-oriented productive landscapes, they now face demands by new players – such as those voicing their views on landscape, recreation, conservation, tourism, life-style residential development and expecting to be heard (Cloke et al, forthcoming). Furthermore sustainable development operates at a range of scales involving decisions made at grassroots, local, regional and national levels.

This change to sustainability has been accompanied by a number of large changes in institutional context in which our lands and waters are managed, researched and supported. During the period 1984 – 2003 three things happened:

- Liberalised economy, removal of subsidies, restructuring of R&D. The transfer of research innovations was felt to be private good, with public good overlapping and devolved to consultants and primary firms.
- CRIs developed and while they are obliged to provide evidence of beneficial outcomes of their work to secure PGSF funding, they are not funded to undertake direct extension work. Furthermore, as commercial entities, there is pressure to market intellectual property profitably where possible.
- Major changes in field of environmental management with Resource Management Act, and Regional Councils implementing programmes to support their new mandates as resource management agencies

Solving problems associated with sustainable development is *not* just about changing the behaviour of individual landowners, but about seeking new ways of thinking about systems, neighbours and whole-farm planning. While landowners may make the ultimate decisions 'on-the-ground', others play an active role in creating the context (positive or negative) that enables sustainable development to happen. Consequently, sustainable development extension is about engaging stakeholders (including agencies, iwi, science, landowners, public interest groups) in the process of learning and adaptive management and about negotiating how to move forward in a complex world, where we do not have all the information we would like.

Sustainability science today – towards dialogue

In a radio broadcast in Australia in June 2001, Ian Lowe (Honorary Professor in the Department of Science at Griffith University and winner of the individual nomination in the Australian Prime Minister's Environment awards 2000) talked in some depth of the new field of science he termed "sustainability science". The essence of the kind of science he was referring to lies in the recognition of several core principles. These are integration, cyclic forms of inquiry, social learning, whereby the role of science generated knowledge is one relevant element within problem systems, and scientists are not just independent information providers outside the nature-society complex (Lowe, 2001). In New Zealand, this concept fits well with the culture of accountability in science and the concerns of science policy makers and funding agencies, who are placing increasing pressure on the science community to provide evidence of relationships with stakeholders.

Ian Lowe's talk highlighted the importance of integration by referencing the failures of solving complex environmental problems to "piecemeal efforts that focused on one aspect of the problem to the exclusion of other equally important aspects". He concluded "...great damage can be done by applying narrow specialised knowledge without an appreciation of the complexity of natural systems" (Lowe, 2001). However, while the notion of integration may be intellectually appealing, there is no doubt about the challenges it presents to a science community with culturally entrenched views on intellectual property rights, very real communication barriers between disciplines and, a funding environment that rewards individual science effort rather than collective endeavour.

Traditional forms of science inquiry operate in a linear fashion, beginning with problem definition, and moving through data collection, theory building and the application of results. Even in a perfect funding environment that might allow for the full exploration of these stages without the pressure of having 'one shot' at the answer, this approach falls into difficulties when dealing with complex environmental problems that include non-sequential events, long time delays between actions and consequences, and cumulative and threshold effects (Freiberg workshop 2000). Within these 'problem' systems, decisions are being taken all the time with the imperfect information available to managers, policy makers and landowners etc, and effects are being observed, largely independently of the research that may be underway regarding that system. What is needed is a form of research and knowledge development that incorporates both data gathering and analysis alongside ways of learning based on adaptive management, action and policy as experiment (ibid).

In contrast to the historically popular standpoint that there is a linear relationship between research and subsequent interventions, observations indicate that within the complexity of environmental problems, information is interpreted and "made sense of" through the lens of the contexts that individual stakeholders apply to any given situation. Ultimately to resolve these complex environmental problems, scientists, communities, and policy makers need collaborative approaches that accommodate multiple perspectives and utilise multiple sources of information (Allen & Kilvington, 1999)

The challenge then, for nurturing this new way of doing science, is to facilitate processes by which science can enter the dialogue of complex problems, not as the independent expert, but as the peer inquirer – ready to combine, without discrimination, the tools of synthesis, analysis, model building and explanation with those of direct experience, and contextualised learning. This is the challenge of forming new ways of creating dialogue and collaboration with new audiences.

Barriers to dialogue

Over the last ten years New Zealand research institutions have come under increasing pressure from the principal government research funder to provide evidence that results of research are taken up and made valuable to stakeholders in resolving environmental problems. This in itself is a substantial pressure to improve pathways by which science can dialogue in new ways and contribute to desirable outcomes for society.

In addition there has been some developing uncertainty over the extent of responsibilities of science to influence on-the-ground decisions. In New Zealand the roles of science research and management are held quite distinct and only overlap in situations of specific contract where management agencies (such as the Department of Conservation) commission studies on select aspects of their management remit. Science researchers could be forgiven for assuming their role in seeing the effective use of their work ended where it passed into the hands of a management agency.

Research institutions have largely responded to these change messages by adapting the existing structures of research programmes e.g., by involving stakeholders in approving research directions or setting up panels of stakeholders to manage research programmes. However, such efforts struggle to achieve meaningful shifts in science and stakeholder interrelations.

Efforts to go beyond traditional relationships are hampered by lack of knowledge of the processes to link management and science. This includes confusion around the concept of 'extension'. This traditional form of information relay was based on a view of science and stakeholder relationships as unidirectional processes of information flow. Such 'extension' can only work in situations where the science 'product' is complete in itself, requiring no integration with other forms of knowledge and where the end-user use of the product requires little contextual interpretation. This worked well for production focussed agricultural systems 20 years ago, but is a far cry from the kind of science needed in complex environmental problems posed by the era of sustainability where there are multiple perspectives on the problem and multiple views on the kind of information and action needed to address it.

These confusions and lack of understanding about how to go about dialogue with stakeholders are coupled with an institutional bias against meaningful participation. Systems of reward within science institutions have lagged behind when it comes to creating incentives for scientists to be involved in experimental processes of developing knowledge, particularly when these new ways of working might compromise their ability to perform well in the familiar endeavours of peer review and publication.

Furthermore, the institution of science research itself rests on the idea of the scientist as expert. Scientists hesitate to lay their ideas alongside the untested knowledge created within external learning frameworks – i.e., the farm, or the District Council. In order to do so they face quite legitimate concerns about interpretation, value, misuse, and appropriation of their ideas and information. Equally, of course, other stakeholder groups are also concerned about the same things in relation to their own knowledge. Finally, the research culture and short term funding horizons encourage single cycle research – a 'one-shot approach' to problem solving where the 'answer' emerges from the research without reference to the wider context.

New approaches to dialogue

Understandably the barriers to new approaches to dialogue in science are hard to change. However, efforts are being made. Evidence of this is in the change in the work of the Collaborative Learning for Environmental Management group at Landcare Research. As social researchers, within a fundamentally biophysically oriented research environment the principal call on their expertise (as little as five years ago) was to explain how external groups could be brought to change – "How do we get them to appreciate our (bio-physical) research?" Today a fundamental platform of CLEM is to look at improving the responsiveness of science to end user needs. This work looks at ways to improve linkages and interactions between bio-physical research and end-users and works on opportunities for facilitating collaborative and adaptive management or 'co-discovery' approaches to environmental problems (www.landcareresearch.co.nz/research/social). It involves developing a shared understanding among researchers and those different stakeholder and tangata whenua representatives that they engage with, helping to ensure that the resulting science is most relevant and responsive to end-user needs.

The role of evaluating collaboration between science and the wider community

Work with the issue of collaboration and the role of science in environmental management has highlighted the need for science to change. While the common perception is that change needs to occur 'out there' in society, the most direct path to science having some influence on this is to change its own way of interacting with that society. As with any form of organisational or social change, building the capacity for science to shift direction requires participant ownership and commitment.

Future 'sustainability science' projects will require increasing emphasis on the ability to identify, gain access to, build relationships with, and negotiate roles with different stakeholders. However, currently resource scientists seldom have the skills necessary for communication processes such as entry and contracting with end-users. Skills are also needed to develop and work cooperatively in multi-stakeholder networks. In particular, this requires team skills and better recognition of the importance of power sharing, inter-agency collaboration, and local knowledge.

Using frameworks from what we know or hypothesize to be important elements in dialogue and relationship building social scientists at Landcare Research apply a questioning approach to aspects of research programme development – such as the aspect of communication with stakeholders. This approach in itself requires the development of trust (no one likes to find out they have been doing it wrong). Participatory and formative evaluations of initiatives that have been trialled contribute to a self-improving system of creating dialogue between science and society. Moreover, such initiatives are essentially experiments providing opportunities for practitioners and action researchers to test their knowledge and experience. In this way much can be learnt about fundamental and cross-cutting questions concerning the best way to model science stakeholder dialogue, or to examine more closely the role that sustainability science can play in helping achieve more environmentally sound management. This information, in turn, can be fed back to shape future science directions and programmes.

Dialogue Strategies: Emerging issues

This working paper reviewed international and national literature as well as web-sites relating to new practices for engaging with the public in decisions about what science is carried out, how it is carried out, and how to manage the impacts of scientific and technological change. These initiatives have arisen in the context of rapid technological development, which, to some extent, has outstripped knowledge about the social, ethical and cultural implications of these changes (Gregory and Miller, 1998; Jagtenberg 1983). There has also been debate about how to promote participatory approaches to government decision making, whether at international, national or local levels (Boston, 1996; Forgie et al, 1999). For example, the Commission of the European Communities has identified the need to 'join up' policy decisions and develop common goals around science (Commission of the European Communities 2003). This has been driven, in part, by the recognition that economic gain depends upon the production of new knowledge, and the need to ensure future generations are attracted to science as a means of generating this new knowledge – an issue relevant to other countries, including New Zealand (Parliamentary Commissioner for the Environment, 2003). To a large extent, the debates and initiatives now in the public arena represent an attempt to deal with perceived challenges to the legitimacy of scientific and technological knowledge production and use, as well as related political decision-making (Barnes et al, 1996; Fuchs, 1992).

One of the major tensions underpinning the trend for increased public participation relates to uncertainty of science, especially in the absence of discussion about social, ethical and cultural impacts (Elam and Bertilsson, 2002; Joss and Durant, 1995, Smith 1998). Additionally, access to the Internet (and other media) has provided many members of the public with varied information, leading to a more questioning society. One of the ways in which uncertainty has been reframed by the public, and scientific and governmental institutions, is through the concepts of risk assessment and management (Dew, 1999; Parliamentary Commissioner for the Environment, 2000). Allied to these concepts is the need for integrating the social, economic and environmental outcomes of science research. Privileging economic outcomes over environmental sustainability, for example, poses both short and long term risks to environmental sustainability.

As the section on Sustainability Science has illustrated, land-owners and resource managers are facing complex and multiple challenges, as productive uses of the environment compete with the needs of different ethnic groups, conservationists, and those who use the environment for recreational activities or for residential life-style developments (Cloke et al, forthcoming). The essence of sustainability science centres on several key principles, which can be summarised as a need for an integrative and interrelated approach to science, policy and land use. This more participative approach means finding alternatives to a linear transfer of knowledge such as from 'expert' to policy maker to land user. Research funding in New Zealand, and elsewhere, has demanded 'end-user' input into scientific agendas, and already this is beginning to change what and how science gets done. The 'extension' model of sustainability science recognises that where there are complex environmental issues to be resolved these are interpreted through the context-driven experiences of individuals and stakeholder groups (Allen and Kilvington, 1999). Thus dialogue, or participatory research, requires an understanding of how different contextual lenses impact upon definitions of problems and solutions.

The section on *Sustainability Science* also draws attention to institutional constraints for a more inclusive science, whereby traditional systems of reward are tied to generating expert knowledge, not its application or dealing with the stickier issues of values and ethics accompanying application of scientific knowledge. Challenges to these traditional divisions, and how past hierarchies of knowledge have operated are occurring on a global scale. This is well illustrated in the section *Maori and Science*.

The findings uncovered by social researchers working with research programmes to trial new approaches to developing collaborative partnerships are useful in building cross-case-study understanding of the issues and possible solutions to science and stakeholder dialogue. However, much of the learning in this system must come from the reflection and analysis of

the participants within the system. Consequently, one of the challenges of action oriented social research in this arena is to ensure that learning and improving occurs within the systems being researched. Participatory and formative evaluation processes (and as a subset of these, stakeholder analysis) provides opportunities for introducing a selfimproving approach to science practices.

The section on *Maori and Science* introduces the global indigenous resurgence challenging past and present effects of colonisation. Appropriation of indigenous knowledge and biological genetic resources is one example of these effects highlighted in this section (Smith 1998), which focuses on genetic engineering biotechnology as a way of offering insights into the how the science-Maori interface has emerged (Tipene-Matua, 2000). In New Zealand, political and scientific institutions are attempting to enact the obligations of the Treaty of Waitangi. This means that research is to be more responsive to Maori needs, Maori knowledge is to be respected, and there is increasing acceptance that we need to work with different kinds of world views and knowledge, in order to engage in fruitful dialogue. Further evidence of involvement of Maori in research and decision-making is increasing numbers of Maori scientists or advisers in Crown Research Institutes as well as activities of the National Association of Maori Mathematicians, Scientists & Technologists (NAMMSAT) This Maori collective supports increased participation and achievement by Maori in the fields of mathematics, science, technology and engineering. Responsiveness to Maori developmental needs is likely to continue through government decision-makers, research funders and regulators as well as through the efforts of Maori themselves.

One of the key questions arising out of the global trend for increased public participation is how this might be achieved - what kinds of situations or developments require dialogue, who should be involved, and what processes of communication provide meaningful interaction? While there are a number of international policy directives embodying general agreement that a culture of dialogue and involvement is necessary, this movement is also being critically analysed.

In a recent essay on 'From bio to nano and beyond', Willis and Wilsdon reflect on the limits to public dialogue. They look at the way dialogue initiatives may have little connection to parliamentary decision-making or the development of specific policies (Rothstein, 2003). They also question whether dialogue initiatives might "encourage governments to abdicate responsibility for difficult questions?" (Willis and Wilsdon, 2003: 10). They argue for attention to the possibility that consensus will not emerge and that people will retain radically opposed views on the use of new technologies. Governments will still have to make difficult decisions informed by responses from those with diverse world views and with very different interests. There is also the issue of who is involved in the dialogue processes and what constitutes a representative debate.

Willis and Wilsdon conclude that, while decisions have to be made by governments, "greater public involvement can help governments make better decisions, through providing governments with the forms of 'social intelligence' needed to better understand the issue and make an informed decision" (Willis and Wilsdon, 2003: 11). However, the regulation of technologies is often determined globally. It is the European Union or the World Trade Organisation that increasingly set the frameworks within which nation states can engage in decision-making on controversial issues relating to the application of new science. Global debate and dialogue between nation states about the regulation of new science and innovative applications of technologies are crucial components of the context in which local dialogue initiatives are currently being pursued.

Critical reflections on directions with respect to dialogue initiatives are also articulated in a paper produced in 2002 by Elam and Bertilsson for the Science, Technology and Governance in Europe project (STAGE). They argue that public understanding of science initiatives are increasingly focused on implementing "public experiments" in public discussion of science and technology. These "political laboratories" for scientific democracy construct environments in which a new type of scientific citizen is being cultivated. They highlight the need to look critically at who is constructing such citizenship and whose purposes are served by it. They

suggest that deliberative democracy strategies may be a new way to legitimate science and technology in the face of critical engagement by political activists.

Elam and Bertilsson (2002: 17) argue that: "Deliberative democracy is good news because it promises to bring legitimacy and productivity gains to the practice of science communication" and "builds on decision-making on 'rational consensus' rather than 'mere agreement'." Like Chantal Mouffe (1999) and Iris Young (2001) they embrace the need for spaces for the expression of dissent and direct action and make the case for attention to forms of 'radical democracy' that assume differences and conflicts rather than the possibility of consensus on every issue of political controversy. Others such as Fung and Wright have argued that those advocating participatory collaboration in a variety of different contexts have often ignored the unequal power of different sets of actors (Fung and Wright, 2003: 286).

This critical engagement with dialogue strategies is an important context for the work of many social, environmental and biological scientists in Aotearoa/New Zealand and elsewhere who consider that better decisions will be made if citizens who are not expert scientists are involved in discussion about the implications of new technologies. Those involved in dialogue initiatives think that new insights and necessary information will be generated through these processes of participation. Their goal is to access this information, not to legitimate science and contain expressions of difference. On the other hand, it is useful to be reminded that dialogue can easily become 'consultation' that carries with it little decision-making power. In a culture in which innovation is increasingly embraced with enthusiasm, it is also useful to reflect on the ways in which public discussion may not result in the lifting of uncertainty, but a process of coming to know and live with indeterminacy in a context in which science has often been seen as a route to control and certainty.

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