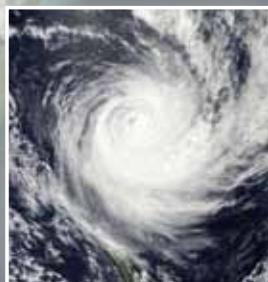**ESR**

Literature Review on Dynamics/Contextual Factors Affecting 'Information for Action' for the Climate Change and Human Health Nexus

Health Analysis & Information For Action (HAIFA)

Virginia Baker, Steven Kelly, Miria Lange, Chris Nokes

Acknowledgements

Disclaimer

Table of Contents

List of Tables

List of Figures

1. Purpose of Literature Review

This literature review aims to develop a robust understanding of the key concepts and factors for supporting 'information for action' with respect to climate change and human health. It is intended that this will help the team in developing the Health Analysis & Information for Action (HAIFA) resource system. Understanding what 'information for action' means for HAIFA requires looking at the dynamics, relationships, activities and components that form the climate change and human health nexus. It also means focusing on the links between knowledge, awareness and action in this context.

'Information for action' is a term commonly used within the data management and health informatics professions. It concerns the importance that data and information gathered and collated in a public health surveillance setting is utilised to inform and support meaningful, practical action. There are questions then of how data and information might be used by professionals themselves, and how it might be utilised by others to support policy planning and coordinated response to a particular issue.

The literature review is intended to support further discussion within the HAIFA team and inform a 'taxonomy' that highlights the critical success factors for 'information for action'. It will also identify barriers that may need to be overcome. This would help identify the key factors/domains/assumptions that may impact on how local planning authorities might utilise information for adaptation to the impacts of climate change on human health. Whilst a taxonomy was sought, the emergent nature of this field suggests that categorisation based on pre-determined factors might not be easily achieved. Rather developing a model could be a more accurate and more useful approach.

Whilst well utilised in professional discourse, there seems to be scant literature that provides a coherent model or unpacks what the term 'information for action' might actually mean. Context is very important, and this literature review aims to identify the component parts and relationships that might form an 'information for action' framework for climate change and human health.

Brief outline of project

The Health Analysis & Information for Action (HAIFA) resource system is designed to provide end-users (professional communities of interest in central, regional and local authorities related to health and the environment) with scientifically robust methods , tools and information to help develop appropriate responses and adaptive strategies that can increase human health resilience to the infectious disease consequences of climate variation and change. The HAIFA team secured four years of funding from the Foundation for Research Science and Technology (FRST) and the Ministry of Science and Innovation for research to develop a 'proof of concept'.

Objective 3 of this work programme aimed to identify the capacity, assumptions and barriers that exist for coordinated adaptive planning between the health and environment sectors, and to better understand two key capacity areas for adaptation responsiveness – *'social capital'* and *'information and communication'*. Several phases of enquiry were undertaken:

1. In-depth interviews with District Health Boards, local and central government, and key stakeholders in a rural area.

2. Development of a vulnerability assessment tool with those involved in managing drinking water.

3. A literature review from the climate change field to unpack the concepts of 'social capital' and 'information and communication' (as well as issues of scale, timing, and coordination mechanisms)

It is the literature review that we present in this report.

Review method

The climate change adaptation planning and human health nexus is an emergent area, so the research on 'information for action' systems specific to this area is sparse. A literature search was undertaken in March 2009, and encompassed other public and environmental health information systems oriented to implementation, adaptive planning for institutional and community-action. From this broader search, items were selected that had relevance to the topic area of climate change and human health. A further review was carried out in March-April 2012, to update this initial review with recent publications since the original was undertaken. Key literature circulated in the HAIFA project team was included, as well as literature from other related projects.

Related New Zealand projects

There are several related projects of relevance to the Objective 3 component of the HAIFA project. Victoria University of Wellington looked at vulnerability and adaptation and we refer to their illustration of dynamics as well as several outputs from their work (see for example Lawrence *et al.* 2011; and Manning *et al.* 2011).

The work completed under ESR's Ministry of Health funded Social Environments (SE) project is also relevant (Lange and Gregor 2009). This project conducted a literature review on 'Climate Change, Human Health and Vulnerability' with a focus on the implications of climate change for urban water supply. Some of that literature is drawn on for this current literature review and we acknowledge Rebecca Craigie, Jan Gregor and the SE project leader Miria Lange. The SE project undertook interviews with key stakeholders in the Taranaki district involved in managing the various aspects of urban water supply, climate change and human health. These included the District Health Board, Taranaki Regional Council, Federated Farmers, an electricity company, New Plymouth District Council, Stratford District Council, Te Tihi Hauora O Taranaki, and the Taranaki Climate Change network.

The output was a resource for health professionals, environmental practitioners and planners with little or no water supply expertise, so that they can plan for the health impacts of climate change and consider water-supply related health issues in Long Term Council Community Plans, health impact assessments and other planning processes. The qualitative data collected for the SE project provides some indication of the relationships, knowledge, attitudes and activities that may form part of an adaptation response.

Structure

This literature review looks firstly at the context and definitions, and introduces several dynamic models that relate to the nexus of climate change and human health. Uncertainty is highlighted as a key feature and potential barrier to adaptation planning. Different terminologies and approaches are discussed with a focus on 'social capital' and 'information and communication' as key components of adaptive capacity for communities and organisations. Then the implications of different institutional characteristics for adaptation planning are discussed, with an emphasis on empirical studies of the local government or environment, and the public health sectors. The section on 'adaptive capacity' explores how concepts extended into working models of how things happen and get done. Finally the process of 'mainstreaming' is addressed with a focus on the implications for HAIFA.

2. Literature Review

Adaptation activities to address climate change-related health risks take place within the context of slowly-changing factors that are partial determinants of the extent of impacts experienced and that are specific to a region or population, including specific population and regional vulnerabilities, social and cultural factors, the built and natural environment, the status of the public health infrastructure, and health and social services. (Ebi 2009, 6)

2.1 Summary and overview

Human health is expected to be affected by climate change in various, complex and interconnected ways. This is reflected in a growing body of literature on adaptation and adaptation planning for climate change, which includes robust debate on a number of core definitions and terms. There is relative consensus in the literature about what the main impacts on human health will be, and also that increased recognition and understanding of these impacts is required by both governments and the general public in order for any policy measures to be effective.

In planning for effective action, there is some debate about the relative emphasis on mitigation or adaptation, with increasing agreement that given the inevitability of climate change, adaptation strategies ought to be key. Thus 'adaptation planning' orients our inquiry into the 'information for action' dynamics for the climate change and human health nexus. Policy-makers require appropriate information, including vulnerability assessments and predictive models to help them prioritise and be guided in the right direction. The problem of how to manage inherent uncertainty is core for those involved in enhancing climate change information. A key problem for policy-makers is how to deal with the uncertainty they are presented with, and how to communicate it to the general public.

The issue of climate change cuts across numerous agencies, regional and local jurisdictions and involves multiple scales and multiple inter-relationships. Different actors within different institutions and professional communities of practice are involved, including policy, academic and applied researchers in the environmental health sector. The roles of different 'communities of practice' and the importance of more effective linkages between academia and policy, as well as global linkages between developing and developed nations is highlighted where initiatives to respond to climate change are inextricably linked and must cut across issues of poverty and equity. Where the climate change and human health issues sit in relation to institutional capacities and jurisdictional activities is important. For instance different priorities, planning mechanisms and sets of assumptions exist in the disaster and emergency preparedness, public health prevention, environmental protection and local government sectors. Whilst there is potential for synergy across, there may equally be risk of disconnection.

For regional responses within the climate change and human health nexus, the relationships and planning activities between local government and local public health authorities are of particular interest. Notions of capacity, planning and preparedness are perhaps quite different in the climate change context than for other interventions for public health. Whilst informatics and surveillance mechanisms are well established in public health, mobilising effective responsive action to climate change may well be less of a priority for the wider health sector.

Climate change is a relatively gradual process. As such, it may be easy for citizens and policy makers to overlook and prioritise more immediate aspects of daily life. Furthermore, the effects are likely to be diffused, and in the case of health, human health effects are distributed across existing disparities, and possibly absorbed by social capital.

Institutional support for climate change adaptation and action planning is fundamental, yet institutions are often slow to change and resources are often mobilised around an immediate crisis. Also responses to climate change will likely require persistent revisiting and concerted action, rather than a once only exercise. A number of papers recognise the importance of 'salience' in mobilising coordinated action across different agencies and sectors. Climate change considerations are unlikely to drive or initiate local government action on their own (Ministry for the Environment 2004, 17). A 'mainstreaming' approach is recommended whereby adaptation to climate change is integrated and anchored in policy mechanisms that are already established to respond to environment and health issues across the different sectors.

2.2 The context: human health impacts from climate change

The range of research covering the human health impacts from climate change is complex and there are a variety of definitions and ways of contextualising and categorising the field, Nonetheless, a growing body of literature identifies a number of risks and likely adverse impacts on human health that are linked to climate change.

A recent *Lancet* published study by Costello *et al.* (2009) provides a comprehensive appraisal of the field in which the authors identify

> 'six aspects that connect climate change to adverse health outcomes: changing patterns of disease and mortality, food, water and sanitation, shelter and human settlements, extreme events, and population and migration' (Costello *et al.* 2009, 1694).

Each of these factors is then 'considered in relation to five key challenges to form a policy response framework: informational, poverty and equity related, technological, socio-political and institutional' (Costello *et al.* 2009, 1694). The authors pursue a theme that 'climate change effects on health will exacerbate inequities between the rich and poor'.

McMichael *et al.* (2006, 860), present a diagrammatic representation of the links between climate and health that provides a widely used framework for illustrating the possible links between climate change and these health impacts:

FIGURE 1: SCHEMATIC SUMMARY OF MAIN PATHWAYS BY WHICH CLIMATE CHANGE AFFECTS POPULATION HEALTH
(This figure was published in: McMichael AJ, Woodruff R, and Hales S. Climate change and human health: present and future risks. The Lancet, 2006; 367: 859-869. Copyright© 2006 Elsevier. All rights reserved.)
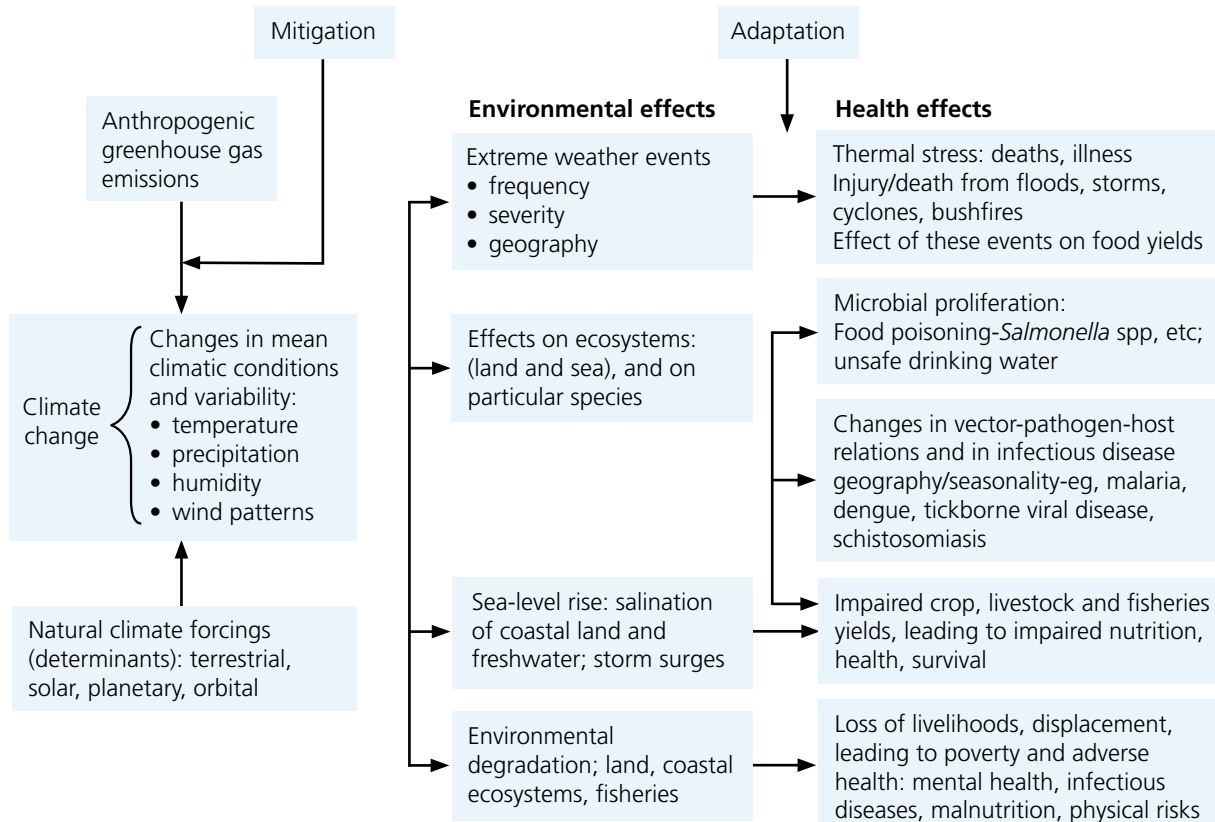
In much of the literature on the health impacts of climate change, several groups in society are repeatedly identified as being more vulnerable than the general population to all types of health issues. Specifically, these groups are identified as the elderly, the young (see Sheffield and Landigren 2011), the poor (Costello *et al.* 2009), the mentally ill, and the immuno-compromised.

There appears to be a trend in the literature towards considering social or socioeconomic vulnerability. Both biophysical and socioeconomic vulnerability are crucial in estimating possible impacts, and they are inextricably linked. Biophysical vulnerability would include factors relating to geography, species distribution and biodiversity. Socioeconomic vulnerability considers factors such as demographics (including population growth and density), infrastructure quality and maintenance, regulatory environments, technological advances, wealth and wealth distribution (Casman *et al.* 2001).

A number of multi-authored studies have identified a common range of possible health impacts, and five main impacts on human health from climate change are expected (Haines *et al.* 2000; Patz *et al.* 2000; Greenough *et al.* 2001; Ebi *et al.* 2006; McMichael *et al.* 2006; Ebi *et al.* 2008). Specifically, these are:

• temperature-related illnesses

• mortality and morbidity as a result of extreme weather events

• air pollution-related illnesses

• vector-borne illnesses

• water-borne and food-borne illnesses

HAIFA Indicator Diseases

The HAIFA project has selected six indicator diseases (encompassing food, water, respiratory, and vector-borne disease) to pilot the development of a web based information system that will support New Zealand authorities in planning and preparing adaptive responses to climate change and human health. The six indicator diseases are:

• Campylobacteriosis

• Cryptosporidiosis

• Neisseria meningococcal infectious disease

• Influenza

• Ross River fever, and

• Dengue fever.

The first four, encompassing food, water and respiratory diseases are found in New Zealand. The last two are overseas mosquito-borne diseases that have been identified as exotic diseases of priority concern to New Zealand.

2.3 Uncertainty

One of the main themes throughout the climate change literature is the issue of uncertainty (see, for example, Patz *et al.* 2000; Adger and Vincent 2005; Ebi *et al.* 2006; McMichael *et al.* 2006; Smit and Wandel 2006; Huang *et al.* 2011). For many of these authors, the inherent uncertainty in predicting the extent of climate change, coupled with how this change will be experienced across a range of scales and by many and varied communities, impacts on the assessment of both human health impacts and vulnerability assessments. The most frequently mentioned sources of uncertainty include:

- uncertainty over appropriate spatial and temporal scales for vulnerability analysis

- uncertainty over the best methods to downscale global projections to regional models

- uncertainty over the biophysical causes and responses (i.e. levels of greenhouse gas emissions and policies that will control emission levels)

- uncertainty over the links between diseases and climate change

- uncertainty over the amount of mitigation effort that will determine the level of climate change

- uncertainty over the existing natural immunity of some regions to new diseases

- uncertainty over the scale at which decision-making should be made (local, regional or national)

There are many more, but these are the most frequently mentioned. In terms of uncertainty, many articles describe the "uncertainty explosion" or 'cascade', a diagram (Figure 2) of which is given below.

FIGURE 2: THE 'UNCERTAINTY EXPLOSION'
(This figure was published in: Adger WN, Vincent K. Uncertainty in adaptive capacity. C. R. Geosci. 2005; 337(4): 399–410. Copyright© 2004 Académie des sciences. Published by Elsevier Masson SAS. All rights reserved.)
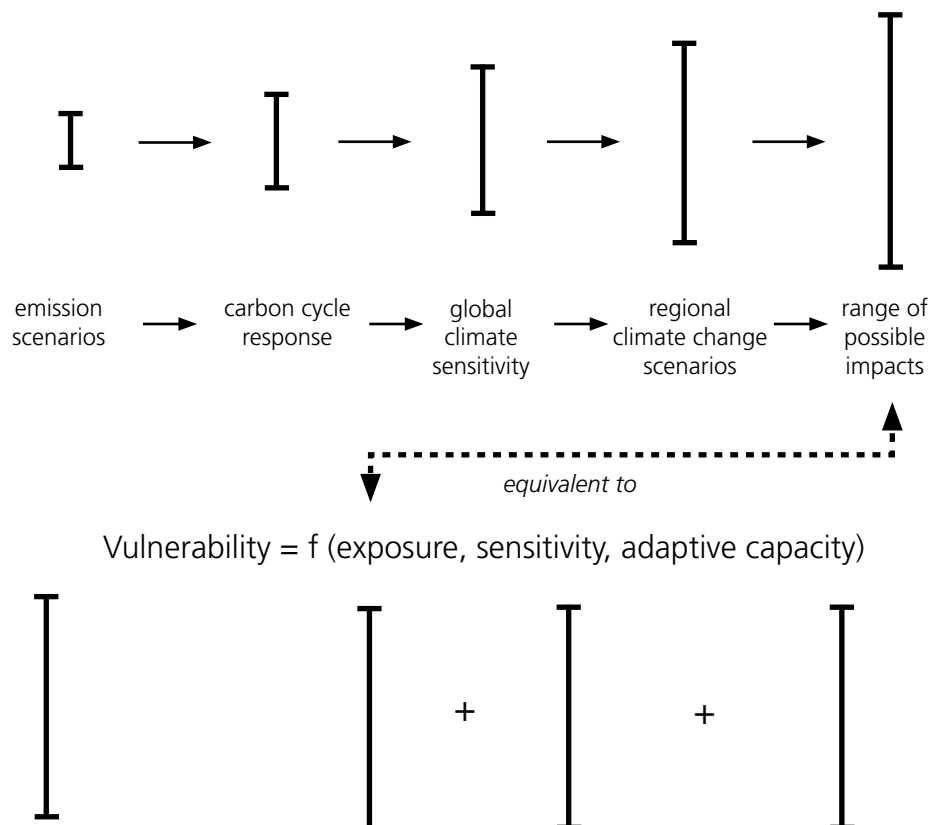
Figure 2 demonstrates the wide range or band of scenarios and calculations for vulnerability, and how uncertainty accumulates through these stages. The amplification depicted in this diagram was developed only in relation to general climate change analysis. It therefore does not factor additional uncertainties in the data sets and considerations relating to human health impacts. A further element of uncertainty is noted in that 'even if adaptive capacity exists or has been developed, there is still uncertainty as to whether individuals, communities or countries will use that capacity to adapt to the projected impacts of climate change' (Adger and Vincent 2005, 408).

Ebi *et al.* (2008) specifically appraise the current state of knowledge of the health impacts of climate change. They develop a diagrammatic representation of this knowledge that demonstrates whether negative or positive impacts on human health are anticipated, the estimated magnitude of each effect, and the current level of certainty about the effect of each impact. It needs to be emphasised that given the lack of quantitative studies there is ongoing debate in the literature on the projected impacts of climate change on human health. The addressing of uncertainty in analyses and communication is also fundamentally important.

Uncertainty is a key concept and could be unpacked further. Outside the climate change literature the 'strategic choice' approach from the systems thinking literature is a framework that illustrates different aspects of uncertainty (Friend and Hickling 2005):

1. Uncertainty about the working environment (facts about the world) - needs biophysical science to help address.

2. Uncertainty about values - needs stakeholder/community engagement to help address (social science can assist).

3. Uncertainty about interactions with related decision areas - needs policy/management co-ordination to address (biophysical and social scientists can identify the need for this and facilitate cross-agency collaboration).

Importantly the more that is known in each of the three areas of uncertainty, the greater confidence decision-makers can have in strategy and implementation.

For the climate change area, it is also important to note the distinction between uncertainty and variability. The areas of uncertainty identified by Friend and Hickling (2005) are, in principle at least, able to be reduced with increased data collection. However, the complexity inherent in addressing issues associated with decision-making for climate change suggests that this uncertainty is not necessarily resolved by increased data collection.

3. Definitions and Interpretations

A plethora of definitions for key concepts related to climate change exist within the literature. "Vulnerability" and "adaptive capacity" are perhaps the most ambiguous terms in the climate change literature, not least in part due to their existing use in general hazard studies. However, other terms, including resilience, adaptation and sensitivity are all important in developing an understanding of the concepts related to climate change.

The Climate Change Research Institute at Victoria University of Wellington through their work on community vulnerability to climate change has developed a diagrammatic representation showing how the key concepts within the climate change literature interact and relate (Figure 3).

FIGURE 3: A SCHEMATIC DIAGRAM OF ADAPTATION
(Source: Manning *et al.* 2011, 10)
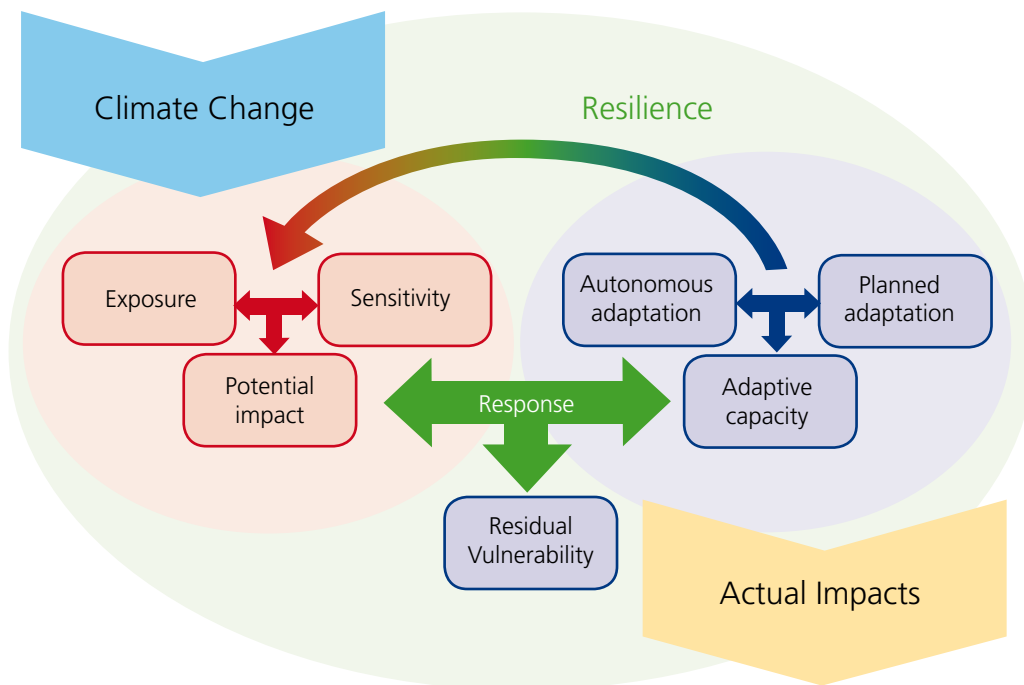
While Nelson *et al.* (2010) warn against using such diagrams as conceptual frameworks, Figure 3 depicts key concepts for the nexus between climate change adaptation and human health. These dynamics are useful to consider in building an intervention framework, and making explicit the flow of information, different types of information required to characterise vulnerability and formulate strategy for planned adaptation.

In the remainder of this section, we begin by detailing the definitions of some key terms used most frequently in the climate change literature provided by the IPCC. We go on to explore how these concepts are deployed within a range of literature. This includes a specific focus on the relationships between vulnerability and adaptation, and what may be termed the range of "forms" which adaptation might take. In addition, we focus specifically on adaptive capacity, being a crucial determinant of the ability to take action and hence conditioning the type of information that may be required to achieve this. We approach this through a focus on the role of social capital as a central component for adaptive capacity followed by a discussion on the role of information and communication.

3.1 Vulnerability, resilience and adaptation

As outlined above, while there is much discussion around many key definitions in the literature (see for example Kelly and Adger 2000), the IPCC definitions are the most authoritative and are used throughout the HAIFA project (IPCC 2007). This section then is intended to provide a summary of these IPCC definitions, which will then be explored through the broader literatures under review.

Vulnerability: The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity (IPCC 2007, 883).

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea-level rise) (IPCC 2007, 881).

Adaptive capacity *(in relation to climate change impacts):* The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC 2007, 869).

Resilience: The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self organisation and the capacity to adapt to stress and change (IPCC 2007, 881).

Beyond the IPCC definition, 'adaptation' and 'adaptive capacity' have been the topic of much discussion in the literature and are further unpacked later.

3.1.1   Vulnerability and adaptation

The relationship between vulnerability and adaptation underpins most climate change studies and frameworks, and the two concepts go hand in hand. Adaptation measures follow from an understanding of vulnerability and are concerned with how to respond, plan and take action to minimise potential impact.

"Vulnerability" itself is interpreted in many ways in different studies. Fussel (2007) finds that over the last several decades, "vulnerability" has been equated with concepts such as "resilience", "susceptibility", "adaptability", "fragility", "risk", "exposure", "sensitivity", "coping capacity" and "robustness". Such ambiguity clearly suggests ongoing contests about how vulnerability might be conceptualised. The most common understanding of vulnerability is described as a function of exposure, sensitivity and adaptive capacity (Klein 2004). Fussel (2007) recommends an approach to vulnerability that aims to remove the confusion associated with it. Any reference to vulnerability should contain the following features:

1) Temporal reference (current vs. future vs. dynamic)
2) Sphere (internal vs. external vs. cross-scale)
3) Knowledge domain (socioeconomic vs. biophysical vs. integrated)
4) Vulnerable system
5) Attribute of concern
6) Hazard

A focus on vulnerability provides a means of assessing the problem, whilst adaptation contains the concrete steps required to address the problem.

3.1.2   Vulnerability and resilience

Another key area of debate on definitions within the climate change field is the distinction, or relationship, between resilience and vulnerability. As the IPCC definition above suggests the resilience of a given social or ecological system is underpinned by complex linkages and interdependencies between various environmental, social and economic factors. Vulnerability assessment involves understanding the current state as well as predicted *impacts* from climate change for different geographic ecosystems, populations, and sectoral economic activities.

Within this context, **social capital** presents as an underpinning component for resilience. Addressed in detail later, it is defined as 'features of social life – networks, norms and trust – that enable participants to act together more effectively to pursue shared objectives' (Putnam 1995).

Some see resilience and vulnerability as flip sides or opposites to the extent that the absence of one results in the other. A paper by Manyena (2006) informed by a literature review on disaster theory and conversations between leading academics makes the point that these two concepts should be seen as discrete and separate entities. However, Miller *et al.* (2010) argue from a socio-ecological systems perspective that the concepts of resilience and vulnerability, while until recently the domains of different disciplinary traditions, nonetheless provide significant scope to approach complex socio-ecological problems.

There are also links between key concepts within other, often related, frameworks. In his discussion on public health preparedness, for example, Keim (2008; see also Castelden *et al.* 2011) locates adaptation to climate change within disaster and emergency preparedness frameworks.

In doing so, the issue of institutional location as well as different temporal scales of response is highlighted. Keim (2008) discusses public health responsiveness for drought, flooding, and wildfires as part of this schema, but many disease-related human health impacts from climate change may well be latent rather than immediate. As such they are oriented to risk reduction rather than a crisis management approach. This raises the question of how the HAIFA information will be used in action planning, prioritisation, and allocation of resources within different institutional settings.

3.2 Forms of adaptation

Many forms of adaptation are described in the 'adaptation science' literature. These include anticipatory or reactive, planned or autonomous, facilitated or spontaneous. A common theme though, is the distinction between adaptation as naturally-occurring (reactive and autonomous) or as planned (facilitated).

The HAIFA project is firmly focused on supporting planned adaptation. Spontaneous adaptation will occur concurrently and does need to be considered as a component of an overall planning model in that information signals or unintended consequences resulting from spontaneous adaptation could affect planned adaptation responses.

Adger and Vincent (2005, 400) note that a clear distinction between the planned and autonomous adaptation was initially hypothesised, but that this failed to account for the 'nested nature of decision making' and that 'each individual adaptation action is constrained by antecedent development and regulatory decisions'. That previous developments both enable and constrain underpins the notion of nested decision-making. This is useful in illustrating the overlays of scale and degree of complexity that may exist in vulnerability assessment and adaptation planning.

Adger and Vincent (2005, 400) also note a 'frequent assumption', that the capacity of societies to adapt to climate change is enhanced relative to their 'access to technology and resources to invest in adaptation'. Yet evidence from traditional societies suggests that the capacity to adapt depends more directly on 'experience, knowledge and dependency on weather-sensitive resources' (Adger and Vincent 2005, 400). Such confidence in technology has been implicated (along with narratives of immunity to the impacts and the perceived lack of immediacy of climate change) in the development of an "unwarranted complacency about adaptation" (Wolf 2011). A range of social agents across various scales influence the adaptation process, expressed by Adger and Vincent (205, 402) as emerging 'through markets, civil society and government action and complex interactions between them' (Adger and Vincent 2005, 402).

Smit and Wandel (2006, 285) note that research focusing on the implementation processes for adaptation is still uncommon, at least, not under the label of 'adaptation' research, and not in the area of climate change. They define research in 'practical application' as investigating 'the adaptive capacity and adaptive needs in a particular region or community in order to identify means of implementing adaptation initiatives or enhancing adaptive capacity'. They note that adaptation planning requires a 'bottom-up' approach (building on local knowledge and resources), in contrast to the 'scenario-based 'top down' approaches' which tend to be expert driven. A mix of both is required for HAIFA to be used as an effective tool.

The importance of 'bottom up' approaches is also noted by Rojas Blanco (2006) in terms of building on local experiences and knowledge and influencing day-to-day adaptation practice. It is important to qualify, though, that Rojas Blanco (2006) comments on climate change more broadly within international development orientation where bridging the gap between community-based organisations or NGO's and science is an important aim. Ebi and Semenza (2008) also develop a framework for a 'bottom-up' approach to community-based adaptation which is detailed later.

Adaptation for human health impacts may initially require less orientation to building relevance and changing day-to-day practice in the wider community, and more orientation to ensuring that appropriate institutional responses and resources exist. In this respect HAIFA could provide information to support those within key institutions for planning an engagement strategy with wider community groups.

Haines' (2008) commentary on strengthening the evidence base for policy for climate change and human health notes a need for adaptive strategies to be evaluated to determine their cost effectiveness. Smit and Wandel (2006) note that whilst adaptation is worked at a local scale, local initiatives can often be constrained by broader economic-social-political arrangements, and that attention to these conditions may equally be part of adaptive strategies. These authors note that whilst there has been considerable scholarship in climate change to calculate indices of vulnerability and adaptive capacities, the practical applications and implications are not so readily apparent (Smit and Wandel 2006, 289).

3.3 Adaptive capacity

There are a number of broader definitions of adaptive capacity that go beyond the definitions from the IPCC, and a number of authors write about different aspects of adaptive capacity. These help further explain the reasons why the literature review focuses on social capital and information and communication.

Adaptive capacity refers to the ability of a system to respond to change, 'making society more robust and more flexible' (Tol 2005, 574). Adaptive capacity is believed to be determined by 'technological options, economic resources and their distribution, human and social capital and governance', but this is a hypothesis only, and not rigorously tested (Tol 2005, 574).

The challenge for emerging insights into adaptation is how to characterise adaptive capacity in a meaningful sense and to find generic determinants of adaptive capacity at various scales to build predictive models of its evolution into the future' (Adger and Vincent 2005, 400).

Yohe and Tol (2002, cited in Adger and Vincent 2005, 402) give eight determinants of adaptive capacity, many of which cannot be quantified. These include:

- the range of technological options available,

- the availability of resources and their distribution,

- the structure of critical institutions,

- the stocks of human and social capital,

- access to risk spreading mechanisms,

- the ability of decision-makers to manage risk and information,

- the public's perceived attribution to the source of the stress (i.e. is climate change legitimate or not), and

- the significance of local manifestations (for example what observed local variations mean and what implications arise for whom).

Further, they advance the notion that adaptation capacity is constrained by its weakest component.

Smit and Wandel (2006, 287) aggregate from the literature a similar range of determinants for local adaptive capacity that include 'managerial ability, access to financial, technological and information resources, infrastructure, the institutional environment in which adaptations occur, political influence, and kinship networks'. They note that these determinants are 'not independent of each other' and that they 'exist and function differently in different contexts' (Smit and Wandel 2006, 288). Kinship networks may be important in subsistence based societies, but institutional structures will be more important determinants in developed economies. Both these would likely factor as determinants of adaptive capacity for New Zealand rural communities, although this would vary depending on the area and history of the community.

It is difficult to accurately model or predict these relationships. 'To date there is very little consensus (or documented support) for a robust, specific model of the elements and processes of local exposure, sensitivity, and adaptive capacity, beyond broad categories' (Smit and Wandel 2006, 288). Furthermore, whilst 'technology' may be a relevant factor in all cases, its ability to influence vulnerability, feasibility, availability, and interactions with political, economic and social processes will vary considerably from community to community. The authors emphasise that researchers need to actively involve stakeholders so that the community themselves can identify which issues are pertinent and which interventions will best strengthen their adaptive capacity.

Moser *et al.* (2008) focus on two areas: the need for a *better understanding of the social determinants and processes of adaptation*; and the need to *better link existing scientific insights about adaptation to policy and practice* (Moser *et al.* 2008, 644). The authors extend Smit and Wandel's (2006) categories to propose a number of tasks or functions that must be evaluated and enhanced if local adaptive capacity is to be realised (Table 1).

TABLE 1: TASKS TO HELP EVALUATE LOCALLY SPECIFIC ADAPTIVE CAPACITY
(Source: Moser *et al.* 2008, 647)

1. Examine the range of available *technological options* for adaptation that would be considered in response to a perceived climate-related stress;

2. Evaluate the availability of *resources* with particular attention paid to equitable distribution across the population;

3. Explore the structure and functionality of critical *institutions* to understand the allocation of decision-making authority, institutional flexibility, and the decision criteria that would be employed;

4. Assess the *human and social capital*, including the distribution of educational achievement, differential access to personal security and robust property rights;

5. Document the system's (and individuals') access to *risk-spreading processes* (both formal and informal);

6. Assess decision-makers' *ability to manage information*, the processes by which these decision-makers determine which information is credible, and the credibility of the decision-makers themselves; and

7. Calibrate the *public's perceived understanding of the stresses* and the population's readiness to engage in implementing necessary adaptation measures.

They also note that frontier research on adaptation and adaptive capacity is exploring how these determinants can be linked to management and policy levers, and resources that exist within institutions.

A further development in research on adaptive capacity is a concurrent desire to integrate the core concepts discussed above, including adaptive capacity, resilience and vulnerability. While Miller *et al.* (2010) explicitly suggest that a more effective engagement of resilience and vulnerability may improve opportunities to address real world problems, Engle (2011) argues that adaptive capacity "is a common thread between vulnerability and resilience frameworks". In both cases, these authors are making an argument for moving beyond studies to investigate the nature of either vulnerability or resilience, to a concerted effort to integrate the two in search of practical solutions to problems associated with global change.

3.3.1   Social capital

Social capital is recognised as underpinning adaptive capacity. It is also discussed as a key component of resilience, the ability of a community to build back, recover from disaster, adjust, and absorb the impacts of a disaster or event.

Putnam's definition is frequently used in the climate change adaptation literature, depicting social capital as 'features of social life - networks, norms and trust – that enable participants to act together more effectively to pursue shared objectives' (Putnam 1995, 664-665).

Pelling and High (2005, 310) describe social capital as a 'deceptively simple concept, the closer one gets to it the more slippery it seems to be'. Competing theories behind the concept are partly responsible for its interest to sociologists. They cite that Bourdieu's (1984) use of social capital, for instance, demarks different social ties, and views social capital as a strategic asset that is consciously built, maintained and utilised by elite groups to reproduce their privileged status. Alternatively, they note that Coleman (1990) views social capital as a more innate, and largely unintentional outcome of social relationships and interactions. This combination of conceptualisations means that social capital has both active and latent qualities.

As a theoretical backbone Pelling and High (2005) suggest two complimentary components; the types of interpersonal relationships, and trust and reciprocity.

Trust is well established in sociological literature as a core shared norm or expectation that is fundamental to social cohesion, and is expressed/maintained through numerous individual and institutional transactions. Some see reciprocity as a more important focus, as a means by which trust becomes active and enacted in interpersonal transfers of information or resources. There are two types of reciprocity, balanced and generalised. Balanced reciprocity takes place between individuals (families or institutions) who exchange gifts of roughly equal value, often routinely. Generalised reciprocity is less direct whereby 'an individual might help another without expecting anything in return but rather in the knowledge that a third party will be predisposed to extend help knowing the reputation of the first individual for generosity and helpfulness' (Pelling and High 2005, 311).

They identify a '*bonding/bridging/linking triplet*' as a '*mainstay*' descriptor of the types of interpersonal relationships (Pelling and High 2005, 310). *Bonding ties* are shared by individuals that co-identify with a religious or ethnic group, for instance family. *Bridging ties* describe relations of exchange between individuals that have shared interests but different social identities, an example is membership of a club, hobby group or school. *Linking ties*, a sub-category of bridging ties, describe relationships that cross group boundaries in a vertical direction for instance between social classes or unequal patron-client relationships. These might be relationships with individuals in other workplaces or institutions. Bonding ties are often described as strong, whereas bridging ties are weak, although the authors note that these distinctions are not necessarily the case and will change through time and in response to external stressors (Pelling and High 2005, 311). Studies that have attempted to categorise further (Woolcock 2002, in Pelling and High 2005, 313) suggest that bridging capital appears stronger than bonding capital in urban communities, whilst in rural communities bonding is stronger than bridging capital. Additionally bonding capital is more likely associated with women, whilst bridging capital is more likely associated with men.

There is a call for researchers to resolve the ambiguities present in the literature by a 'concentrated effort towards a common understanding of social capital' that will provide a 'coherent institutional theory of adaptation to climate change' (Pelling and High 2005, 313). Three areas are important – the *formation* of social capital, the *operation* of social capital, and the *utility* of social capital.

The *formation* aspect is concerned with how social capital accrues or declines. Specifically there exists a fundamental assumption from some policy makers that policy interventions can build or construct positive social capital. However, there is only inconclusive or 'cloudy' evidence to support this claim. The authors continue that 'the search for general rules regarding the distribution of different types of social capital according to social variables has had little success'. With regard to *operation*, the authors note the importance of making clear the distinction between individual or informal networked relationships and relationships that are embedded in formal organisational structures. They note that this distinction will help understand patterns of inclusion and exclusion that may exist for freedom to act and structural constraint. *Utility* concerns how social capital is used, and also needs to incorporate an understanding of power relationships into an analysis. Understanding all three aspects of social capital arguably requires an understanding of institutional and political theories as well as the specific context or issue.

The recommendations for investigating social capital have implications for HAIFA. Social capital is a nebulous concept, and beyond indirect indicators it would be difficult to factor into predictive models. Many of the data are qualitative and the authors note that a 'combination of local qualitative studies linked to larger scale quantitative surveys may be an appropriate way to proceed' (Pelling and High 2005, 313).

3.3.2   Information and communication

Information and communication are interrelated. Communication is the process and information is what the process acts on or uses. The two exist together. Communication does not exist unless there is the transfer of information through it; and information is of no value unless it is communicated. Information is one thing, but how information is used by others and who uses it relies on communication, as well as institutional factors that include coordination, roles and responsibilities, resources and capacities.

Communication

Maibach *et al.* (2008) focus on communication and marketing of climate change awareness and adaptation to public audiences. This article raises a fundamental premise on which much of the environmental and public intervention logic is based: that people fail to think or act appropriately because they lack relevant knowledge. They continue that this 'information deficit' view of population behaviour has been largely supplanted by ecologic views of population behaviour. Outlined in Figure 4, this makes the distinction that behaviour is determined by people and place related factors.

FIGURE 4: A 'PEOPLE AND PLACES' FRAMEWORK
(This figure was published in: Maibach E, Roser-Renouf C, and Leiserowitz A. Communication and Marketing as Climate Change Intervention Assets: A Public Health Perspective. American Journal of Preventive Medicine, 2008; 35: 488-500. Copyright© 2008 Elsevier. All rights reserved.)
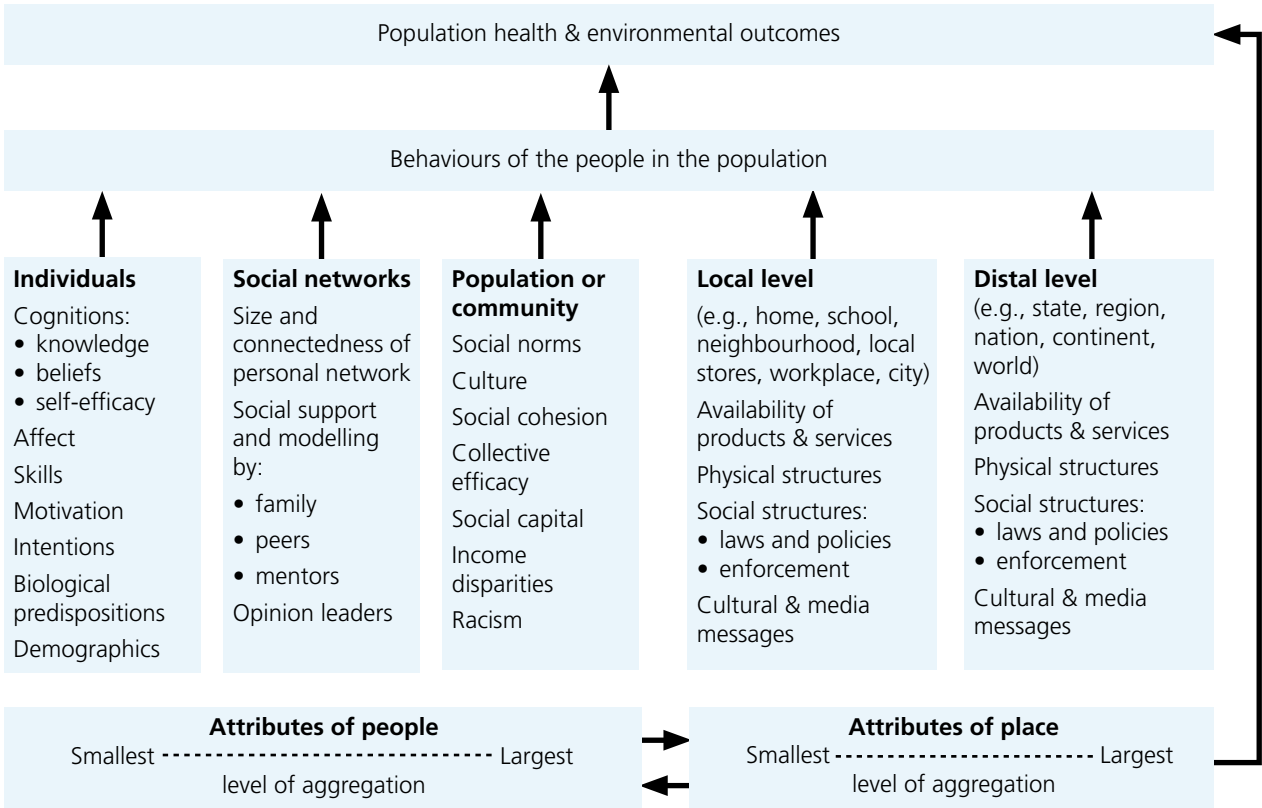
Whilst the authors criticise the 'information deficit' view, they still maintain that information is important. This notion is developed through marketing approaches, calling for research to understand the range of existing population knowledge and attitudes, and then market segmentation and framing of different climate change messages and interventions for different audiences.

Frumkin *et al.* (2008a) note that climate change requires a 'thoughtful approach to communication', and that the 'current discourse features scientific complexity, considerable uncertainty, ample misinformation and many vested interests – with the resulting potential to frighten, alienate or confuse people' (Frumkin *et al.* 2008a, 401). In a related article Frumkin and McMichael (2008) advocate the use of longer time frames for planning and the use of 'systems thinking' as approaches to help institutions manage complexity and introduce a language and frameworks for adaptation that recognise reciprocal effects and feedback loops, nonlinearity and thresholds, tipping points, unanticipated consequences, legacy effects and time lags. They also recommend 'social marketing', 'risk communication' and 'health communication' as three models or frameworks that may be helpful in delivering messages that will prompt individual or community action. They seem to locate climate change in the existing traditions of health communication within public health and preventative medicine (Frumkin and McMichael 2008, 405) where it could be observed that such behavioural change interventions often have variable success.

Ebi and Semenza (2008) on the other hand, advocate a 'bottom up' approach to the challenge of communication for community-based adaptation around 'stepwise action' for ongoing engagement, assessment and action. In this approach social capital, participation and involvement are linked as concepts that underpin community and individual adaptive actions. They also develop the notion of qualitative storylines as tools to facilitate adaptation to climate change. This links also to Whitmarsh's (2008) observation of the importance of experience in shaping attitude and action.

Information

Hess and Ostrom (2006, 339) put forward an 'institutional analysis and development' (IAD) framework as a tool for exploring the shaping of knowledge 'commons' for scholarly information. They specify two 'duelling revolutions' that lead toward conflicting outcomes. 'One trend is a movement toward enclosure and privatisation of scientific information. The other is a movement toward greater access and exchange of information' (Hess and Ostrom 2006, 336). Whilst not specific to climate change and human health, it is relevant that HAIFA could be viewed as a 'common pool resource'. In this respect it is designed to perform a public good, and could likely evolve as one of a suite of tools used by a 'broad array of resource users and regulatory authorities' to 'help resolve complex externality issues across traditional functional and geographic boundaries' (Berardo 2009, 186).

Several points about the use of information within knowledge and governance systems may be useful to consider for HAIFA. Particularly that 'information must be matched with the level of aggregation that individuals are using to make decisions', and that 'information must also fit with the decision-makers' needs in terms of timing, content and form of presentation'. Hess and Ostrom (2006, 346) further note that 'informational systems that simultaneously meet high scientific standards and serve ongoing needs of decision-makers and users are particularly useful'.

The authors present the IAD framework as a 'scaffolding that holds a universal set of intellectual building blocks' (Hess and Ostrom 2006, 339). As such it is an orientation for the types of questions that could be asked and the nested concepts that would exist in a given context; the action arena of adaption planning for climate change and human health.

Heikkila and Gerlak (2005) address the formation of multi-institutional arrangements for collaborative environmental resource management and explore the roles of stakeholders, science and institutions. Raising awareness is a key factor in mobilising collaborative action. They note that access to science and technical information can inform public debate and help trigger public and media interest in an issue, but that science and technical information can be resisted. Translational expertise is important in transferring knowledge from one professional or institutional community to another, or to a wider public. Leadership and champions are also important for adaptive planning. The authors noted that institutional actors became organised around issues that were salient (important or relevant) for their region, and that a concurrence of problem salience with widespread technical and information support is important.

Meinke *et al.* (2006) maintain that *salience* (the perceived relevance of the information), *credibility* (the perceived technical quality of the information), and *legitimacy* (the perceived objectivity of the process by which the information is shared) are three essential components in order to translate climate information into real-life action. Commenting across three case studies in Australia, Brazil and India, the authors conclude that 'climate risk management requires holistic solutions derived from cross-disciplinary and participatory, user-oriented research', and that integrated models will provide the scientific capabilities to support 'borderless institutions'.

The authors locate their core enquiry around 'why the available information is generally not used and embraced by decision makers' (Meinke *et al.* 2006, 102). Lack of ownership of the information by the intended end users is one reason prompting more scientists to move out of their 'disciplinary confines' and initiate participatory shared learning processes with their end users; a strategy the authors note 'is easy to say, but extremely difficult to implement'. Moser *et al.* (2008) elaborate that scientist-initiated commitments to work with decision-makers are 'challenging, time-intensive, and frequently not rewarded by the normal academic incentive-structure' (Moser *et al.* 2008, 655).

Meinke *et al.* (2006) note problems in climate change forecasting being used inappropriately by decision-makers in ways that can erode the effectiveness of traditional subsistence based risk management practices, and that this often occurs on the 'naive assumption that knowledge can be transferred as an unambiguous signal' (Meinke *et al.* 2006, 102). Crate (2008) gives an anthropologists account of adaptive strategies for climate change from indigenous groups in Siberia and voices a concern that climate change may well be pushing the limits of traditional coping mechanisms.

Meinke *et al.* (2006) also note that there may be a 'disconnect' between the science and decision-making knowledge domains. They suggest that 'decision makers usually manage risk holistically, while scientific information is generally derived using reductionist approaches' (Meinke *et al.* 2006, 102). This can lead to the scientific information lacking relevance, causing a 'relevance gap' between the information necessary to support policy and decision making and that supplied.   The solution suggested 'lies with overcoming institutional constraints' (Meinke *et al.* 2006, 104). These include incongruence between policy demands and science funding alignments, and disincentives for the multi-disciplinary cross-institutional cooperation necessary to deliver integrated information on policy outcomes' (Meinke *et al.* 2006, 104). The authors emphasise the need for integrated information systems and mainstreaming.

Frumkin *et al.* (2008b, 439) maintain that information is key to a responsive and functioning public health system, and that it is essential that data collected at different spatial scales and through different methods be harmonised and integrated. They also note that early warning systems need to be strengthened.

The importance of participatory design is a focus for Driedger *et al.* (2007) who advocate for end-user involvement in the design of GIS applications and extend the notion of this being a 'third space' – 'a hybrid realm that overlaps the work domains of a software professional and the end-users' (Driedger *et al.* 2007, 2). Exploring this third space through participatory design supports mutual learning and capacity building between end users and developers, and gains in research and development. This also ensures user buy-in, better tailored end products, and helps avoid 'spatial illiteracy' where GIS tools are not utilised due to lack of training and understanding. GIS – 'health services agencies tend to be data rich but information poor' (Driedger *et al.* 2007, 2)

HAIFA is a tool for health institutions and associated professional communities to help plan and develop responses for climate change adaptations for human health. Huntingford *et al.* (2007) look at what is required of climate change modellers, suggesting that the climate modelling and health disciplines, skills and data sets need to be brought closer together via multidisciplinary research teams. Uncertainty is a key issue and better information is needed to inform planning and spending priorities. The authors review other literature and note that for Marten and McMichael (2002) many of the contributions are qualitative, heavily dependent on socio-economic assumptions and lack formal equations (Huntingford *et al.* 2007, 99). This points to a key divide between the qualitative data that may exist, and the need for data to be quantitative in order to be useful from a modelling perspective.

3.4 Balancing adaptation and mitigation

There is relative consensus in the more recent climate change literature that planners and policy-makers should focus their efforts on adaptation. Mitigation, such as reducing greenhouse gas emissions, is important because it is the means by which the extent of climate change can be limited. However, there is now increasing scientific recognition that 'climate change cannot be avoided' no matter how hard we might try (Tol 2005, 572). Therefore adaptation is necessary as a risk management strategy.

Some authors see mitigation as a mirror image of adaptation, implying that mitigation strategies should be accompanied by corresponding strategies for adaptation. How closely the concepts and planning should be interlinked is a matter of conjecture. Pursuing their concerns for global equity, Costello *et al.* (2009) attest that 'climate change mitigation and adaptation are essential elements to overall development policy. They are not separate issues that can be divided from the agenda for poverty alleviation or closing the gap on social inequalities and health' (Costello *et al.* 2009, 1728). They note that 'any adaptation interventions must sit alongside the need for primary mitigation' and put forward a framework for responding to the health effects of climate change through 'adaptation strategies, which in turn embeds mitigation strategies to improve human health worldwide' (Costello *et al.* 2009, 1728).

Tol (2005) takes a rather different view and looks at adaptation and mitigation as very different approaches that for the most part should not be integrated and instead kept separate in policy planning and decision-making, largely in order to avoid trade-offs and competition for resources. He emphasises that the two approaches operate at mismatching scales, making integration impractical. 'Mitigation is primarily a matter of national governments in context of international negotiations. Adaptation is primarily a matter of local managers of natural resources, and individual households and companies in context of a regional economy and scale' (Tol 2005, 573). This means that different sets of clients, accountabilities, decision criteria, parameters and reporting requirements exist. Mitigation brings into play a need for cross-departmental coordination between central government agencies.

Facilitative adaptation enhances adaptive capacity. Whilst adaptation is typically understood to occur at a local level, facilitative adaptation is a form of planned or anticipatory adaptation where there is a clear role for central and regional government on the basis that central government actions can enable households, companies, and local authorities to better adapt (Tol 2005, 574). Thus, facilitative adaptation is an exception to Tol's (2005) recommended separation of mitigation and adaptation strategies.

Most adaptation is necessarily local and a need for coordination exists at a local or regional level across local health officials, regional and local council officials, water managers, farmers, tourism and energy suppliers, architects, as well as numerous other business, family, iwi etc. Tol (2005, 574) notes that 'decision-makers on a national level would only sideways be involved'.

Whilst cross departmental working is challenging in itself for national decision-makers, this type of local cross-sectorial coordination is altogether more diffuse and raises potentially challenging questions of who is responsible, who drives it, who will resource the coordination and how to get people involved in taking effective adaptation action.

Tol (2005) is also concerned with a mismatch of time scale. Mitigation strategies attempt to structure short-term action that can impact on potentially detrimental long-term effects. Adaptation strategies look at short-term actions in context of medium to short term developments.

Tol (2005, 572) opens his article with the view that adaptation occurs anyway, is 'an everyday fact' and therefore nothing novel. Furthermore he notes an increasing 'flurry of consultants and academics' advising government and international bodies what to do about adaptation. He invokes further difficulties in achieving action, noting that 'although researchers like to talk about multi-scale, multi-stakeholder research of immediate policy relevance, reality is different' (Tol 2005, 577).

Alternately, Costello *et al.* (2009) argue for a coalition of global expertise and a well financed academic led 'advocacy movement' to support dialogue-based engagement with policy and community leaders on the issue. Accountability mechanisms are crucial and accountability indicators ought to be part of ongoing governance frameworks. Financing support needs to be available for the sharing of resources and information to be facilitated between developed and developing countries in order for improvements to occur.

4. Barriers to Adaptation Planning

While adaptation planning is emphasised as important by many authors in this field, the contested nature of many of the definitions and models presented above suggest that complexity may present a significant barrier for those wanting to engage in adaptation planning. This manifests in a number of ways as a significant barrier to action, not the least in generating uncertainty in interrelationships, cause and effect, and in there being multiple definitions and terms. Indirect effects are much harder for organisations to pay attention to and to justify allocating resources.

A number of authors note barriers to adaptation for climate change and human health. Huang *et al.* (2011), through an extensive review of the literature, characterise a range of constraints and barriers to public health adaptation. These include:

1. Uncertainties of Future Climate and Socioeconomic conditions

2. Financial Challenges

3. Technologic Limits

4. Institutional Arrangements

5. Social Capital

6. Individual Cognition

These categories are also reflected in the broader literature which this review has evaluated. As Huang *et al.* (2011) suggest, many of these barriers and constraints are institutional factors, and as such we detail these extensively in Section 4.3. However, we begin by addressing two important and interrelated factors: awareness and recognition, and uncertainty.

4.1 Awareness and recognition

Local councils may pay more attention to one sort of impact over the other. Due to existing emergency plans and the immediacy of action required, councils may focus on direct impacts to a greater extent. How possible impacts are divided then does have significance given that policy-makers may intuitively treat direct effects as more urgent, despite the literature arguing that indirect effects will be more damaging in the long run.

A common theme in the literature on climate change and health is the division of expected impacts into direct and indirect effects. Whether or not differences in divisions into direct and indirect effects even matter has not been discussed. The general consensus exists that although direct effects are likely to be more observable, indirect effects will probably have a far greater total impact (McMichael and Haines 1997). Indirect effects tend to be considered over a longer time scale; for example, any direct effects of temperature-related illnesses are expected to be realised on a particularly hot day or group of days, whereas changes in vector-borne diseases are expected to occur over longer periods of time as temperature and precipitation change.

Whitmarsh (2008) looks into the role that direct experience of floods or air pollution might play in accentuating concerns of climate change. She points to well established literatures that describe how direct experience is a major influence on risk perception, learning and action. Yet her study involving qualitative interviewing and a postal survey found that 'flood victims viewed climate change and flooding as largely *separate* issues' (Whitmarsh 2008, 368), and that visible local features such as blocked drains, land development and roading surfaces were considered primary causes of flooding rather than climate change. Climate change remains 'intangible' and is 'not a priority concern for the public', even to those with direct experience of flooding. This suggests that climate change is a risk 'buried' in familiar natural processes, temperature change and weather fluctuations, and has low salience as a risk issue (Whitmarsh 2008, 352). Whitmarsh also brings into question the utility of 'second hand information', noting that interpretation varies, and that people will 'more readily trust the evidence of their senses' (Whitmarsh 2008, 353).

Milfont (2010) explores psychological barriers further. He cites work by Pawlik (1991) which outlines five characteristics that act as barriers to recognition and awareness of climate change. These barriers are: *psychophysiological* where there are only weak physical signals that the climate is changing; *temporal* where there is a lapse between human actions and their influence on climate; *judgemental* where people minimise events with a small probability of occurring; *geographic and social* where maladaptive behaviour have consequence for people living in other places; and *social dilemma* barriers where environmental behaviour has low cost effectiveness for the individual involved, for example, cycling to work may be perceived as risky, uncomfortable and inconvenient. The author introduces construal level theory to view this combination of weak physical signals and uncertain outcome as high level construals. This degree of abstraction and distance inhibits social action, as opposed to the more concrete, immediate and detailed characteristics of low level construals. This author suggests that moral principles and ideals are better motivators of behaviour for high level construals.

The psychological literature refers also to the concept of 'environmental numbness' where people intentionally choose not to think about climate change and focus on other issues. A growing body of work within social psychology specifically, and the social sciences more generally, has offered insights on the importance of developing appropriate communication processes for climate change. The Centre for Research on Environmental Decisions has produced a detailed guide for scientists, journalists, educators, political aides and the interested public on the psychology of climate change communication (CRED 2009). In this guide they document the importance of ensuring that such communication takes into account the range of factors that influence effective communication, with an emphasis on translating complex scientific information into experience understandable to a specific audience. In addition, work within marketing has also suggested that there are opportunities to improve communication of climate change information (see, for example Futerra Sustainability Communications undated). These and other related literatures relating to the processes of technology transfer are further explored in a companion review.

The SE project highlighted that previous experience of floods or drought is a factor that may positively influence institutional adaptive planning and preparedness for the impacts of climate change. However, in line with Whitmarsh's work, very few interviewees linked flood or drought with climate change *per se*, and some were highly sceptical that climate change might cause a drought or flood.

4.2 Uncertainty

Projections of climate change are inherently uncertain, so the extent of the expected impacts is also uncertain. This creates significant difficulties when scientists try to communicate information on climate change to decision-makers and the general public. Not only is the language of uncertainty likely to be too technical for most people to properly understand, but there is also concern that decision-makers may find that there is too much uncertainty for them to implement any practical policies. Uncertainty can lead to inertia. Decision-makers are often required to provide sufficient justification for their decisions; if their justification is full of uncertainty, they may be unable to get policies implemented. Although all predictions are subject to uncertainty, climate change projections are even more so given the vastly complex nature of the issue.

The inclusion of uncertainty in analysis and communication is fundamentally important. For any guidance to be useful and practical for decision-makers uncertainty must be dealt with effectively, through clear communication of its nature in each case, as it cannot be removed. It allows decision-makers to understand the boundaries within which they make their decisions, and the full range of consequences that could result. Decision-makers are less likely to make ineffective, wasteful or potentially damaging decisions if they are aware of the possible range of consequences that could flow from them. The distinction between uncertainty and variability is also important.

Huang *et al.* (2011, 185) argue that there is a need to recognise both the uncertainty of climate change projections themselves and the potential impact of these predictions, as well as the "uncertainties of future demographic, socioeconomic, and technologic conditions that will change the exposure, sensitivity, and adaptive capacity of populations".

4.3 Institutional or organisational factors/barriers

Objective 3 of the HAIFA project aims to identify the capacity, assumptions and barriers that exist for coordinated adaptive planning between the health and environment sectors. This section of the literature review looks at key institutional factors that may impact on how local planning authorities might utilise information for adaptation to the impacts of climate change on human health.

There is a vast literature on institutional theory and organisational behaviour (for a summary see Sage Handbook of Organizational Institutionalism; Geenwood *et al.* 2008). Within the climate change and human health nexus Moore *et al.* (2007, 284) give a simple definition of organisations as 'goal-directed, boundary-maintaining and socially constructed systems of human activity'. Organisations include public or government agencies, non-government organisations and private entities. The authors elaborate that five types of organisations have been defined in the disaster response literature. These are 'adapting organisations', which maintain their original structure and personnel but adapt their functions; 'expanding organisations' which increase their personnel; 'extending organisations' which increase their range of services and activities; 'emerging organisations' which are created out of the disaster situation; and 'redundant organisations' which play no role during a disaster (Moore *et al.* 2007, 284).

The term 'institution' has broader application than 'organisation' and is used by sociologists to describe 'social practices that are regularly and continuously repeated, are sanctioned and maintained by social norms, and have a major significance in the social structure' (Abercrombie *et al.* 2000).

The challenge of working with institutions is deemed 'overarching' (Costello *et al.* 2009, 1722), and most key authors in this field (see for example Tol 2005; Ebi *et al.* 2006, 2008; Smit and Wandel 2006) reference a variety of institutional factors that may underpin effective adaptation planning and action.

For the purposes of the HAIFA project it may be useful to think of institutional factors as well established and routine expectations, professional rules, hierarchies, roles, and practices that exist in a place of work. Institutional culture and behaviour is often implicit and taken for granted by the individual actors within an institution. As such it can be difficult for an outsider to understand fully how institutional culture may affect or impact adaptation planning.

In dealing with organisations, certain 'constraints' may become evident. It is well established in sociology that institutions are difficult to change and will typically adapt slowly and incrementally. Complex power relationships, divisions of responsibility, and various administrative and governance mechanisms typically exist within larger organisations. Additionally, formal arrangements for governance and structure, role demarcations and communication protocol may also exist across the different organisations that constitute a sector. In addition to these *formal* arrangements, it is also important to be mindful that organisations are composed of many individuals, varied interpretations of roles and responsibilities exist, and a show of support from one person within an organisation may not necessarily result in an outcome desired by the HAIFA research team.

It is also well recognised in institutional theory that *informal* (day-to-day or rule of thumb) rules and practices co-exist alongside the more formal procedural expectations and activities that are often espoused, and are often more important. In this respect the informal practices and networks that exist as part of a formal organisation (akin to social capital – see earlier discussion) can create valuable 'opportunities' for new ideas, adaptation and entrepreneurship.

Where the climate change adaptation issue sits institutionally is key. The 'information for action' nexus is subtly different for health and environment. The climate change and human health literature did not identify any empirical studies to date that have looked at the relationships between health, environment and local government sectors for coordinated adaptive planning. Thus, understanding this institutional nexus is a key aim of the semi-structured interviews with stakeholders and informants (Phase 1 on page 1).

The environment sector, arguably, is more reliant on the support of the general public, for without collective action many measures to combat or adapt to climate change will be ineffective. Framing and communication are important in informing the public about the possible impacts of climate change to encourage action, but avoid creating fear and a sense of hopelessness.

Public health professions are perhaps less dependent on public buy-in. Medical models tend to shape behavioural change and this is typically managed individually in a clinical context, or through more recent use of social marketing and community development approaches for community health.   Public health also has stronger traditions and established methods of surveillance for the monitoring and control of disease.

Both the environment and public health sectors increasingly use surveillance frameworks where indicators provide de-facto points of feedback for complex effects occurring in complex systems. Despite some communal frameworks, differences exist in languages and terminology, professional expertise, sets of end user relationships and points of accountability.

Demarcations of responsibility may also exist between central, regional and local agencies in both the health and environment sectors. There may be differences in the aims and priorities of central government environmental agencies, which may have a dedicated focus on environmental protection and climate change, and local or district councils who need to balance competing interests for regional development within their constituency, and whose actions are mediated through democratic process.

The interplay between local, regional and national agendas and institutional practices is however vitally important. As Adger and Vincent note, 'the experience of climate change is finely resolved in spatial scales and the challenges of adaptation in markets, networks and communities may be largely invisible to many aspects of national governments' (Adger and Vincent 2005, 403).

Commenting on federal efforts to adapt to climate change in the USA, Stephenson (2009) describes several challenges. First, adaptation to climate change is 'one of many competing priorities for decision makers' (Stephenson 2009, 5). Agencies' strategic plans did not address climate change specifically, and resource managers had a wide range of responsibilities with a tendency to focus on immediate rather than long-term issues. Second, there was a 'lack of guidance' on how managers could specifically address climate change. Such guidance would give an imperative for action and help resolve differences of interpretation within the organisation about roles, responsibilities and actions. Third, there was a 'lack of site-specific information'. Managers lacked computational models for local projections of change as well as adequate baseline data. A fourth challenge was 'uncertainties in making decisions based on projected future conditions' especially in mobilising resources when the usual practices in the private and public sectors are based on historical knowledge, probabilities and patterns of variation.

4.3.1   Institutional capacity in the environment sector

Much of the literature regarding 'mainstreaming' as a solution for overcoming institutional barriers has developed from observations of climate change adaptation strategy within the local and regional government, environmental and urban planning sectors.

Allman *et al.* (2004) report that most Welsh and English local authorities were not making substantial progress in responding to climate change. The authors conducted two postal surveys, in 2000 and 2002, with a total of 410 responses (a 35.4% response rate for 2000 and a 50.5% response rate for 2002). Where local authorities were successful, they noted three factors as being important: recognition of the secondary benefits of tackling climate change (i.e. potential employment and improved quality of life); strong political professional and technical support necessary to champion climate change activities; and working in partnership with utilities, private, public and voluntary groups to raise finance needed to implement adaptation and mitigation measures.

Complex strategies that required cooperation between different departments showed the slowest progress. The authors listed the barriers presented in Table 2.

TABLE 2: BARRIERS TO LOCAL AUTHORITIES ADDRESSING CLIMATE CHANGE
(Source: Allman *et al.* 2004, 280)

Barriers
Lack of awareness or interest from councillors
Lack of awareness or interest from other public sector organisations (e.g. health)
Lack of funding
Difficulty coordinating different departments within the authority
Lack of appropriate government guidance
Difficulty coordinating between county and district councils
Insufficient staff or staff time
Lack of awareness or interest from voluntary and community sector organisations
Difficulty delivering climate change actions through other plans and strategies (e.g. reducing pollution, traffic congestion, etc.)
Lack of awareness or interest from council staff
Other issues take priority within council
Difficulty coordinating regionally between adjacent areas
Lack of information and communication technology (ICT) support
Lack of awareness or interest from local business
Lack of awareness or interest from the public
Insufficient local authority powers
Difficulties in exploiting European Union (EU) assistance
Local resistance to specific schemes (public, community, business, etc.)
Need to bid for project funding uses too many resources
Risk of litigation (planning appeals etc.)

Overall Allman *et al.* (2004) found that those involved in climate change adaptation planning in local government organisations felt they were lacking in skills and resources. Factors that participants felt would support climate change adaptation planning included increased awareness of climate change amongst council members, officers, the public and local businesses, and innovative mechanisms for raising funding, sharing knowledge and developing best practice between authorities.

Roberts (2008, 536) noted similar factors that included the importance of capacity building, the importance of climate change champions, and the need for local government to prioritise adaptation over mitigation.

In regards to assisting policy-makers in their planning processes, Demeritt and Langdon (2004) gave a useful description of how local authorities in the United Kingdom perceive the information they receive about climate change. There appears to be a fine line between too much and too little information. Guidance needs to be practical, which requires it being simple enough to understand and yet sufficiently detailed. It would be useful if similar studies could be carried out in New Zealand.

More recently, Measham *et al.* (2011) have investigated the barriers and challenges to adapting to climate change through local municipal planning. They outline the range of common constraints recognised by the adaptation literature (lack of information, institutional limitations and resource constraints) before drawing on literatures of community-based environmental planning to 'demonstrate a wider set of constraints that are known to affect planning processes when incorporating community involvement' (Measham *et al.* 2011, 891). Based on interviews with staff from three municipal councils in Sydney, and with a specific focus on adaptation rather than mitigation, they identify leadership, competing priorities, the planning process, information constraints and institutional constraints as of specific importance. Of particular relevance to this review, the authors note two distinct sources of institutional limitations, being 'those stemming directly from council internal structures and those occurring at higher levels of government' (Measham *et al.* 2011, 905). The latter is seen as more problematic, as it suggests that these constraints are defined externally, and therefore require a political intervention as a solution.

4.3.2   Institutional capacity in the public health sector

Frumkin *et al.* maintain that mitigation efforts will occur mainly in sectors other than health, and that adaptation efforts correspond closely to conventional medical and public health practices, and that this set of practices is collectively known as public health preparedness (Frumkin *et al.* 2008b, 436-7).

For public health, *prevention* is the term analogous to *adaptation* used by the climate change community. Public health prevention is classified as primary (preventing the onset of disease in an otherwise healthy population), secondary (preventative action in response to early evidence of health effects, dependent on surveillance), and tertiary (measures to reduce the impact of existing disease, often involving treatment) (Ebi 2009, 5). Surveillance systems, measurement, monitoring and sound identification of risks and population vulnerability are important aspects of a public health response.

Ebi (2009) locates 'adaptation' to climate change within the 'risk management' framework and terminology, familiar to public health. She emphasises that both adaptation and prevention are continual ongoing processes that require constant revisiting, rather than onetime assessment. She gives several categories of adaptation measures. These are determining population vulnerability in ways that combine climate change factors and socio-economic scenarios, policies and technologies including surveillance, infrastructure development etc., and public education and outreach programmes.

Ebi notes that the 'roles and responsibilities vary by health outcome' (Ebi 2009, 7). This points to some degree of complexity, demarcation and fragmentation, suggesting that understanding these demarcations of responsibility and the coordinative mechanisms within health sector institutions may be useful for HAIFA. Ebi concludes that in the USA there is no central agency responsible for climate change adaptation, and that the elements needed are 'spread across multiple agencies and organisations with lack of effective collaboration' (Ebi 2009, 10).

Costello *et al.* cite several studies that note the absolute importance of the health sector in supporting the 'development of coherent, population-based, and bottom-up health planning'. Yet they are also cognisant of the health systems currently being 'fragmented, with little attention being paid to long-term sustainability' (Costello *et al.* 2009, 1729).

In relation to the public health sector developing and implementing services to address climate change, Frumkin *et al.* (2008) highlight several practical realities that will need to be confronted. These are that the effects of climate change will vary considerably by region, that they will vary by population group, and that the effects will be highly complex and planning and action will need to be multi-dimensional (Frumkin *et al.* 2008b, 438).

Maibach *et al.* (2008) report on the results of a telephone survey administered with 217 USA public health directors to look at climate change preparedness within this sector. There was high recognition of climate change as a threat to health in their jurisdiction, but the majority (77%) believed their department lacked expertise in assessing risks and planning for adaptation or mitigation. Furthermore 77% felt that their departments' ability to respond to climate change would be enhanced if additional resources were available. The resources included funding, additional staff, staff training and equipment. Whilst some climate change related activities are being undertaken, climate change adaptation is not a priority for most.

Moore *et al.* (2005) provide a glossary of the most important terms and concepts that underpin public health preparedness. 'Capacity', 'competency', and 'coordination' are key terms. 'Capacity' refers to the ability and potential that an individual or institutional actor has to respond to an event. This includes regional networks and 'surge capacity' to enable flexibility and resource allocation. 'Competency' refers to organisations having the necessary combinations of skills and abilities. 'Coordination' refers to the degree of integrated activities, programmes and policies that exist within and across different agencies, including the extent of interaction and the degree of resource exchange among agencies. The terminologies show an orientation to disasters, and either mitigation or planning for immediate responses to events. This orientation to emergencies and immediate or rapid response planning may be somewhat incongruous with the more gradual anticipated impacts to human health and climate change, especially in the area of infectious disease. This helps explain why climate change and human health impacts have less salience, urgency and priority within a public health setting.

The link to 'salience' is also noted by Costello *et al.* (2009) who see the engagement of the health community as vital to ensuring that threats from climate change will attract more attention. 'Health professionals have come late to the climate change debate, but health concerns are crucial because they attract political attention' (Costello *et al.* 2009, 1696).

Yet in the public health sector, adaptation planning for human health impacts of climate change sits alongside other competing priorities. Ebi *et al.* (2008) note there has been 'limited engagement' to date within the health sector, 'due partly to limited understanding of the immediacy of the climate change risks and partly due to significant competing demands' (Ebi *et al.* 2008, S62). They continue that 'to effectively prepare for, and cope with, climate change impacts, public health must move from a focus on surveillance and response to a greater emphasis on prediction and prevention' (Ebi *et al.* 2008, S62). They note that the principle components of a public health early warning system include 'meteorological forecasts, models to predict health outcomes, an effective response plan, and a monitoring and evaluation plan, all set within a disaster management strategy'. Ebi *et al.* (2008) also note that prevention programmes 'must be designed with a better understanding of the sub-populations at risk and the information necessary for effective responses to warnings', and that monitoring and evaluation of the system and individual interventions is important (Ebi *et al.* 2008, S62-63).

The setting of public health early warning systems within a disaster management strategy raises interesting tensions. Keim (2008) also sets public health responses to climate change within a disaster and emergency preparedness framework, but focuses on more immediate visible catastrophes such as wildfires, landslides and floods. This raises the question as to whether mainstreaming public health responsiveness with a disaster response setting will enable adequate responses to gradual effects and more latent and less visible threats to human health that may arise from climate change.

Wiseman and Nolan (2008) offer a commentary on climate change as the next revolution in public health. They highlight the need for public health researchers, practitioners and policy makers to play a crucial role in shaping public debate and the need to extend the boundaries of traditional public health paradigms to broader questions about securing sustainable relations of production and consumption. They note that transformation will likely require 'significant tradeoffs between individual and communal rights and choice and the societal and legal frameworks and structures required to facilitate change' (Wiseman and Nolan 2008, 363).

5. Mainstreaming

'Mainstreaming' is a development from applied research in climate change adaptation. It aims to address climate change adaptation alongside other existing programmes of work within key institutions, and provides a way of overcoming some of the barriers identified above.

A fundamental finding is that it is 'extremely unlikely for any adaptive work to be undertaken in light of climate change alone' (Smit and Wandel 2006, 285). The work of adaptation to climate change is not discrete or stand alone, and tends to occur as incremental modifications to existing initiatives (Smit and Wandel 2006, 289; see also Clarke and Berry 2012; Paterson *et al.* 2012). Thus 'practical climate change adaptation initiatives are invariably integrated' or 'incorporated into existing policies, programs, or decision-making processes related to resource management, community development, livelihood enhancements, coastal zone management, sustainable development and risk management' (Smit and Wandel 2006, 286).

It is also suggested that as information and understanding increases, so too will the mainstreaming activities associated with adaptation to climate change (Patterson *et al.* 2012). However, as Clarke and Berry (2012: 172) note:

> "In order to mainstream climate change concerns, public health decision making requires information about climate related health risks to inform existing risk management activities. These activities, such as population health assessment, surveillance and public education and outreach can only account for climate factors if information on climate- related risks is available to public health practitioners and researchers (e.g., what are the climate hazards and associated health impacts, where will they occur, when will they occur and who will be most affected?)."

Such a statement of the importance of information in supporting the mainstreaming of climate change adaptation clearly supports the role of HAIFA in developing such information.

Where this issue sits is important. Disaster and emergency preparedness approaches straddle across public health and local government. These are useful places to start mainstreaming. But different languages, paradigms and priorities exist in different settings which explain why integrated environmental and public health responses to climate change are key, but difficult to achieve in practice. In addition, the tendency for climate change adaptation to be categorised within the environment section of local government has been highlighted as having implications for presenting such adaptation as a "cross-sectoral" issue which needs to be addressed across "institutional silos" (Measham *et al.* 2011, 905).

The movement to 'mainstreaming' may have particular relevance for the uptake of the HAIFA decision support tools by stakeholders or communities of professional interest. The degree of uptake and use of HAIFA will vary between institutional settings and so too will be the systems used for mainstreaming.

A broad awareness and understanding of existing related adaptation management initiatives and the opportunities for integrating responses to climate change is important. The specific focus on human health will also require an additional layer of understanding and integration with existing public health responsiveness. Broader economic-social-political constraints may also be important to consider.

There is increasing feeling from theorists in this area that strategies for adaptation be focused on 'no regrets' options. "No regrets" strategies are steps that address climate change, but in so doing they yield other direct and indirect health and/or other benefits. Developing 'no regrets' strategies (Rojas Blanco 2006, 141) is an aspect of mainstreaming, and an approach that helps manage dilemmas, uncertainties, lack of precision in forecasting, multiple sources of contestation, and the fact that adaptation capacity is constrained by its weakest component. A 'no regrets' strategy enables climate change to be dealt with in relation to other issues. It ensures that actions taken to address the effects of climate change produce benefits, even if the effects of climate change are not as marked as anticipated. Others use the term 'co-benefits' to describe a process whereby steps to address climate change also yield other direct and indirect health benefits (Frumkin 2008b, 437).

In one of the few empirical studies on mainstreaming, Roberts' (2008) study of local government climate change initiatives in Durban, South Africa, identifies several institutional markers that can help evaluate the extent to which climate change has become successfully institutionalised in day to day operations, planning and decision-making. These are the emergence of identifiable political or administrative champions for the climate change issue, the appearance of climate change as an issue in mainstream municipal plans, the allocation of dedicated resources (human and financial) to climate change issues, and the incorporation of climate change considerations into political and administrative decision making (Roberts 2008, 527).

Mainstreaming requires particular attention to institutional structures and knowledge of polices, activities, roles, responsibilities, capacities – constraints and opportunities that exist for integrating adaptation approaches for climate change and human health.

6. Conclusions

This literature review has developed a robust understanding of the key concepts and factors for supporting 'information for action' with respect to climate change and human health. We have endeavoured to unpack what 'information for action' might mean for HAIFA, organisations and professional communities of interest by looking at the dynamics, relationships, activities and components that form the climate change and human health nexus. This review intended to focus on the links between knowledge, awareness and action in this context, and aimed to develop a taxonomy structure to identify the component parts and relationships that might form an 'information for action' framework for climate change and human health. This literature review has presented definitions and related concepts. It has not however managed to develop a coherent taxonomy or hierarchy of interlinking concepts or relationships that might underpin effective adaptation planning. In this respect the literature reviewed in this emergent field has possibly raised more questions than are easily answered.

Overall, the literature strongly supports the importance of information and the development of HAIFA tool to assist with adaptation in regional planning. As a scenario planning tool, HAIFA will start making visible the connections between climate change and human health. In the first instance this is through the projected effects for six indicator diseases encompassing food, water, respiratory and vector-borne disease. These are:

• Campylobacteriosis

• Cryptosporidiosis

• Neisseria meningococcal infectious disease

• Influenza

• Ross River fever, and

• Dengue fever.

HAIFA is intended to provide information to help plan responses for climate change adaptations for human health by health and local government institutions and associated professional communities. This literature review has shown that a number of institutional barriers may exist that could impact on HAIFA being utilised to support local adaptation planning. The uptake and utility of HAIFA as a tool for adaptation planning will depend on several factors, some of which are within control of the researchers, such as careful consideration of how to communicate uncertainty, and ensuring policy relevant information. Other factors remain more difficult for the researchers to control such as salience, competing priorities for attention, and limited human and financial resources within institutions. This literature review has identified a number of characteristics of the climate change issue that mean that prioritising action planning informed by HAIFA could be challenging. These include uncertainties, scepticism, and that change may be slow and diffuse.

There are also questions of the fit of climate change adaptation for human health for mainstreaming within disaster preparedness planning frameworks (at local and regional government level). The different temporal scales that exist may mean that actors and institutions are mobilised around immediate crises. It is also important not to assume that disaster planning frameworks are the only ones that HAIFA could be a part of. An important consideration however is that the issue of human health effects from climate change may lack prioritisation in the health institutional setting.

Currently much of the development of climate change tools seems driven globally. Whilst links to local action are equally important and considered, for the moment climate change seems more salient in New Zealand's international relationships. Thus, HAIFA represents New Zealand's first step in developing locally informed tools.

References

Abercrombie, N., Hill, S., and Turner, B. 2000. *The Penguin Dictionary of Sociology*, London: Penguin.

Adger, W. N., and Vincent, K. 2005. Uncertainty in adaptive capacity, *Geoscience*, 337: 399-410.

Allman, L., Fleming, P., and Wallace, A. 2004. The progress of English and Welsh local authorities in addressing climate change, *Local Environment*, 9: 271-283.

Berardo, R. 2009. Generalized Trust in Multi-organizational policy Arenas Studying Its Emergence from a Network Perspective, *Political Research Quarterly*, 62: 178-189.

Bourdieu, P. 1984. *Distinction: A Social Critique of the Judgement of Taste*. Routledge, London.

Casman, E., Fischhoff, B., Small, M., Dowlatabadi, H., Rose, J., and Morgan, M.G. 2001. Climate change and cryptosporidiosis: A qualitative analysis. *Climatic Change*, 50: 31.

Castelden, M., McKee, M., Murray, V. and Leonardi, G. 2011. Resilience thinking in health protection, *Journal of Public Health*, 33 (3): 369-377.

Clarke, K. and Berry, P. 2012. From theory to practice: a Canadian case study of the utility of climate change adaptation frameworks to address health impacts, *International Journal of Public Health*, 57: 167-174.

Coleman, J., 1990. *Foundations of Social Theory.* Harvard University Press, Cambridge.

Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R., Friel, S., Groce, N., Johnson, A., Kett, M., Lee, M., Levy, C., Maslin, M., McCoy, D., McGuire, B,. Montgomery, H., Napier, D., Pagel, C., Patel, J., Antonio, J., de Oliveira, P., Redclift, N., Rees, H., Rogger, D., Scott, J. Stephenson, J. Twigg, J. Wolff, J., and Patterson, C. 2009. Managing the health effects of climate change, *Lancet* 373: 1693-1733.

Crate, S. 2008. Gone the Bull of Winter? Grappling with the cultural implications of anthropology's role(s) in global climate change, *Current Anthropology*, 49: 569-595.

CRED - Center for Research on Environmental Decisions 2009. *The Psychology of Climate Change Communication: A Guide for Scientists, Journalists, Educators, Political aides and the Interested Public.* New York.

Demeritt, D., and Langdon, D. 2004. The UK Climate Change Programme and communication with local authorities. *Global Environmental Change*, 14(4): 12.

Driedger, S. M., Kothari, A., Morrison, J., Sawada, M., Crighton, E.J., and Graham, I.D. 2007. Correction: Using participatory design to develop (public) health decision support systems through GIS, *International Journal of Health Geographics*, 6.

Ebi, K. 2009. Public Health Responses to the Risks of Climate Change Variability and Change in the United States, *Journal of Occupational and Environmental Medicine*, 51(1): 4-12.

Ebi, K., Mills, D., Smith, J., and Grambsch, A. 2006. Review - Climate Change and Human Health Impacts in the United States: An Update on the Results of the U.S. National Assessment, *Environmental Health Perspectives,* 114: 7.

Ebi, K., and Semenza, J. 2008. Community-Based Adaptation to the Health Impacts of Climate Change, *American Journal of Preventive Medicine,* 35: 501-507.

Ebi, K., Helmer, M., and Vainio, J. 2008. The Health Impacts of Climate Change: Getting Started on a New Theme, *Prehospital and Disaster Medicine,* 23: S60-64.

Engle, N. L. 2011. Adaptive capacity and its assessment, *Global Environmental Change*, 21 (2): 647-656.

Friend, J. and Hickling, A. 2005. *Planning Under Pressure: The Strategic Choice Approach*, Oxford: Elsevier Butterworth-Heinemann.

Frumkin, H., and McMichael, A.J. 2008. Climate Change and Public Health Thinking, Communicating, Acting, *American Journal of Preventive Medicine*, 35: 403-410.

Frumkin, H., McMichael, A.J., and Hess, J. 2008a. Climate Change and the Health of the Public Introduction, *American Journal of Preventive Medicine*, 35: 401-402.

Frumkin, H., Hess, J., Luber, G., Malilay, J., and McGeehin, M. 2008b. Climate change: The public health response, *American Journal of Public Health*, 98: 435-445.

Fussel, H. 2007. Vulnerability: A generally applicable conceptual framework for climate change research, Global Environmental Change, 17: 155-167.

Futerra Sustainability Communications. undated. *Sizzle: the new climate message*. Available at: www.futerra.co.uk/downloads/

Greenough, G., McGeehin, M., Bernard, S., Trtanji, J., Riad, J., and Engelberg, D. 2001. The Potential Impacts of Climate Variability and Change on Health Impacts of Extreme Weather Events in the United States, *Environmental Health Perspectives,* 109: 8.

Geenwood, R., Oliver, C., Suddaby, R., and Sahlin, K. (Eds.). 2008. *The Sage Handbook of Organizational Institutionalism.* London: Sage Publications.

Haines, A. 2008. Climate Change and Health, *American Journal of Preventive Medicine*, 35: 411-413.

Haines, A, McMichael, A.J., and Epstein, P. 2000. Environment and health: 2. Global climate change and health, *Canadian Medical Association Journal,* 163: 6.

Heikkila, T, and Gerlak, A. 2005. The formation of large-scale collaborative resource management institutions: Clarifying the roles of stakeholders, science and institutions, *The Policy Studies Journal*, 4: 583-612.

Hess, C., and Ostrom, E. 2006. A framework for analysing the microbiological commons, *International Social Science Journal,* 58: 335-349.

Huang, C., Vaneckova, P., Wang, X., FitzGerald, G., Guo, Y and Tong, S. 2011. Constraints and Barriers to Public Health and Adaptation to Climate Change, *American Journal of Preventive Medicine*, 40 (2): 183-190.

Huntingford, C., Hemming, D., Gash, J., Gedney, N., and Nuttall, P. 2007. Impact of climate change on health: what is required of climate modellers?, *Transactions of the Royal Society of Tropical Medicine and Hygiene,* 101: 97-103.

IPCC. 2007. *Appendix I: Glossary from the IPCC Fourth Assessment Report (Working Group II Report "Impacts, Adaptation and Vulnerability"),* Intergovernmental Panel on Climate Change, Pp. 15.

Keim, M. 2008. Building Human Resilience: The Role of Public Health Preparedness and Response as an Adaptation to Climate Change, *American Journal of Preventive Medicine,* 35: 508-516.

Kelly, P., and Adger, W. 2000. Theory and practice in assessing vulnerability to climate change and facilitating adaptation, Climatic Change, 47: 325-352.

Klein, R. J. T. 2004. "Vulnerability Indices - An Academic Perspective: Expert Meeting "Developing a Method for Addressing Vulnerability to Climate Change and Climate Change Impact Management: To Index or Not To Index?" Bonn, Germany, 26 January 2004." Pp. 17.

Lange, M., and Gregor, J. 2009. *Climate Change, Water Supplies and Health: A resource for health professionals, planners and small water suppliers,* ESR Report to the Ministry of Health, Client Report Number FW09083. Available at: www.esr.cri.nz/publications/Pages/MinistryofHealth.aspx

Lawrence, J., Tegg, S., Reisinger, A. and Quade, D. 2011. *Vulnerability and adaptation to increased flood risk with climate change – Hutt Valley summary,* New Zealand Climate Change Research Institute, Report 2011-02. Available at: www.victoria.ac.nz/sgees/research-centres/ccri/ccri-publications

Maibach, E., Roser-Renouf, C., and Leiserowitz, A. 2008. Communication and Marketing as Climate Change Intervention Assets: A Public Health Perspective, *American Journal of Preventive Medicine,* 35: 488-500.

Manning, M., Chapman, R., Hales, S., Howden-Chapman, P., King, D., Kjellstrom, T,. Lawrence, J. and Lindsay, G. 2011. *Synthesis: Community vulnerability, resilience and adaptation to climate change in New Zealand,* New Zealand Climate Change Research Institute, Report 2011-01. Available at: www.victoria.ac.nz/sgees/research-centres/ccri/ccri-publications

Manyena, S. 2006. The concept of resilience revisited, *Disasters*, 30: 433-450.

Martens, P., and McMichael, A.J. (eds.) 2002. *Environmental Change, Climate and Health: Issues and research methods.* Cambridge University Press, Cambridge, UK.

McMichael, A.J., and Haines, A. 1997. Education and debate: Global climate change: the potential effects on health. *British Medical Journal,* 315(7111): 5.

McMichael, A.J., Woodruff, R., and Hales, S. 2006. Climate change and human health: present and future risks, *The Lancet*, 367: 859-869.

Measham, T. G., Preston, B. L., Smith, T. F., Brooke, C., Gorddard, R., Withycombe, G. and Morrison, C. 2011. Adapting to climate change through local municipal planning: barriers and challenges, *Mitigation and Adaptation Strategies for Global Change,* 16 (8): 889-909.

Meinke, H., Nelson, R., Kokic, P., Stone, R. Selvaraju, R., and Baethgen, W. 2006. Actionable climate knowledge: from analysis to synthesis, *Climate Research*, 33: 101-110.

Milfont, T. (2010) Global warming, climate change and human psychology, in Corral-Verdugo, V., Garcia-Cadena, C. H. and Frias-Armenta, M (eds) *Psychological approaches to sustainability: Current trends in theory, research and practice,* Pp. 19-42.

Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., Walker, B., Birkmann, J., van der Leuw, S., Rocström ,J., Hinkel, J., Downing, T., Folke, C. and Nelson, D. 2010. Resilience and Vulnerability: Complementary or Conflicting Concepts, *Ecology and Society,* 15 (3): 11 [online]. Available at: www.ecologyandsociety.org/vol15/iss3/art11/

Ministry for the Environment (MfE) 2004. *Preparing for climate change: A guide for local government in New Zealand,* Pp. 29: Ministry for the Environment (New Zealand).

Moore, S., Mawji, A., Shiell, A., and Noseworthy, T. 2007. Public health preparedness: a systems-level approach, *Journal of Epidemiology and Community Health*, 61: 282-286.

Moser, S. C., Kasperson, R., Yohe, G., and Agyeman, J. 2008. Adaptation to Climate Change in the Northeast United States: Opportunities, processes, constraints, *Mitigation and adaptation strategies for global change,* 13: 643-659.

Nelson, R., Kokic, P., Crimp, S., Meinke, H. and Howden, S. M. 2010. The vulnerability of Australian rural communities to climate variability and change: Part 1 – Conceptualising and measuring vulnerability, *Environmental Science and Policy,* 13: 8-17.

Patterson, J. A., Ford, j. D., Ford, L. B., Lesnikowski, A., Berry, P., Henderson, J. and Heymann, J. 2012.

Adaptation to climate change in the Ontario public health sector, *BMC Public Health*, 12: 452. Available at: www.biomedcentral.com/1471-2458-12-452

Patz, J., Michael A., McGeehin, S., Bernard, M., Ebi, K., Epstein, P., Grambsch, A., Gubler, D., Reiter, P., Romieu, I., Rose, J., Samet, J., and Trtanji, J. 2000. The Potential Health Impacts of Climate Variability and Change for the United States: Executive Summary of the Report of the Health Sector of the U.S. National Assessment, E*nvironmental Health Perspectives*, 108: 10.

Pelling, M., and High, C. 2005. Understanding adaptation: What can social capital offer assessments of adaptive capacity?, *Global Environmental Change-Human and Policy Dimensions,* 15: 308-319.

Putnam, R. 1995. Tuning in, tuning out: The strange disappearance of social capital in America, PS: *Political Science and Politics*, 28 (4): 664-683.

Roberts, D. 2008. Thinking globally, acting locally - institutionalizing climate change at the local government level in Durban, South Africa, *Environment and Urbanization,* 20: 521-537.

Rojas Blanco, A. 2006. Local initiatives and adaptation to climate change, Disasters, 30: 140-147.

Sheffield, P. E. and Landigren, P. J. 2011. Global Climate Change and Children's health: Threats and Strategies for Prevention, *Environmental Health Perspectives,* 119 (3): 291-298.

Smit, B, and Wandel J. 2006. Adaptation, adaptive capacity and vulnerability, Global Environmental Change, 16: 282-292.

Stephenson, J. 2009. Climate Change: Observations on federal efforts to adapt to a changing climate, in *GAO-09-534T* (ed.) Washington DC: Government Accountability Office.

Tol, R. 2005. Adaptation and mitigation: Trade-offs in substance and methods, *Environmental Science and Policy,* 8: 572-578.

Whitmarsh, L. 2008. Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioural response, *Journal of Risk Research*, 11: 351-374.

Wiseman, J., and Nolan, T. 2008. Climate transformation: the next revolution in public health?, *Journal of Public Health*, 30: 362-363.

Wolf, J. 2011. Climate Change Adaptation as a Social Process, *Advances in Global Change Research*, 42 (1): 21-32.

Yohe, G., and Tol, R. 2002. Indicators for social and economic coping capacity - moving toward a working definition of adaptive capacity, *Global Environmental Change*, 12: 16.