BUILDING PERFORMANCE

Global Resiliency Dialogue Second Survey of Building Code Stakeholders – New Zealand

Delivering Climate Responsive Resilient Building Codes and Standards

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government

Contents

About Building Performance

MBIE is the over-arching regulator of New Zealand's building system. Our Building System Performance (BSP) branch provides policy and technical advice on New Zealand's building system, rules and standards, and implements building legislation and regulations to meet New Zealand's current and future needs.

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Executive Summary

Climate change and its potential impacts right across society and the economy is centre stage in New Zealand (NZ), and the Government as well as a number of cities have declared climate emergencies.

NZ is a signatory to the Paris Agreement and The Climate Change Response (Zero Carbon) Amendment Act 2019 requires the government to publish an emissions reduction plan by 31 May 2022. This will set out how NZ will meet its climate targets. The Act also requires the publication of a National Climate Change Risk Assessment (completed in 2020) and a National Adaptation Plan (scheduled to be completed in 2022).

NZ has had a performance-based Building Code since 1992 and it is primarily focused on life safety. Feedback from the 2020 Global Resiliency Dialogue survey identified that there is an opportunity to address issues of building resilience and occupant wellbeing in the face of expected changes to the climate in the NZ Building Code. Outcomes of improving requirements for resilience identified in the survey included:

- reduced economic losses,
- improved public health, safety and wellbeing, and
- faster post-disaster recovery.

People living and working in buildings that are more resilient would have greater confidence in surviving climate change induced scenarios, such as extreme weather events. This would positively contribute to social stability, both in the short term and long term.

Improved requirements for greater resilience has the perceived potential for reduced social disruption to residents and communities, and a reduced number of "uninsurable" buildings. Recovery times could be reduced and there would be less financial strain on communities and service providers.

Barriers to achieving this include a perception of increased upfront building costs, as well as lack of industry capacity and expertise. The need for improved quality and availability of future climate data in suitable formats for government agencies, local government, other end users and the public was highlighted, and a role for central government agencies to fund and curate this was identified.

Drivers for change include the NZ Government's National Adaptation Plan, which will address climate resilience across the whole NZ economy, and MBIE's Building for Climate programme, which is considering changes to the building regulatory system specifically, including Building Code settings, in light of projected future climate scenarios.

While building codes have an important role to play, they are only part of what is required. Society needs 'the right buildings in the right places'. The resource management and planning systems need to be responsive to climate change and prevent buildings and infrastructure being built in locations where climate change will exacerbate natural hazards and risk damage and stranded assets. A current restructuring of the resource management regulatory system in NZ offers an opportunity to address disconnect between central and local government policy in this space.

In addition to building code settings and resource management and planning systems, there is a range of non-regulatory levers such as information and guidance (e.g. a web portal) that can be used to drive interest and momentum in more climate resilient buildings. These can also target existing buildings where building codes usually have limited application, such as in major refurbishments and alterations. The availability and cost of insurance will also play a role in where and how buildings can be built.

Background

The Global Resiliency Dialogue was launched in July 2019 by building code development and research organisations, along with interested government and non-governmental stakeholders, based in Canada, Australia, New Zealand and the USA (CANZUS). The joint goal of this international collaboration is to collectively identify solutions to help address the global challenge posed by the impact of increasingly frequent and extreme weather events and hazard risks (including heatwaves), on building occupants and buildings.

The Global Resiliency Dialogue has two overarching objectives. Firstly, to share leading practice and help inform the ongoing development of building codes that draw on the latest technical building practices and climate science to improve the resilience of buildings and structures. Secondly, it is about enhancing the utility of existing building codes to respond proportionately to rapidly changing and predicted extreme weather events such as flooding, storms, cyclones/hurricanes and wildfires/bushfires and heatwaves.

The founding members of the Global Resiliency Dialogue, together with supporting stakeholders, recognise that current building codes around the world may not provide the same level of safety and resilience for future extreme weather events as they have in past.

Dialogue partners agree in principle that it is desirable and increasingly necessary for codes and standards to respond to the latest research and data from the perspective of both building/technical science and climate/environment science, if they are to maintain not only an expected level of safety and amenity, but also an appropriate level of resilience. By working together, the participating organizations can pool their collective resources, experience and knowledge to create guidelines that will be of both national value and global benefit[1].

The first report[2] developed through the collective engagement of the Global Resiliency Dialogue partnership, investigated how climate-based risks are currently treated in national building codes and standards. In addition to input from the four founding Global Resiliency Dialogue participants – the Australian Building Codes Board (ABCB), the National Research Council of Canada, the New Zealand Ministry of Business, Innovation and Employment (MBIE), and the International Code Council (based in the United States) - responses to the first survey were received by counterpart organisations in Germany, the Netherlands, Norway and Japan. This broadening of international interest offered a more contemporary snapshot of the current status and approaches to integrating climate science in existing building codes around the world.

The second phase of the Global Resiliency Dialogue's research was a survey distributed in late 2020 to selected stakeholders based in Canada, Australia, New Zealand, and the USA. The survey sought input from climate scientists, design professionals, standards developers and peak industry, emergency management and professional bodies on a range of opportunities and challenges to better address resilience needs in the built environment.

The second survey also sought to better understand and determine what possibilities and different types of climate modelling exist or are under development to enable building codes to be more predictive and forward-looking in anticipation of extreme weather events and hazards that are likely to impact the built environment.

The findings from both reports will provide the foundation for the development of international Building Resilience Guidelines, anticipated to be released in 2022.

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[1] See https://www.iccsafe.org/wp-content/uploads/Findings_ChangingRisk_BldgCodes.pdf
[2] The Use of Climate Data and Assessment of Extreme Weather Event Risks in Building

Survey Responses from New Zealand stakeholders

In December 2020, the Ministry of Business, Innovation, and Employment (MBIE) invited 21 stakeholders to respond to the Global Resilience Dialogue second survey.

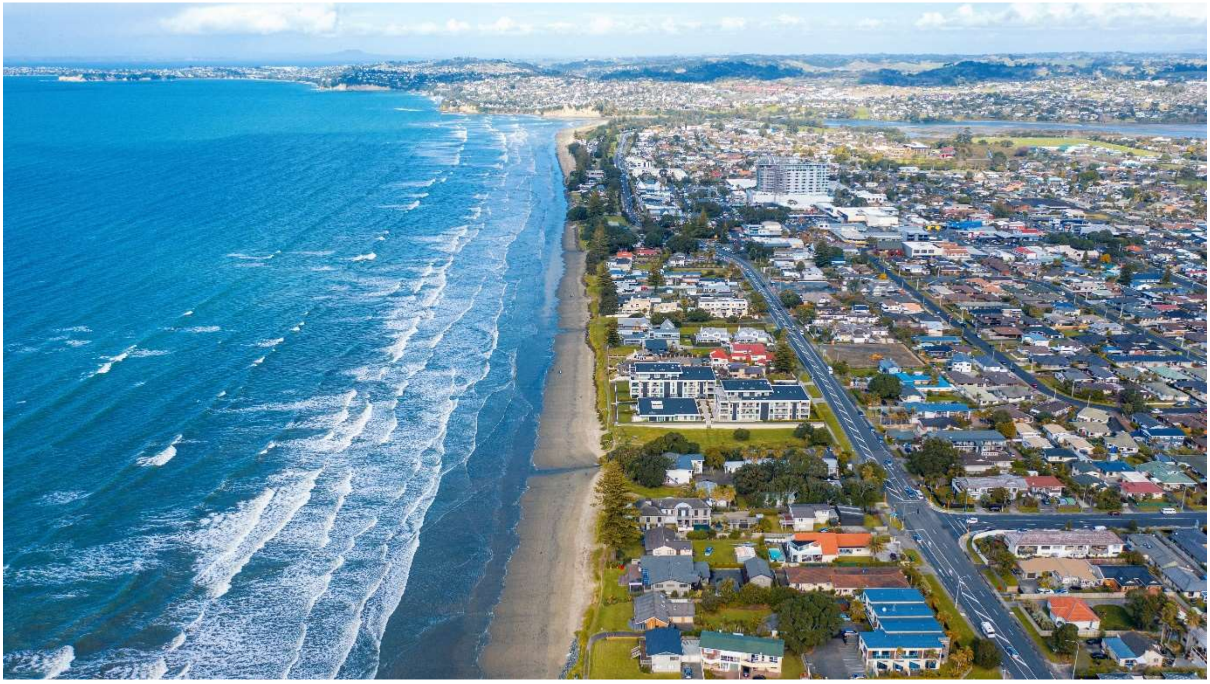
The majority of survey recipients were New Zealand government agencies with an interest in climate change adaptation. Other respondents included:

- research organisations
- professional associations
- local government organisations

Six responses were received. The low response rate can be attributed to the survey coinciding with the summer break as well as a busy period for government agencies involved in climate change policy work. Given the low response rate, the survey results cannot be viewed as representative of the New Zealand construction sector or Government, but nevertheless give an indication of the main issues as seen by some of the main stakeholders.

New Zealand's Cross-Government Climate Change Initiatives

The New Zealand Government is currently developing an Emissions Reduction Plan and a National Adaptation plan as part of its climate change commitments. A reform of the New Zealand resource management system is also underway. The Resource Management Act will be replaced by three new acts - the Natural and Built Environments Act, the Strategic Planning Act and the Climate Adaptation Act. There will be extensive consultation across the sector as these initiatives progress.



Orewa, a suburb of Auckland, an example of a community at risk from greater frequency of storms, as well as rising sea levels (credit: Rodrigo.NZ/Shutterstock.com)

Introducing Building Resilience into the New Zealand Building Code

Impacts and Barriers to achieving a more resilient Building Code

The survey asked about potential barriers and impacts of using the New Zealand Building Code to helping achieve more resilience. Some of the major themes have been listed below.

Impacts

One of the most notable impacts was that building codes had potential to improve the health and safety of occupants in buildings. The view was that the goal should be about moving beyond a life safety focus in the Building Code towards addressing the broader issue of building durability, restoration and resilience.

Outcomes of improving building code requirements for resilience identified in the survey included:

- reduced economic losses,
- improved public health, safety and wellbeing, and
- faster post-disaster recovery.

It was also noted that people living in more resilient buildings would have more confidence in surviving climate change induced scenarios, such as extreme weather conditions. This would positively contribute to social stability, both in the short term and long term.

There was potential for reduced social disruption to residents and communities, and a reduced number of "uninsurable" buildings that would be in existence. Recovery times could be reduced and there would also be less financial strain on communities, service providers. Less displacement of individuals was also noted as an impact.

Knowledge and understanding of climate change were common themes. Since climate change was a gradual and slow process, some impacts couldn’t be seen or predicted accurately yet and there were ongoing discussions and arguments around its causes and solutions as a result.

Barriers

Cost was seen as a barrier to improving building performance and resilience if it resulted in higher initial building costs, even if the whole-of-life costs to the occupants and public were lower. There were challenges with ensuring costs were fairly distributed across society and with significant costs falling on individual building owners if required to undertake expensive retrofits.

Industry capacity and expertise were also themes. There was a poor understanding of the link between building design and well-being, and a lack of skills and information to design and construct buildings suitable for the future.

Disconnections between decision makers, unclear roles and responsibilities, slow process to roll out, long life of assets, difficulty in shifting communities were also identified as barriers.

Main drivers for achieving a more resilient Building Code

A key government action and driver flagged was the need to reduce disruptions and costs arising from inadequate building performance.

In New Zealand, Cabinet has agreed to implement a framework which will drive climate change policy towards low greenhouse gas emissions (emissions) and climate resilience. It also passed the Climate Change Response (Zero Carbon) Amendment Act and established an independent Climate Change Commission (CCC). A national climate change risk assessment has been completed and a National Adaptation plan is in development. The plan would include; outcome-focussed action plans for homes, buildings and places, and infrastructure.

In the past there has been disconnect between central and local government over resource management. This is being addressed with a restructuring of the resource management system.

Some regional councils in New Zealand had proposed that where a new build is constructed in an encroachment zone, it would be required to be relocated if necessary.

There was some community demand for more resilient buildings, but often only after a damaging event when the gap between expected performance of the building stock and the actual performance was realised. Damaging events also highlight for the public the benefits of resilient buildings and infrastructure for social and community cohesion

Climate change and natural hazard researchers in New Zealand, as well as climate change lobby groups, were increasingly vocal on climate change risks and the need to mitigate and adapt. They have been actively promoting this directly to central government and the general public.

Changes in insurance due to climate change was another driver. Insurance cover for buildings was widespread and was generally a requirement from financiers. However, it was increasingly likely that insurers would retreat from areas of high risk from climate change in the future.

Current Challenges

Data and Research

Data use in Codes

Responses to the question of what is the ideal source and format of future climate data for codes generally supported the role of central government agencies or entities in funding and curating climate data.

In New Zealand, the National Institute for Water and Atmosphere (NIWA) and MetService NZ have a complete network for climate and weather monitoring. Meanwhile, some regional councils were running their own networks for monitoring of contaminants of concern (e.g. nitrogen and sulphur oxides and particulate matters (PMs)). Climate data is available from the National Climate Database. Ideally, all data should be available from an open source and be integrated with material performance data.

Other sources suggested included:

- A National science agency to facilitate procurement, funded by the Government building regulator.
- The building regulator, in partnership with the engineering profession.
- Central government, as the building system regulator - not local authorities or private/ non-government entities. Government was potentially better resourced with more influence and broader networks.

- Maps and intensity / scenario severity to inform minimum actions and decisions for users, and a centralised geographic information system (GIS) model containing nationally agreed forecast data.

There were many organisations, e.g. the Resilience National Science Challenge, that were or would be studying the processes of global and local climate changes and their impacts on buildings from different angles. Consequently, a large amount of data, would be produced. It would be ideal if these studies were supported and/or encouraged, through e.g. more research funding opportunities from government. Meanwhile, suitable channels should be established or streamlined to ensure information essential to inform building code change or upgrade was available.

Future climate data would ideally be in EnergyPlus format to support building performance simulation.

Gaps

Data and research are needed on:

- the relationship between building design, climate and occupant/public well-being to support the development of design tools and building solutions;
- performance of current buildings in future climates, to develop a baseline for proposed changes to codes; and
- testing future building systems to establish their performance under future climates.

Long term trends of climatic and environmental data were critical. Changes in some climatic and environmental factors were slower however, and their influence on material durability and building performance may not be identified in time. Long-term monitoring via a system approach would be necessary (e.g. how climate change is affecting microclimates) to understand how changes would interact with change in building typology and construction methodology.

The Downscaling Issue

Measured data and mapping of impacts would be valuable to industry and communities. Representative concentration pathways (RCP) scenarios from the Intergovernmental Panel on Climate Change (IPCC) / NIWA overlaid with regional maps would help to understand spatial impacts.

Robust regional climate risk data, consistent flood maps, standardised RCP scenarios, greater research on non-asset implications, better holistic understanding of the building within the supporting ecosystem would help. Reliable modelled future climate data was needed at a local and national level in location tables and/or maps.

What Representative Concentration Pathway (RCP) should be used for future climate scenarios?

Responses to this question were not all explicit, and focused on the need to be context specific. The climate scenario used for code development should be selected based on what the consequences would be if greater changes to climate occurred. The selection of a climate scenario should consider impacts on materials durability, building performance and occupant health & safety, in terms of extent and time scale.

Whilst some respondents suggested there was no consensus on a particular RCP to adopt across the board, RCP8.5 was put forward as the one we are currently tracking, and sensible as the worst case option.

Risk Assessments

Key risks and challenges included unpredictability, and gaps in understanding about how existing risks impact existing and future infrastructure and buildings, and the ability to influence / impact before vs. during life of infrastructure. There was also a risk with underestimating extreme events and potentially suffering significant building failures in the future, or overestimating events and locking in excess embodied carbon and high costs.

Others issues were around limitations of existing data sources, inconsistent methods and resourcing and research costs. There were also limited channels for disseminating risk information. Integrating building regulation and codes with land use planning decision-making was important. One view was that given the uncertainty in predicting future climates, risks should be treated simply in codes.

Changing risks needed to be balanced against certainty of performance for building development and maintenance. Context specific approaches based on thresholds for change could be beneficial. How you include regulatory requirements to monitor changes in climatic conditions and climate risk was seen as tricky, but in some cases may be unavoidable and the building regulatory system would also need to adapt.

Emphasis should be on predicted risks and prevention rather than cure. Monitoring and standardization would be useful for confirming predicted changes. Monitoring was needed to ensure solutions were appropriate and to grow the body of knowledge. There was a balance to be struck between the quality and granularity of information, and difficulty and cost of collecting it. This would likely be an open question until we better understood the magnitude of projected climate changes relative to extremes already included in current design processes.

The current state of climate science was seen as limiting for designing for extreme events. Uncertainty limited confidence in decision making. There was also a lack of knowledge and comprehension about the potential impacts, fragmented activities, and uncertainty about the best solutions. Many actors in this space may need to come together to optimise solutions.

Designers could account for extreme events but were hard-pressed to determine and communicate the benefits of resilience to clients. Some extreme events (e.g. wind, snow loading, water penetration) were not well accounted for in current weather and climate hazard models.

Advances needed

Modelling could be more expansive and would be helpful if environmental or climatic factors were modelled together with other factors to show collaborative effects. Current modelling was more focused on temperature which may directly/indirectly influence material environmental degradation, and durability. When considering the amplitude of temperature change, it was difficult to evaluate/predict their influences.

Advancements in modelling data were needed, and there were significant gaps in pluvial/ fluvial flooding modelling data and also when two climate variables intersect.

A need for more regional-focused approaches to addressing key climate risks would also help. Anticipating droughts may prompt considerations for alternative water conservation means, such as rainwater and greywater.

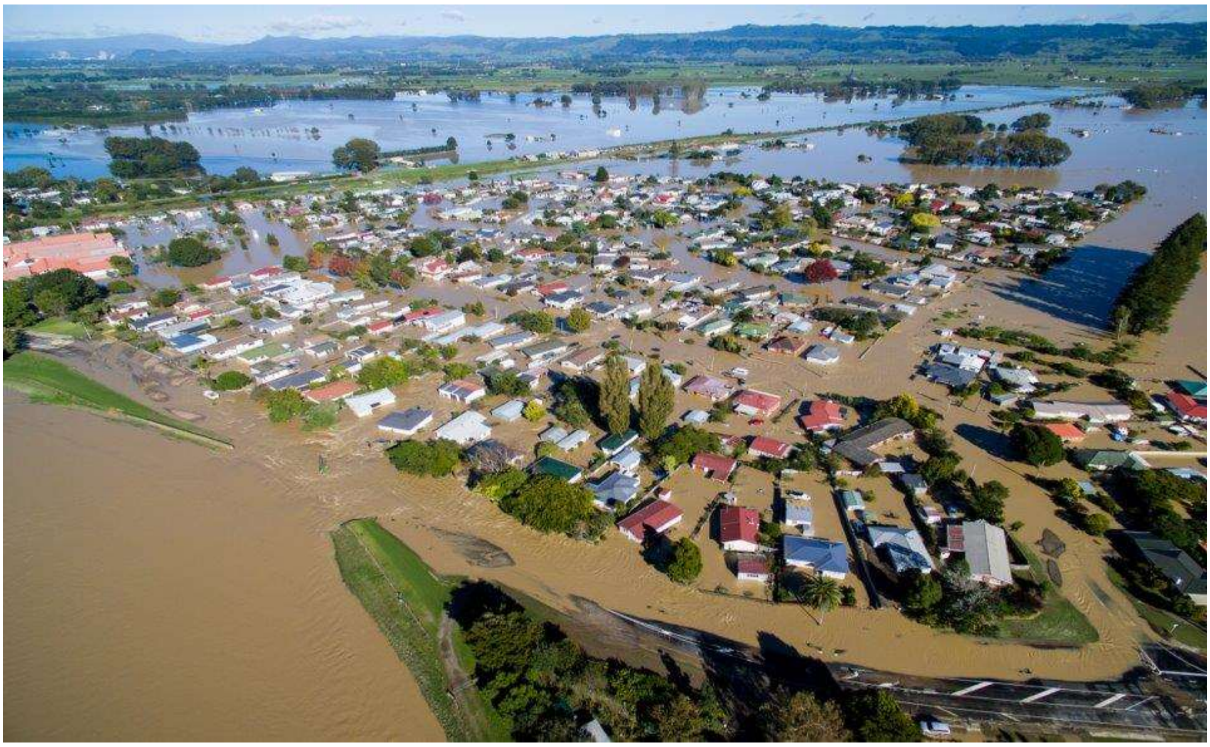
More advancement in modelling of regional forest/rural fire risks, wind speeds, and regional flood and inundation mapping was required. Mapping of areas where future rises in the water table from climate change may be subject to liquefaction during seismic events should also be considered.

More funding was required to support research around legal aspects of climate change in relation to buildings, and is an area of underinvestment in New Zealand.

There was a need for more collaboration between New Zealand building research institutes, consulting engineers, and building regulators to identify scope, data and science gaps. Research was underway on climate change in a number of universities and research institutions across New Zealand. Areas of focus include:

- more accurately forecasting New Zealand's weather at the landscape-scale,
- characterising New Zealand's recent climate so that recent changes and trends can be identified and risks to New Zealand's building stock, infrastructure and economy due to weather-related hazards can be assessed,
- extreme events and the emergence of climate change, and
- machine learning approaches to downscale seasonal climate forecasts and for advanced coastal storm surge predictions.

Two collaborative national science challenges -'Resilience to Nature's Challenges' and 'The Deep South' - also had research looking at climate change and its impacts.



Flooding in Edgecumbe New Zealand, caused by a cyclone in 2017 damaged over 300 homes (credit: Whakatāne District Council)

Policy Issues

Policy, such as selecting a future climate scenario (RCP) for design, or setting a minimum service life for a building, needed to be context-specific. Design for service life would make sense for important pieces of long-life infrastructure (both public and private). Designing for adaptation would make more sense in areas of potentially highly dynamic change. This emphasised the need to link building code regulation closely with land use planning and decision making.

Policy Discussions

Current policy discussions were highlighted in the survey results. There was a need for an all-of-government approach to policy in order to support the inclusion of resilience considerations in the Building Code. A key discussion needing to take place was around how different resilience regulations, standard and international commitments (e.g. the Paris Agreement) interacted with each other. Within New Zealand, discussions are already taking place around reforming the Resource Management Act, which would introduce separate climate change adaptation regulations[3].

Changes to the New Zealand's Building Act and Building Code were also likely, but will be preceded by policy work and sector and public consultation. These would need to consider construction material innovation and performance testing in light of climate change. Social housing agencies and providers did not set the Building Code, but had their own internal policies around performance requirements. In some areas these performance requirements were higher than the Building Code. These requirements took into account multiple perspectives - construction, customers (users/occupants), and maintenance - all with their own lens on them.

The Department of Internal Affairs (DIA) which administers the Local Government Act, had a programme looking at community resilience.

Complementary resilience tools/activities

Complementary tools and activities identified in the survey included:

- Appropriate components could be included in relevant training and educational practices/courses for the building and construction industry, especially where updates to codes were concerned. In situations where modelling was important, open access data to help with modelling was highly important.
- Suitable and updated information should be delivered to communities through appropriate channels continuously. Clear and consistent language was needed and building capacity for solutions and ways to address, encourage and incentivise innovative solutions. The use of case studies to provide practical examples of changes and impacts would be important to help people think through decisions.
- Financial incentives to assist building owners to retrofit existing buildings and design more resilient new buildings have a role. The availability (or lack of) insurance cover and the price of premiums was an effective way of communicating risk to communities.
- Innovation in the performance and installation of construction materials could improve resilience.

[3] https://www.mfe.govt.nz/rma/resource-management-system-reform

Social equity concerns

Equity issues needed to be informed by research on the performance of existing buildings subject to climate change and the consequences on occupant/public well-being.

Appropriate consultation and stakeholder engagement was key, especially for vulnerable groups and indigenous contexts to ensure alignment with cultural practices. Equal access should be understood in economic and cultural terms.

Financial incentives for retro-fits of existing buildings, equity of funding, risks and consequences should inform funding decisions.

Building regulations could extend building code requirements to apply retrospectively to existing buildings. This had already been done to a limited extent, for earthquake prone buildings and for fire and accessibility purposes. These requirements were not popular with many owners due to cost.

Cost, mitigation & resilience

Both initial and whole-of-life building costs should be considered from the perspectives of building owners/occupants and the public. When considering resilience options, the operational and embodied carbon emissions must also be considered to ensure the optimal solutions are adopted. Beyond financial terms, co-benefits should be considered, building resilience can mean reduced energy bills (energy efficiency, on site generation), less displacement of individuals etc.

In terms of design, working within a planetary boundaries approach, especially a carbon budget for an individual building was helpful, as it allowed flexibility in terms of materials selection.

Community engagement would be key to establishing levels of acceptable risk and resilient performance expectations.

Planned Data/Research

In terms of planned research to address gaps, a range of actions were noted:

- The Building Research Association of New Zealand (BRANZ) had studies looking at the potential effects of climate change on New Zealand's atmospheric corrosivity. BRANZ was developing a monitoring network with long-term environmental and material performance components. The data would provide a baseline for climate change assessments and investigations on its impacts on materials durability.
- NIWA's ‘Our Future Climate New Zealand’ programme was looking at wind speeds, hot days, frost days, precipitation, wet days, very wet days, surface radiation and relative humidity.
- At least one government agency had a resilience project underway to provide a roadmap for greater resilience across their estate. Their ‘Change Roadmap’ was also underway, highlighting key hazards and risks to estates and operations, and information gaps.
- Studies by the Ministry for the Environment (MfE) and NIWA to scale down the predictions of IPCC reports to local levels.
- Work on a National flood model led by DIA.

Other Considerations

The Treaty of Waitangi (Te Tiriti o Waitangi) is a founding document of New Zealand that provides ongoing obligations in regards to the rights and interests of Māori. The Treaty, related legislation and settlements are key considerations in the development of policy in New Zealand and will be important considerations within any resiliency initiatives.

Communication

Stakeholder engagement

Government

Key government stakeholders that were identified for engagement included:

- Building code regulators: the Building Performance branch of MBIE, and Ministry of Housing and Urban Development (HUD),
- Ministry for the Environment (MfE)
- The Climate Change Commission (CCC)
- Treasury
- Building Consent Authorities/local government.

Industry

Industry stakeholders identified included: product suppliers, building designers and engineers, insurance, finance, building practitioners (large organisations such as Master Builders, but others like Passive House and small and medium enterprises (SMES) and building users (consumer groups and citizens) should be engaged. Climate modellers and researchers and the Lifelines Council should also be engaged.

Information and format

One of the themes that emerged was that more information was required about the costs and benefits of improving resilience. Also, context around international responses to climate change and comparisons to national contexts. Information on causes, impacts and potential adaptation/mitigation plans should also be covered, along with case studies.

Clear, easily accessible guidelines for different audiences would also help. Clear messaging, robust guidance on how to integrate, and strong imagery/interactive maps showing where/how climates would change in locations over time would be beneficial.

Implementation in codes

The information in the New Zealand Building Code should be tailored to a range of different stakeholders, i.e. regulators may prefer scientific data, while building users may prefer evidence and costs. Processes involving local communities have worked, and dynamic adaptive pathways planning should be used in urgent cases with specific communities.

Appropriate levels of engagement early on would also help. The MfE website contains helpful information including a climate change regional map. [4]A number of councils had online maps showing climate hazard zones and were starting to include forecast flooding and inundation

[4] https://www.mfe.govt.nz/climate-change/likely-impacts-of-climate-change/how-could-climate-change-affect-my-region.

maps (e.g. Wellington). In some cases owners were proactively informed of future risks by the local council.

Code content

Resilience and sustainability should be considered in all functional performance requirements. Planning regulations should be in parallel with codes to harmonise resilience, and applied for land uses and consenting.

There was general agreement that they should apply to public sector buildings, but there were mixed views on private sector buildings, due to affordability and complexities. Regulation was appropriate to set minimum acceptable levels of resilience and meet international commitments. Insurers and financiers could also withdraw cover.

Agreeing on thresholds for code changes could be problematic, with different views expressed:

- It would be better to agree on desired building states/timeframes/actions
- Thresholds for determining building performance and durability required, but unsure how these could be developed/quantified based on reliable data.
- A need to understand at what point change makes sense and how close we are to a threshold. Careful consideration required in decision making for large scale developments when thresholds may be close.
- Step changes would allow time for adjustment and improve chance of success. Solutions should be flexible due to the complexity, and outcomes-focussed rather than prescriptive.

Climate data referenced in codes

In terms of how often climate data referenced in codes should be updated, there were mixed views. These included 10 years, annually (but with NIWA advising on accuracy, certainty and availability of update), and five yearly when an agreed threshold was exceeded.

Another view suggested a more dynamic adaptive approach, at a rate commensurate with changing baselines and thresholds, and the expected lifetime/utility of the built structure/infrastructure. It should reflect the best available evidence, because climate impacts and trajectories are constantly changing.

Future climate states and climate modelling

The climate scenario used for code development should be based on the consequences if greater changes to climate occur. Both the worst case and optimistic situations should be presented. This would give designers/ users space and flexibility to accommodate specific demands and requirements.

A dynamic adaptive pathway planning approach was being considered by agencies with built assets and infrastructure.

Non-stationary climate

In terms of ways non-stationary climate could be addressed in codes, in New Zealand this could include aspects of materials specification, structural integrity/stability and carbon emissions. This would include mapping of atmospheric corrosivity zones, wind zones, climate zones and earthquake hazard zones (due to water table level changes influencing ground liquefaction risk).

This could also be done by ensuring a conservative RCP is used for modelled climate data and regularly review which RCP is appropriate as future carbon emissions are reported globally.

Cultural and heritage issues

In regards to how cultural, environmental and heritage issues should be balanced in land use planning and building codes, this was seen as a difficult and challenging area.

The impact of climate change on cultural and heritage sites had been examined by the Department of Conservation (DOC[5]). More research was required to determine how this could be applied to the New Zealand Building Code. A range of frameworks existed for considering these factors, and often there were strong co-benefits for cultural, environmental and heritage issues for improving resilience.

Better engagement by government and agencies with Treaty partners, local iwi and hapu, and better integration of Te Tiriti o Waitangi in the code should be considered. Use of natural renewable and rapidly renewable materials would be excellent for resilience. Early and extensive consultation with affected communities was essential to achieving outcomes, and the Crown's Treaty partnership with Maori meant particular attention needed to be taken to ensure their involvement in decision making.

Expected life service

Regarding the ideal expected service life of different buildings, location, function, value, usage and maintenance should be considered. A balance between durability, environmental impact and cost was necessary. The Building Code's default was 50 years minimum but clients could choose longer lives. Embodied and operating emissions over the life of the building needed to be considered.

In terms of the ideal expected service life of different building systems and materials, the service life of a specific material or a component should be considered with the corrosivity of the surrounding atmosphere, building microenvironments, usage, function and maintenance requirements. A balance between service life and overall embodied carbon should also be considered.

There are 15 year minimum defaults for non-structural cladding and windows, but many products exceeded this. Proposed incorporation of operational and embodied carbon targets over a building's life would influence design choices.

Occupancy and design considerations

There was a need to differentiate buildings according to occupancy during the design stage.

Greater occupancy, and a higher importance level should mean higher performance expectations: this is a feature currently built into the Building Code in a number of areas. More vulnerable occupants should be considered, as they have less ability to respond and adapt, which puts them at higher risk. For example, importance levels for the seismic performance of buildings are currently set in a standard referenced by a Building Code verification method (VM) for structural stability, although policy work is underway to look at whether these should be contained in the VM rather than a referenced document. The same approach could be adopted for climate resilience performance expectations.

[5] https://www.doc.govt.nz/documents/science-and-technical/sfc322high_res.pdf.

Appendix A: Survey Questions

1. Ideal State
1a. What impacts and outcomes can potentially be achieved from the design of codes to ensure life safety and building durability in the context of future natural hazards influenced by changes in climate? (i.e. social, financial, design goals)
1b. What barriers (e.g., understanding the science and how to integrate it, organization learning, capacity for change, political will, cost, etc.) exist to achieving this ideal end state?
1c. What are the main drivers for achieving resilient codes? What entities are leading the discussion/movement?
1d. In which cases should regulation be considered for achieving resiliency goals? In which cases should it not? What alternatives exist to achieving the same goals?
1e. Should entities be established/assigned to monitor and evaluate changing conditions to inform code changes? If yes, should those entities be governmental or non-governmental?
1f. Should thresholds be established to help inform when a code may need to change?
2. Data and Research Requirements
2a. What data and supporting research is needed to enable codes to consider future climate states and extreme weather events? (Examples: measured data, maps, material properties, pilot studies, etc.)
2b. Describe any studies that were undertaken or are planned to identify these gaps
2c. Describe any ongoing research or planned research/programs to address these gaps
2d. What is the ideal source and format of future climate data for codes?
2e. How often should the climate data referenced in the codes be updated to achieve resiliency goals?
3. Climate Science
3a. What advancements in current climate modelling are needed to support codes?
3b. Describe any efforts underway or planned to advance climate science in support of codes.
3c. How can (or should) the uncertainty in future climate states and climate modelling be addressed and communicated in codes?
4. Choice of Future Climate Scenario
4a. In what ways can/should non-stationary climate (climate change) be addressed in codes? Describe any efforts or discussions currently underway (e.g. design for end of service life, design to adapt, etc.).
4b. What needs to be/is being considered in selecting a future climate scenario (RCP) for design? What scenario is currently being used or considered by practitioners?
4c. What is the ideal expected service life of different types of buildings?
4d. What is the ideal expected service life of different types of building systems and materials? (e.g. windows, roofing, cladding)

4e. How does or should differences in occupancy type or importance of buildings factor into design considerations?
5. Extreme Events
5a. What are the current challenges in predicting future risk of extreme weather events?
5b. How should risk from extreme weather events ideally be considered in the design of buildings in a non-stationary climate? (For example: uniform risk vs uniform hazard - should the facility be designed to adapt to changing conditions or should the code include criteria for monitoring change, etc.?)
5c. Is the current solution for designing for extreme events limited by the state of climate science? Will a different solution be possible in the future?
6. Stakeholder Engagement
6a. What stakeholders need to be engaged to ensure the successful integration of resiliency into codes?
6b. What information, and in what format, is needed to successfully engage stakeholders?
6c. Describe any best practices for engaging stakeholders and communicating climate change related information.
6d. What policy discussions are needed to introduce resiliency in codes? Have any occurred in the past or are already underway?
7. Achieving a Culture of Resilience
7a. In addition to codes, what complementary tools or activities are needed to achieve a culture of resilience in the building sector?
7b. What can be done to ensure equal access to resilient buildings? (codes generally apply to new buildings, and only the population who can afford new homes will be initially impacted by codes changes)
7c. How can/should cost, mitigation and resilience considerations be considered and balanced in the design of buildings?
7d. What could happen to buildings that are impacted by an extreme weather event? (e.g. rebuilt, rezoned, loss of insurance)
7e. How is land use regulation and attitudes towards land use adapting to changes in climate? (e.g. managed retreat)