16th World Conference on Earthquake, 16WCEE 2017
Santiago Chile, January 9th to 13th 2017
Paper N° 2397
Registration Code: S-G1461957434

A CASE STUDY OF EARTHQUAKE RESILIENCE DATA PRACTICES: 2010-2011 CANTERBURY EARTHQUAKE DISASTER

S.B. Miles[(1)], L.A. Ritchie[(2)], C.D. Poland[(3)], Y. Xiao[(4)] , N.R. Hedley[(5)]

[(1)] *Senior Research Scientist, Department of Human Centered Design and Engineering, University of Washington, milessb@uw.edu*
[(2)] *Research Assistant Professor, Institute of Behavioral Science, University of Colorado Boulder, liesel.ritchie@colorado.edu*
[(3)] *Consulting Engineer, cpoland@cdpce.com*
[(4)] *Associate Professor, Department of Landscape Architecture & Urban Planning, Texas A&M University, yuxiao@email.tamu.edu*
[(5)] *Associate Professor, Department of Geography, Simon Fraser University, hedley@sfu.ca*

Abstract

In March 2014, an interdisciplinary research team travelled to New Zealand to study issues related to Canterbury's recovery from the 2010-2011 earthquake sequence. One goal of the overall project is to evolve the practice of earthquake reconnaissance from immediate post-disaster investigations to learning about community recovery from earthquakes over the long-term. Towards this end, the aim of the New Zealand case study described here is to understand how stakeholders in New Zealand are measuring, monitoring, and acting upon data-driven indicators of recovery after the Canterbury earthquakes. The research team interviewed a wide range of decision-makers and researchers in the Christchurch region. A broad cross-section of organizations are represented in the qualitative data collected for the study, including Canterbury Earthquake Recovery Authority, Christchurch City Council, and Stronger Christchurch Infrastructure Rebuild Team, as well as 22 other organizations. Initial evaluation of the study data shows that a large variety of data are being collected as part of the recovery, for example a region-wide survey of wellbeing, but it does not appear the available data contributed significantly to ongoing decision making. The large volume of data made it challenging for organizations to analyze and interpret it for decision-making. The public health sector, however, seems to be an exemplar for using data for recovery decision-making. Data describing social vulnerability, homelessness, out-migration, business recovery, and the rental market were found to be less well documented. And while the disaster motivated unprecedented levels of data sharing within and between public and private organizations, privacy concerns and siloes still presented challenges. For future disasters, a possible role for outside experts typically involved in earthquake reconnaissance could be the facilitation of analysis of existing data, promoting access to data that can be compared across disasters, and specific guidance on what data should be collected by researchers to be archived for future cross case study comparison.

Keywords: resilience; reconnaissance; Christchurch

1. Introduction

As one of the most data-rich disasters in history, the 2010-2011 Canterbury earthquake sequence provides a unique opportunity to examine an understudied topic: how key stakeholders in recovery processes collect, share, and use data for recovery-related decision-making. The case study presented here is part of a National Science Foundation grant entitled "Seismic Observatory for Community Resilience—A Program to Learn from Earthquakes" #1235573). [1] The purpose of this component of the research was to gather information about how stakeholders in New Zealand are measuring, monitoring, and acting upon data-driven indicators of recovery after the quakes. The types of recovery data to which this paper refers are associated with indicators about the built environment; the economy; social and human wellbeing; culture; and natural resources. More specifically, the goal of this case study was to identify significant themes related to recovery data practices for the Canterbury earthquake sequence that can inform alternatives for developing institutional and technological arrangements for future seismic resilience observatories.

2. Research Design and Methods

The research design for this case study employed a qualitative approach to create a primary data set describing data practices across a broad array of recovery sectors. In March 2014, a five-member interdisciplinary research team representing sociology, geography, urban planning, information systems, and civil engineering from the United States travelled to New Zealand. There, they interviewed a diverse range of managers, decision-makers, and researchers involved with or studying recovery from the 2010-2011 earthquake sequence. The purpose of the interviews was to gather insights about organizational data practices for measuring and monitoring disaster recovery.

The study used a purposive or criterion-based sampling approach to identify stakeholders from government agencies, academic institutions, and private sector organizations that either had a direct role in recovery management (broadly defined) or research. A list of 122 potential participants was developed through a combination of reaching out to existing contacts, background research conducted by members of the team, and snowball sampling. The research team sent emails or telephoned each of the individuals on the list to request an interview. Ultimately, members of the research team held 45 meetings—typically with multiple stakeholders—during a two week period of site visits in New Zealand. Interviewees included both "high level" users of data (e.g., decision-makers or those who requested the creation of the data), as well as managers and creators of data. Table 1 lists the organizational affiliations of participants in the study.

During these meetings, the research team framed conversations using an eighteen-item semi-structured interview guide designed to facilitate consistency across sessions. In all cases, participants were asked the following primary question: *How do you or your organization understand or monitor recovery from the Canterbury earthquake sequence?* This focusing question was intended to encourage stakeholders to think about and discuss the data and data practices used to support disaster recovery with respect to their responsibilities or research interests. The remainder of the interview guide protocol was used to direct conversations toward relevant insights for the study.

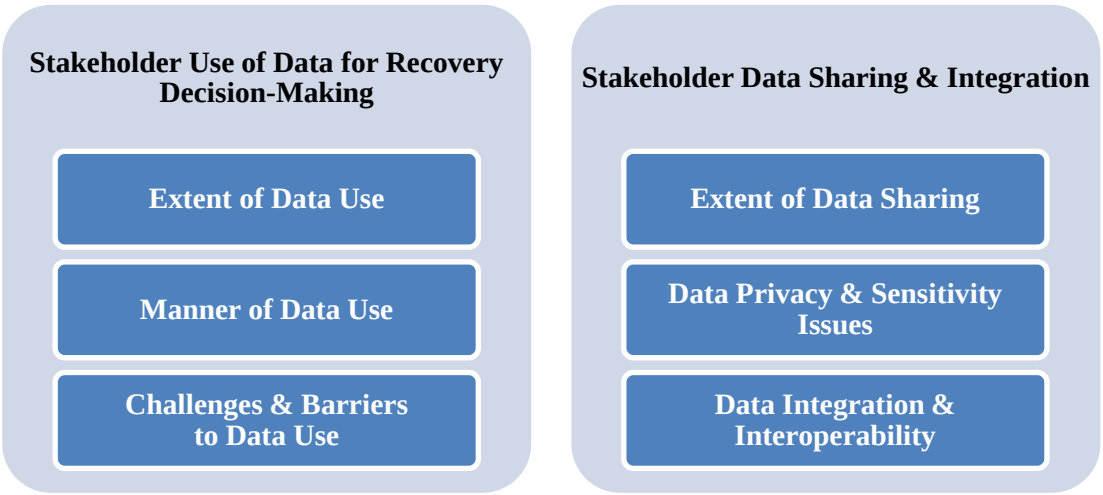
Study participants offered a wide range of insights about how they understood the state of recovery in Canterbury. Many agencies and organizations in New Zealand Data collected or managed data describing a wide range of indicators related to the Canterbury earthquake sequence recovery. Some organizations, such as Statistics New Zealand, were responsible for collecting a variety of data prior to the earthquake and were thus in a position to use this information as a baseline to monitor recovery. Other organizations, such as the Canterbury Earthquake Recovery Authority (CERA) and Strong Christchurch Infrastructure Rebuild Team (SCIRT), were established after the quake and collected data specifically to monitor indicators related to reconstruction and recovery. Similarly, a number of researchers from various universities and institutions collected data to study effects of the earthquakes and recovery trends.

Table 1 – Organizational affiliations of study participants

Building Officials Institute of New Zealand Canterbury Development Corporation (CDC) Canterbury District Health Board (CDHB) Canterbury Earthquake Recovery Authority (CERA) Canterbury Employers Chamber of Commerce Christchurch and Canterbury Tourism Board Christchurch City Council (CCC) CORE Education Ltd. GNS Science Healthy Christchurch Holmes Consulting Group Human Rights Commission (HRC) Lincoln University	Massey University Ministry of Business, Innovation, and Employment (MBIE) Ministry of Education New Zealand Historical Places Trust Pegasus Health Reserve Bank of New Zealand (RBNZ) ResilOrgs Strong Christchurch Infrastructure Rebuild Team (SCIRT) Statistics New Zealand University of Canterbury University of Otago Victoria University

Each member of the research team generated initial themes from the interviews based on their own notes, using excerpts and quotes as exemplars of their findings. Based on these data, the research team leads identified and enumerated major themes related to stakeholder use of data in Canterbury. Then, associated excerpts and quotes were coded and compiled in a qualitative database of the case study interviews. This process yielded six major themes broadly related to (1) *stakeholder use of data for recovery decision-making* and (2) *stakeholder data sharing and integration*. Themes associated with use of data for decision-making include extent of data use, manner of data use, and challenges and barriers to use of data. Themes for stakeholder data sharing and integration include extent of data sharing, data privacy and sensitivity issues, and data integration and interoperability (Fig. 1).

Figure 1 – Key themes in stakeholder data practices for recovery decision-making following the 2010-2011 Canterbury earthquakes disaster.



3. Stakeholder Use of Data for Recovery Decision-Making

Pursuant to understanding whether and how data have been used to inform decision making for recovery following the Canterbury earthquakes, the research team explored these topics during our interviews with study

participants. This line of inquiry generated the following three broad themes that are associated with decision-making and various factors that influence decision-making processes: (1) the extent and manner of data use in recovery-related decision-making; (2) challenges and barriers to the use of data in decision-making; and (3) concerns about how data were used, misused, and not used in decision-making.

3.1 Extent of data use

Study participants held a variety of perspectives with respect to the extent to which data were employed to make post-quake, recovery-related decisions. At two extremes, interviewees tended to characterize the use of data in decision-making as either nonexistent or that it was used extensively—with the latter driving decisions as well as actions.

Perhaps not surprisingly, almost every study participant agreed that data can be very useful to support and inform decision-making, and that decisions should be data-driven. One Victoria University professor believed that the lack of data or its analysis did not contribute to any recovery delays; rather, legal obstacles had caused delays. According to one interviewee, decisions at the highest levels were only informally influenced by data, and not by formal decision support protocols. In New Zealand, as he described it, there is no systematic consultation process. Rather, information exchanges occur primarily through informal interactions and discussions. An environmental health researcher stated that it was "unethical" to collect data and not use it, suggesting that this had occurred.

Some interviewees indicated that data were used selectively—"cherry picked"—or not at all and that data could be used more effectively. A GNS scientist was of the opinion that recovery activities were not particularly informed by data. Several interviewees, including individuals from Christchurch City Council (CCC), Massey University, and Lincoln University, including one elected official, said that CERA's Wellbeing Survey had not been used for decision-making. A Victoria University researcher suggested that Statistics New Zealand or other more data-oriented organizations should have been responsible for post-quake data collection data, rather than CERA. Even so, the researcher believed that CERA data played a limited role in post-quake decision-making. Similarly, an interviewee from the Human Rights Commission (HRC) described CERA's housing decisions and creation of the residential red zone as unsystematic, having not drawn upon available data. A Massey University researcher recounted having provided research to CERA that was ignored.

Interviewees offered several comments related to limited use of data in decision-making. According to a Chamber of Commerce representative, its own organizational decisions were "not data driven"—rather, they went on instinct in the weeks and months following the quakes. A Victoria University researcher was confident that New Zealand Inland Revenue did not use data her research team was commissioned to develop, suggesting their research findings did not facilitate the agency meeting goals set prior to the earthquake. A GNS study participant commented that despite relevant and available data, earthquake-prone building policy changes were being implemented without including this valuable information.

From another perspective, one participant at CDC applauded SCIRT's organizational model as fostering data-driven decision-making. He observed that SCIRT effectively used data to define and prioritize projects, as well as to evaluate contractor performance. This participant believed that SCIRT had been more effective than other groups in their use of data for decision-making because of their innovative organizational arrangement, their leadership, and their relative independence from government bureaucracy.

3.2 Manner of data use

Most of those who reported that they themselves had used data to inform decisions were from the health and mental health sectors (four study participants). For example, representatives from the health arena used data about changing demands for their services to make decisions about how to distribute patients to hospitals and how to provide care with limited facilities. A representative from the HRC cited the Canterbury District Health Board (CDHB) as the exemplar organization in the recovery process for prudently using data to inform decision-making. Data used by CDHB influenced outreach programs and efforts to offer home care, as well. Interviewees

from another health care organization described how they updated their existing databases after the February earthquake to facilitate the information needs of general practitioners and pharmacies they served. Subsequently, this organization utilized its database as a "vehicle" to prioritize levels of need and to manage their recovery activities.

Although many study participants indicated that CERA's Wellbeing Survey was not being used for decision-making, interviewees from the public health sector commented about their use of the CERA Wellbeing Survey data. They used the data to monitor how negative impacts of the quake had evolved over time, as well as to make decisions about the development and location of service offerings.

Interviewees provided several additional examples of how data were used by stakeholders. Two study participants mentioned that SCIRT used data developed by University of Canterbury to understand the effects of liquefaction on sewer systems and that this was the platform for some of their rebuild efforts. An interviewee from the CDC was enthusiastic about his organization's use of data to support the development of an agreement between the city and the ministry to subsidize developers to build affordable housing in the months after the disaster. Although the Chamber of Commerce reported that their own decisions were not driven by data driven, the organization representative did recount sharing data about area and facility closures with callers who in turn may have used the information to make their own decisions.

3.3 Challenges and barriers to data use

Interviewees articulated numerous challenges and barriers to the use of data in decision-making. Among these were: (1) competing interests; (2) the time lag between the need to make a decision and the immediate availability of data; and (3) lack of data analysis or interpretation.

3.3.1 Competing interests

Several individuals illuminated issues of competing interests and different entities vying for attention, resources, and support—describing how in some cases these overrode the use of solid data. Similarly, a researcher lamented that policies were not research- or data-driven, but catered to business interests instead. Another interviewee contended that the insurance industry was dominating recovery and rebuilding activities in the region, and that anything that appeared to interfere with settlement processes was ignored.

A somewhat controversial perspective is that government officials decided they did not need data because they believed that the market would sort things out over time (especially with regard to housing). According to one individual, decision-makers did not lack advice, but they perhaps lacked appropriate data and the experience to use data effectively. A number of interviewees noted that SCIRT and CERA alike lacked leadership capabilities with respect to data collection, interpretation, and management. An economics researcher discussed the ethical responsibilities and risks to government that are associated with collecting data. That is, data collection may provide evidence that requires attention that may or may not be part of an agency's mandate, or that may not reflect well on the organization.

Although Land Information New Zealand (LINZ) is mandated to support government policy through data development and dissemination, interviewees from Ministry of Business, Innovation, and Employment (MBIE) and GNS lamented that issues of political power, national government bureaucracy, and inadequate leadership in LINZ diminished the use of their products. One study participant observed that LINZ did not adequately involve other government agencies in their data practices.

As previously noted, several interviewees expressed concerns about "cherry picking" of data—selectively using data for purposes that support specific agendas or ideologies. As an example, two individuals—one from Massey University and the other from the Ministry of Education—mentioned controversial school closures. According to one, these decisions were based on no apparent data. He maintained that such irresponsible use of data resulted in a "corrosion of trust" between the public and government. According to the other interviewee, there was considerable critique of both the quality and the quantity of data employed in making these school closure decisions.

At a micro level, a group of Victoria University researchers explained how their findings were used inappropriately. They maintained their data had been used to push responsibility for resilience to individuals in the work place, rather than attending to organizational level issues that could be applied across systems to enhance regional and national recovery and resilience.

A study participant from the CDC observed that SCIRT might serve as a good model to avoid the political fray, bureaucracies, and competing interests described above. According to him, this organization worked effectively to collect and use data, and as a result was able to track their progress. From another perspective, a social scientist contended that—to avoid conflicts of interest or the appearance of them—agencies that are leading recovery efforts (in this case, SCIRT and CERA) should not be responsible for the collection, management, storage, or presentation of data. Similarly, a GNS scientist pointed out that CERA was a policy agency and so should have commissioned technical work rather than do it.

3.3.2 Data availability and time lag

In post-disaster settings, especially, decisions often have to be made before data are available or can be analyzed. In many cases, this is an issue of resources (e.g., human and financial) not being available in a timely manner. A CDHB employee explained that she couldn't make best use of CERA's Wellbeing Survey because there was about a nine-month lag between data collection and reporting. One study participant at the HRC noted "data looks backwards"—data is based on what has happened, rather than on what is happening. It is a balancing act, he pointed out, between waiting until there is enough data to make an informed decision and determining when there is enough information to move forward with some level of certainty. Another interviewee, from Massey University, commented on the fact that there are multiple cycles at work, ranging from research and data collection cycles to local, regional, and national political cycles. These often tend to clash and inhibit the timely availability of data, exacerbating data-related challenges in a post-disaster setting.

Of course, the greatest time lag occurs when data does not exist. Data are not necessarily one-size-fits-all in the aftermath of catastrophic events such as the Canterbury earthquakes. Several interviewees noted that different agencies and organizations have different data needs than those of the central government. As a result, it may appear to some that topically relevant data exist, while potential users may not agree. At the time of the interviews for this case study (March 2014), some study participants described a lack of data for decision-making. For example, one engineer noted that a lack of detailed structural engineering information about damaged buildings hampered the building inspection process in Christchurch. Most frequently mentioned were lack of data about housing and post-quake population movement—particularly former residents of the residential red zone and members of vulnerable groups.

3.3.3 Analysis and interpretation of data

Several researchers contended that an underlying problem in terms of data use is lack of capacity to analyze and interpret existing data. A researcher at Massey University claimed that too much time had been spent gathering data and not enough time analyzing it, while a public health researcher highlighted that most agencies don't have in-house research capacity.

Multiple university researchers maintained that central government agencies did not respond well to researchers suggesting areas for research and analysis. A Massey University participant reflected that government tends to be responsive only when it requests work from researchers and maintained that this one-direction relationship does not position researchers to provide the necessary evidence to influence policy. At least three participants observed that decision-makers often don't know what data analysis to do, what is possible, and how data might support their efforts. A CCC analyst commented that any analysis done to that point had been fairly basic because decision-makers had not made many requests. She further revealed that her unit did not have enough people to do much analysis or time to consider what analysis could be done. As a GNS scientist noted, it is difficult for agencies to synthesize the available data into useful insights.

4. Stakeholder data sharing and integration

More than one participant working on daily data integration and analytical tasks in the post-quake context noted dependencies on external data providers—other agencies, jurisdictions, or commercial providers. This circumstance meant that many aspects of recovery data practices, such as data development and dissemination, were beyond the immediate control of analysts and decision-makers in need of particular data. Generally speaking, the workflow of organizations depends upon how quickly they are able to acquire the necessary data. Three themes were identified regarding the sharing of data after the Canterbury earthquake sequence: (1) extent of data sharing; (2) issues of data privacy and sensitivity; and (3) data integration and interoperability.

4.1 Extent of data sharing

Because of the strong data dependencies between agencies and other organizations, multiple study participants mentioned the importance of informal data networks during the recovery process—the establishment of trust and personal relationships between specific individuals providing and using data within various organizations. Based on feedback from interviewees, these networks (e.g., among CCC, CERA, and SCIRT) seemed relatively robust and were even strengthened as a result of recovery efforts. Several interviewees indicated that data sharing had increased for the benefit of the rebuild.

As an example of this perspective, a University of Canterbury civil engineer thought that data sharing after the earthquakes was, overall, "incredible and unprecedented," with a collective attitude of open-mindedness. Another University of Canterbury researcher said the recovery process is a good case study in collaboration between private companies, public agencies, and academia. He explained that access to data for research and education improved over time since the February 2011 earthquake. Similarly, a CERA analyst saw the disaster as a largely successful example of public-private data sharing, saying that the immediacy and universal impact of the earthquakes resulted in open data sharing. He described his stakeholders as now having an increased awareness of the potential for sharing data because of the earthquake recovery experience—beginning to view data as a public capital. Specifically, he highlighted that after SCIRT was formed data access suddenly changed. A University of Canterbury researcher described how, since the quakes, he can take data from SCIRT and funnel it into research and education, inside and outside of his institution.

Study participants cited numerous examples of sharing between government agencies. Statistics New Zealand's data was cited often as the most transparent and widely used data by government agencies and researchers. Many participants mentioned using Statistics New Zealand data, including CERA, Reserve Bank of New Zealand, CECC, Christchurch & Canterbury Tourism, Opus Consulting, and several university researchers. As additional examples, CERA regularly released reports to agencies and the public presenting the results of each Wellbeing Survey and CDHB supported CERA reporting by providing their data on mental health services. A CCC analyst noted that CERA made concerted efforts to facilitate data sharing among specific stakeholders. SCIRT had relationships with many agencies and, according to SCIRT representatives, provides access to their web-based GIS data to other organizations. SCIRT interviewees also said they had provided raw data for research projects conducted at University of Canterbury, GNS, and Opus Consulting, specifically. At the time of the case study interviews, SCIRT was already working with CCC to prepare for transferring data back to the jurisdiction's data team after SCIRT had sunset.

Not all statements and examples about data sharing were positive. A GNS scientist said he that on a scale of 1 to 10, where 10 was the best, he would rate data sharing success between agencies as less than a 5. He had particular concerns that CERA did not do well with their spatial data and similarly that CCC did not see the need to connect building data to other data. A SCIRT representative stated that it was difficult to get good data describing original pre-earthquake assets from CCC, as well as up-to-date operations and maintenance cost data. At the same time, a CCC elected official thought that SCIRT lacked integration in some cases, particularly related to data collection and monitoring. Representatives from the Reserve Bank of New Zealand (RBNZ) said that they "don't really talk to GNS or EQC." At the same time, they admitted that it is key to have direct contact with other agencies. That said, the data needs of RBNZ are perhaps too dissimilar to other the needs of other

agencies, both in terms of scale and types of indicators, and that there is not much utility in sharing. By March 2014, some interviewees expressed that attitudes about openness had reverted to pre-quake status. A CERA analyst said that a year after the February 2011 earthquake the "shutters came down again," reporting that commercial data is once again behind closed doors.

Issues exist for public-private data sharing. SCIRT mentioned that while data that existed prior to the earthquake did not present a cost issue, cost was a factor in procuring new data. Unlike the CERA analyst interviewed, a CCC analyst maintained that private companies were not completely open with their data. Along these lines, University of Canterbury researchers indicated that requests to Twitter, Facebook and Google for various data were either refused or unanswered.

Researchers interacting with government agencies conveyed similar examples. Interviewees at a private consulting firm were frustrated that the agency that contracted them did not make the data they collected publicly accessible and that, consequently, it was not used in decision-making. A Victoria University researcher noted that a central government agency would not provide requested data to them even though the agency had commissioned the research. The general consensus among university and consulting-based researchers who participated in this case study was that government data was not easily obtained and that in many cases, requests for data had gone unanswered

4.2 Data privacy and sensitivity issues

A reality of sharing data is the sensitivity of some data and the need to ensure at least minimum levels of privacy for those data. Two study participants explained that public sentiment in New Zealand is supportive of an open and transparent society. As a result, there is strong support for open data. Coincidentally, the earthquake occurred when the New Zealand government was actively moving towards open data and encouraging other local jurisdictions to foster open government and innovation. One participant suggested that post-earthquake data practices would not have been so open if the earthquakes had happened at a different time in history. A University of Canterbury researcher said that most of the data sharing in New Zealand is not done with formal data sharing agreements. As another researcher pointed out, with such informality comes the need to have pre-existing relationships and the establishment of trust.

Many interviewees lamented the barriers that sensitive data posed and the need to deal with privacy issues. A CERA manager put it simply: privacy laws limit sharing data. Different providers have different privacy requirements, with health data representing considerable challenges. For example, an interviewee from the private health care sector stated that they had been reluctant to give data to central government agencies due to patient privacy concerns and lack of trust. According to one MBIE manager, commercial insurance companies limited access to their data due to legal disputes following the earthquakes.

Anonymizing data to avoid privacy concerns and facilitate data sharing takes both time and resources. As one example, a GNS scientist recounted delays in obtaining access to CERA's database of detailed engineering evaluations because of personal data included in each record. The organization experienced similar delays when requesting claims data from the EQC; EQC had to aggregate the data to anonymize it. University researchers indicated that they dealt with this issue, as well.

A handful of study participants had specific examples of being denied access to data or when privacy issues delayed decisions. A University of Canterbury researcher told an anecdote that a central government agency asked telecommunications providers for data for them to estimate where people were moving in order to make decisions about temporary housing. According to his account, the companies denied the request citing confidentiality of the data. Multiple engineering researchers and a CERA manager spoke of an engineering firm contracted by EQC withholding important data for a significant period of time, potentially slowing land use decision-making. Another interviewee said that Orion and insurance companies had data on vulnerable populations that should have been shared, insisting that there are human rights issues in not sharing such data in the context of crisis.

4.3 Data integration and interoperability

A large number of study participants mentioned the need for integrating data from multiple agencies during the recovery process in order to understand the big picture, comprehensively assess damages from the quakes, and understand effects of various decisions associated with recovery efforts. Data integration requires resolving questions of custodianship, as well as balances between centralized and decentralized storage and management. Sharing requires additional considerations of interoperability. As articulated by a Statistics New Zealand analyst, "data is rarely in the format you want."

A CCC staff person commented that it had generally been clear regarding what organizations own which data and that, for the most part, only the owners are updating their data. She further described metadata practices as effective. A CERA analyst stated that there were many ways of accessing data and he noted the obvious advantages of having a multiplicity of data access. He also suggested that there were disadvantages, such as not knowing what data was available from what organizations and whether anyone was using those data. In this context, he went on to describe the existence of competing or redundant data efforts. A GNS scientist indicated that numerous data custodianship issues remained unresolved.

A CDC participant lamented the lack of an operational model to better facilitate coordinated data sharing. He said there were instead several separate institutional arrangements. A GNS scientist echoed this statement, claiming that technical issues of sharing had become greater over time. Although there was much talk about having common protocols, he expressed that concerns about issues including cyber-terrorism limited progress in this arena. Some University of Canterbury researchers attributed the lack of progress and the siloed approach to a lack of leadership and financial support. An interviewee from the HRC was also concerned about the silo-ed approach to data collection and storage, but was encouraged that public agencies had begun to overcome the issue.

A University of Canterbury engineering researcher and a CERA manager suggested that part of the problem for CERA had been in the use of private consulting companies for data collection, management, and service provision. Another University of Canterbury researcher said that CERA's data was extremely disorganized. In sum, the general sentiment of study participants was that CERA's outsourcing model was not good for data sharing and integration because subcontracting complicates how data can be shared, analyzed, and used. Interestingly, the analyst most intimate with the outsourcing model contended that the arrangement was effective because government is not agile enough and does not have the capacity to deal with such highly technical and fast evolving issues. Ultimately, the CERA participant explained, the urgency of the recovery context may have prevented the development of comprehensive or innovative solutions, whether or not other issues are addressed.

Many interviewees offered examples of tools and systems for managing and providing access to data; most were developed and maintained by government agencies. The Canterbury Geotechnical Database—a central repository for collectively contributing and accessing soils data for a majority of the Canterbury region—was one of the most cited examples of data integration and interoperability in this case study. Funded by EQC, the database was maintained by CERA at the time of the interviews. Data are contributed by government agencies, university researchers, SCIRT contractors, and other private companies. Staff at MBIE referred to the database as a "game changer" for the reconstruction effort. Interviewees from both CERA and the CCC described the database as an amazing example of collaboration between agencies and the private sector.

A University of Canterbury researcher expressed that people in government thought mostly about sharing or storing data, not about making data useful for decision-making, conducting research, or drawing lessons from the recovery experience. He argued that an effective system for integration and storage should ultimately be the responsibility of researchers who are in a position to be the facilitators and hosts of resilience and recovery-related data.

5. Conclusions and Implications of Findings

Findings of this case study reveal themes associated with use of data for decision-making and stakeholder data sharing and integration. In describing their experiences following the Canterbury earthquake sequence,

interviewees illuminated ways to improve data practices for future disaster events, articulating lessons they had learned and explaining ways in which they change their approaches if given the opportunity. The implications of their insights represent important advances in understanding recovery and resilience. The findings presented here offer practical perspectives regarding data practices. Based on information provided by study participants, the research team identified three general recommendations. These include (1) foster innovative ways to share and link data; (2) promote data for decision-making; and (3) balance speed and deliberation.

5.1 Foster innovative ways to share and link data

Practitioners and researchers who participated in this study widely agreed that some or all aspects of data sharing agreements, especially privacy issues, should be negotiated in advance of a disaster as part of broader preparedness and resilience efforts. There is a wealth of potential knowledge about how to establish data sharing agreements in New Zealand—for example UC CEISMIC created many such agreements as part of the development of their data repository. Managers from SCIRT and CERA suggested expanding typical mutual aid agreements to include data sharing and that mutual aid agreements could specify a standard or unified data system or GIS. A CERA manager suggested establishing an office in Christchurch to facilitate data sharing and develop trust in the process of doing so.

SCIRT representatives offered several technology insights regarding ways to facilitate efficient data sharing and to be forward looking. A SCIRT analyst said that jurisdictions should encourage asset owners to inventory their assets and have established GIS-based platforms for managing asset data. Other SCIRT participants suggested standardizing spatial data metadata to make data interoperable between owners, contractors, and designers. Similarly, data practices should be consistent among organizations departments, management, and partners. A SCIRT information specialist described the need to choose software for daily operations that can scale to meet disaster recovery needs. Learning datasets, software, and protocols is extremely time-consuming and personnel need time to become proficient with processes outside of a disaster context. The choice of software should consider the potential workflows in both disaster and non-disaster settings.

A GNS scientist observed that data needs to be kept by those who create it and then data should be shared in a distributed manner—a centralized database is not workable. An MBIE manager expressed that even the ideal of seamless system integration across organizations is unrealistic. The focus instead should be on having mutually agreed upon inter-organizational protocols, as well as the goal of interoperable technology. According to one CCC study participant, in the New Zealand context an external agency is best suited to link data across agencies and silos. Another possibility mentioned was temporarily transferring data ownership and maintenance responsibilities from the original data owner to the rebuild agency during the rebuild period. A participant from GNS believed there is a need for government agencies to advertise what data they have, what format it is in, and who to talk to. Any feedback from external users will help a provider's data.

5.2 Promote the use of data for decision-making

Interviewees suggested ways to encourage and support organizations in using more data for decision-making. One GNS scientist recommended that there be a government-wide mission to integrate scientific data across agencies and within their decision-making processes. This would require the onerous task of tailoring delivery and analysis of data. A researcher at Massey University stated that universities should do more relationship building to foster the use of research results in decision-making. A manager at CERA echoed that personal relationships with scientists are needed to make scientific data useful. The Massey University professor also stressed that communities should work in advance to define a core set of research questions that would need to be answered in a post-disaster context, thus making data more relevant to recovery decision-making. Similarly, several participants noted that primary data collection instruments, such as CERA's Wellbeing Survey, should be more effectively piloted in order to ensure not only the appropriateness of the questions, but the utility of the responses and the data gathered. The researcher from Massey University thought that people at the front-line of recovery management within the government should be consulted to assist in defining research questions. Lastly,

a CDC manager stressed that organizations need to communicate—to other organizations and to the public—that data was used to support decisions and explicitly how.

Researchers from University of Canterbury and Massey University also pointed out that data practices should be revised so that people—including the public—take ownership of data and the decisions made from them. Among other things, this means broadly asking the public about their wants and needs. A CCC elected official echoed this statement, emphasizing the need to understand the public sentiment regarding recovery-related policy decisions.

5.3 Balance speed and deliberation

Some participants asserted that data collection and analysis must be timely. Interviewees from both the public health sector and HRC were frustrated about the delays in data collection, analysis, and information dissemination. They expressed that the information was not released quickly enough to inform real time decision-making. A participant at CERA stated that it would be better to give 90 percent accurate data quickly, rather than 99 percent accurate data slowly.

Conversely, some researchers and practitioners interviewed believed that the recovery would have been better with more deliberation. For example, a researcher at University of Canterbury thought that many buildings in CBD were demolished too quickly. A participant from CERA noted that optimal and innovative use and analysis of data are limited due urgency. Participants from SCIRT suggested that a longer planning and discovery phase might facilitate the use of data in both decision-making and research.

References

[1] Miles, S.B., Ritchie, L.A., Poland, C.D., Xiao, XU, and Hedley, N. et al. 2016. *EERI Resilience Observatory Case Study Report: Use of Data for Measuring and Monitoring Recovery following the Canterbury Earthquake Sequence*. Report prepared for the Earthquake Engineering Research Institute as part of NSF grant #1235573 to develop a “Seismic Observatory for Community Resilience – A Program to Learn from Earthquakes.”

Acknowledgements

This project is funded by National Science Foundation grant #1235573 “Seismic Observatory for Community Resilience - A Program to Learn from Earthquakes.” Logistical support was provided by the New Zealand Society for Earthquake Engineering and the New Zealand Natural Hazards Research Platform.