

Disaster Waste Management: a systems methodology

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Abstract

Natural disasters can generate large volumes of debris. In some cases, many years worth of waste can be generated in a single event – overwhelming local solid waste management facilities and personnel. However, the role of debris in disaster management is still largely under-estimated and misunderstood – presenting as more of a logistical technical exercise and road-block to recovery than an action integrated into both the emergency response/recovery and solid waste management system, with social, environmental and economic effects.

To research this complex, highly variable and multi-disciplinary problem a systems approach has been adopted. A research model has been developed using primarily qualitative data gathered from five international, multi-hazard, disaster events. The research involves the analysis of six key components of a disaster waste management system for each case study: coordination structures; legislative frameworks; funding mechanisms; implementation strategies; environmental approaches; and public health approaches.

For each of the above components a cause and effect analysis was carried out. Causes included contextual constraints and influences such as institutional frameworks and disaster impacts. The effects analysed included timeliness; completeness; environmental; economic; and social impacts of the disaster waste management system.

The analysis will be used to develop a framework for designing effective and appropriate disaster waste management programmes. As a result of the 2011 Christchurch Earthquake, the framework will be tested and refined through real-time application, using an active participatory approach during the disaster response.

This methodology has allowed for a multi-disciplinary and holistic analysis of a complex problem across many different contexts. The research results have shown strong linkages and synergy between seemingly diverse case studies. These common findings can then be applied to a number of different disaster situations and contexts.

Keywords: disaster research methods, recovery, disaster waste, systems, multi-disciplinary

1. Introduction

Depending on their type and severity and the nature of the built environment, disasters can create large volumes of inert and hazardous debris. Recent natural disasters such as the 2011 Christchurch Earthquake, 2010 Haiti earthquake (Booth, 2010; Johnson and Correa, 2010; Kahn, 2010), Victorian Bushfires 2009 (Brown et al., 2010), Hurricane Katrina 2005 (Luther, 2008; USEPA, 2008) and the 2004 Indian Ocean tsunami (Basnayake et al., 2005; Petersen, 2006) have all generated volumes of waste which overwhelmed existing solid waste capacities and required extraordinary management approaches.

Disaster debris can impede rescuers and emergency services reaching survivors; inhibit provision of lifeline support; pose a public and environmental health hazard; and hinder the social and economic recovery of the affected area. Poor management of a clean-up effort can result in a slow and costly recovery which is potentially risky to public and environmental health in both the short and long term.

Existing disaster debris management plans are generally comprehensive technical 'how-to' guides. They are generally quite prescriptive and do not adequately consider the impacts of different disaster types and scales. The documents are also predominantly context specific and do not consider the effectiveness of various organisational, financial and legal structures (Brown et al., 2011).

Until a community has had to deal with a large scale disaster event it is difficult to determine whether the systems they have in place (if any) will be suitable. And even then, the community is only testing their systems on a specific event. Research is needed to systematically gather the experiences from past disaster events from around the world to develop some guiding principles (referred to here as a framework) for management of disaster waste.

This paper discusses the methodology selected to gather and analyse data from a series of case studies with the aim of developing a disaster waste management framework.

2. Methodological overview

The overall research methodology is summarised in Figure 1. Currently data has been gathered from five international case studies to form the basis for the disaster waste management framework development. The framework, once developed, will then be applied to a disaster scenario prior to finalisation.

As shown, the process includes feedback loops which allows the analysis and framework development to be continually validated. For example, as the framework is developed it will be applied to the international case studies to test applicability and transferability between cases. The framework will be adjusted as necessary until a final framework is determined.

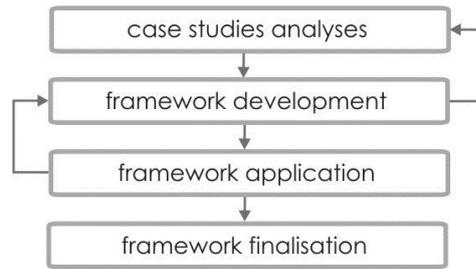


Figure 1 Basic disaster waste management research methodology flowchart

Disaster waste management is a complex dynamic problem or ‘system’ with complex interactions between the environmental, social, economic and political systems that govern our world. Systems thinking theory acknowledges that systems are dynamic in nature and comprise interconnected parts such that the whole is greater than the sum of the parts. The dynamics and complexity arise largely from the relationships between the individual parts. Consequently systems thinking will be an over-arching concept under which this research is being carried out.

3. Case study analyses

3.1 Rationale

According to Yin (2009) case study research methodology is appropriate when a researcher is aiming to understand “how” or “why” a certain social phenomenon works. In particular case studies are useful where the researcher has no control of behavioural events, the research focuses on contemporary events and where decisions are the focus of the study – all of which apply to this research topic.

As discussed in Section 1, the aim of the research is to develop guiding principles for management of the complex and multi-disciplinary challenge of disaster waste. To do this it is necessary to take experiences from specific disaster events in a given context. To understand the impacts of different disasters and contexts, and to provide a platform for transferability between contexts, a multi-case study approach was deemed necessary.

3.2 Case study selection

Yin (2009) recommends five or more cases if the theory is subtle. Due to time constraints five case studies were analysed. The studies selected were (*study location in brackets*):

- Hurricane Katrina (*New Orleans, Louisiana, US*), 2005
- Victorian Bushfires (*Victoria, Australia*), 2009
- L’Aquila Earthquake (*L’Aquila, Abruzzo, Italy*), 2009

- Samoan Tsunami (*South eastern Coast of Upolu Island, Samoa*), 2009
- Canterbury Earthquake (*Christchurch, New Zealand*), 2010

The case studies were chosen for a number of different reasons:

- Access to data. Where possible, cases were selected where contacts and/or relationships already existed, a site reconnaissance was feasible and/or there was good access to published data (in english).
- Timing of the event. Reconnaissance and interviews were ideally carried out 6 – 12 months after the disaster event to minimise disruption to response activities and to gain benefit from participant reflection.
- Scale of disaster. In all cases waste volumes overwhelmed existing capacities and extraordinary measures, above existing emergency plans and capacities, were implemented.
- Multi hazard. The case studies reflected four different disaster types to align with the current multi-hazard approach to emergency research and planning.
- Multi-contextual. A multi-contextual approach allowed for the analysis of different institutional frameworks (refer Section 3.4) and for a wider selection of case studies. Understanding the impact of contextual influences will also allow for a greater application of research findings.

3.3 Data collection

For each case study, qualitative data has been gathered from both pre and post disaster literature (government reports, documents and legislation; newspaper; practitioner reports etc) and semi-structured interviews with professionals involved in disaster waste management. For all but Hurricane Katrina, face to face interviews were carried out with personnel involved directly in the waste management process including solid waste managers, local authorities and emergency managers. Where possible all data was triangulated between data sources.

A community based survey / questionnaire was carried out with those that had been affected by the Victorian Bushfires to gauge attitudes on and impacts of the management of disaster waste. Questionnaire aspects included community attitude towards debris after an earthquake, community perception of insurance and public funding, and the effect of the waste management programme on their overall recovery including timeliness and completeness.

3.4 Case study analyses

The analysis principles followed are as set out by Yin (2009) for an embedded multi-case study. Case study data were analysed to draw out information on a number of different themes. This is also referred to as thematic analysis (Cassell and Symon, 2004). Figure 2 shows the model which all case studies were analysed. A single model was adopted to ensure consistency of analysis between case studies. The model acknowledges the interdependencies and links

involved in this complex system but also simplifies it sufficiently for analysis and provides a potential template for framework development.

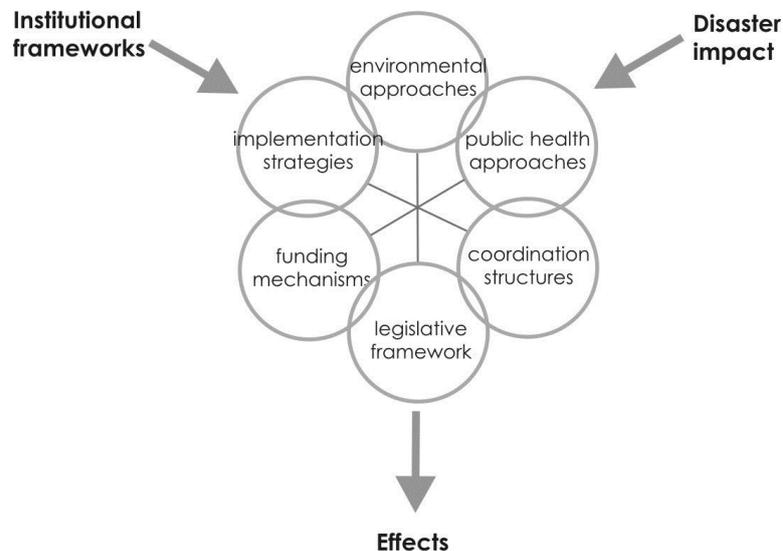


Figure 2 Case study analysis model

The circles represent the six themes or components within a disaster waste management system: coordination structures; legislative structures; funding mechanisms; implementation strategies; environmental approaches; and public health approaches.

For each case study, a description of the disaster waste management system was made, divided into the above six themes. Then a cause and effect analysis was carried out for each them, that is, an analysis as to why the waste management approach was taken and how effective the approach was. The cause or external influences on the disaster waste management system are categorised here as institutional frameworks¹ (such as organisational structures, disaster recovery governance, legislative frameworks, funding mechanisms) and disaster impacts (number of displaced persons, degree of hazards in the waste, geographical spread of waste etc). It is envisaged that these external influences will be translated into 'indicators'. The indicators will be used in the framework development as described below.

Then for each system component a qualitative assessment of effects was also carried out. The effects were categorised as: timeliness; completeness; environmental; economic; and social. These impacts will be semi-quantitatively ranked (using impact ratings of low, medium, high) to facilitate clear cross case comparisons and enable framework development.

¹ Note that a number of the institutional framework elements are also components in the disaster waste management system. A distinction is made in the model between those institutional frameworks within the disaster waste management system and those which externally influence the disaster waste management system.

As this is the first research of its kind, the model is intentionally simple. As greater understanding of the variability and complexity of disaster waste management is gained, the model will be further developed.

4. Framework development and application

The framework development will be based on a cross case synthesis, as defined by Yin (2009), of the above case studies. The analysis will be based around the six system components described above. Using the semi-quantitative assessments the analysis will aim to link institutional framework and disaster impacts with successful waste management approaches. That is, determine what disaster waste management approaches are most suitable in what circumstances. To achieve this, disaster impact and institutional ‘indicators’, as above, will be linked to the effects of a given disaster waste management approach. A combination of pattern matching, explanation building and logic models (Yin, 2009) will be used to build a picture of how to design an effective waste management system in the presence of these given indicators.

The framework will be validated in two ways. First, each of the international case studies will be reviewed and relevant indicators assigned. The framework will be used to design a waste management programme and this theoretical programme will be compared to the actual programme. This comparison will check that the positive system attributes are maintained while the unsuccessful approaches are replaced. Second, it was planned that the framework would be applied to a hypothetical disaster scenario. However, due to the unfortunate events of the 2011 Canterbury earthquake, the framework will be applied, as far as practicable, to the response following this event. The author is currently involved in the response to the 2011 Christchurch earthquake. An active participatory approach will allow for a greater understanding of the design and development of a disaster waste management system which will in turn be reflected in refinement of the proposed framework.

5. Discussion

5.1 Case study selection

While variability of disaster events and contexts was desired during case study selection, it was found that the study in Samoa was significantly different to the other studies. The developing country context of Samoa meant that some of the institutional frameworks (legislative structures, environmental standards, public health and safety etc) that the research focuses on were not as rigid or critical to the management of disaster waste as in developed countries. The case study was still useful, particularly around organizational structures and public participation, however, in general limited comparisons were able to be made between Samoa and the other case studies.

Aside from the Samoan case study, the case studies represented a wide range of disasters and contexts. There was a range of funding mechanisms (full private insurance reliance to full government sponsorship), organisational structures, waste management approaches etc. It was fortunate that the timing of the research and funding availability coincided with such a diverse range of case studies.

The case studies did not, however, represent a wide range of disaster scales. All events investigated, apart from the 2010 Canterbury Earthquake where no lives were lost, were catastrophic events involving loss of life and property. The recent events of the 2011 Christchurch earthquake will allow for a comparison of scale with the 2010 Canterbury earthquake. The events were within 20km of each other but had significantly different economic and social impacts and completely different responses to waste management.

5.2 Data collection

Access to robust, accurate and complete data is one of the major challenges of disaster research. The data in this research relied primarily on individual accounts 6-12 months after the event, supplemented by written documents where available. The quality of the information is limited by: the memory, understanding and interpretation of the situation by the interviewees; language translation (Samoa and L'Aquila); cultural interpretation by the interviewer; the interviewer – interviewee relationship; and the availability of written documents.

The semi-structured interviews allowed for complete, personal accounts of the waste management decision-making and implementation process post-disaster where often published data are not available. However, interviews have a number of limitations. De Vaus (2002) notes that in face-to-face interviews interviewees may be more likely to give acceptable rather than true answers (social desirability). The interviewees here, for instance, as participants and decision-makers in the waste management process have a vested interest in having a positive report on their work. Similarly, the Katrina case study was based on written, published documents, so again there is a possibility that only 'desirable' information was available. And the published accounts were predominantly organizational rather than individual accounts.

There may also have been an effect from the cultural difference between the interview and interviewees, or as De Vaus describes it – the effect of observable characteristics. This is where an interpretation of a situation is influenced by one or other's cultural background. This may include language nuances, voice tone and body language. The use of a translator in L'Aquila increased the potential for cultural misunderstanding as it is likely the translator paraphrased and inadvertently added their own interpretation.

There were a number of limitations with forming the Katrina case study purely from published documents. These include: presentation of final decisions rather than decision-making processes; predominantly government documents; inability to clarify unclear statements; presence of information gaps.

Accepting and accounting for these limitations is an important part of disaster research. Every effort was made here to ensure the data collection and interpretation was consistent across case studies and triangulation of information was carried out. Given the high level information sought during this research it was felt that generally these limitations had minimal impact on the data collected.

5.3 Case study analyses

As discussed, the adopted analysis model was an important tool in ensuring consistent analysis both within and between case studies. However, in a complex and dynamic systems such as disaster waste management systems there is a risk of losing the complexities and interdependencies by over-simplifying a system. This is a weakness of the model but a decision that has been consciously made to enable analysis to be carried out in a systematic way. The inclusion of institutional frameworks as both external influences and as system components in the system model was an attempt to recognize and account for some of the key interdependencies. It is envisaged that the cross-case analyses will enable more of these interdependencies to be drawn out and understood.

For the effects analysis, semi-quantitative assessments were used. The aim was to provide a measurable comparison in the absence of a fully quantitative assessment. Obviously this is a subjective rating, however, given the ratings are made by the same researcher with the same reference frame, it is believed that the ratings are valid relative to other ratings within this research. In many cases, it is difficult to assess the impact directly related to a specific system component. For example, overall the timeliness of the recovery of L'Aquila earthquake was very poor. The majority of the respondents agreed that this was due to the lack of waste disposal sites. However, the lack of disposal sites could have been caused in this case by a number of factors including coordination structures, legislative frameworks, environmental approaches, implementation strategies or funding mechanisms. It is envisaged that the systems approach will provide a conduit to look beyond proximate causes to underlying causes.

5.4 Framework development and application

The structured case study analyses will considerably aid in the framework development. The development of indicators will hopefully help disaster waste managers to design systems appropriate to the disaster event and context they are working in.

Validation of the framework has been identified as a difficult task. The researcher's active involvement in the 2011 Christchurch Earthquake response has allowed for a unique opportunity to test and develop the theories derived from the case studies. However, the researcher is conscious that the framework is only being tested within one particular context and one disaster. Ensuring that conclusions drawn from experiences during the event response can be applied to other events will be challenging. The feedback loops between framework

development and the original case studies will help to test the robustness and transferability of the framework.

6. Summary

This methodology has allowed for a multi-disciplinary and holistic analysis of a complex problem across many different contexts. The research results to date have shown strong linkages and synergy between seemingly diverse case studies. Once these common findings have been developed into a framework and validated, it will be possible to apply the findings to any number of different disaster situations and contexts.

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