

Disaster Waste Management on the Road to Recovery: L'Aquila Earthquake Case Study

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ABSTRACT:

Earthquakes impacting on the built environment can generate significant volumes of waste, often overwhelming existing waste management capacities. Earthquake waste can pose a public and environmental health hazard and can become a road block on the road to recovery.

Specific research has been developed at the University of Canterbury to go beyond the current perception of disaster waste as a logistical hurdle, to a realisation that disaster waste management is part of the overall recovery process and can be planned for effectively. Disaster waste decision-makers, often constrained by inappropriate institutional frameworks, are faced with conflicting social, economic and environmental drivers which all impact on the overall recovery.

Framed around L'Aquila earthquake, Italy, 2009, this paper discusses the social, economic and environmental effects of earthquake waste management and the impact of existing institutional frameworks (legal, financial and organisational). The paper concludes by discussing how to plan for earthquake waste management.

Keywords: Waste Management; Disaster Recovery; L'Aquila earthquake; Disaster Management

1. INTRODUCTION

Depending on their nature and severity, and the level of seismic design of the built environment, earthquakes can create large volumes of debris that often overwhelm existing solid waste management facilities and personnel. 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.

Earthquake debris typically comprises construction material, personal property and sediment {USEPA, 1995 #8} and includes varying degrees of hazardous substances. The waste can be highly mixed as it is often difficult to salvage household goods from earthquake affected homes prior to demolition due to safety concerns. Typically earthquake debris is too heavy for individuals to manage themselves (Booth, 2010). Table 1.1 gives a list of some earthquake events in the last 16 years that required major debris management.

Establishing a solid waste management system in 'peace' time is a complex challenge – balancing stakeholder desires, community needs, environmental factors and political will. Adding a disaster to the challenge adds another level of complexity by introducing extremely large volumes of debris, time pressures and a shocked community.

Table 1.1 – Debris Quantities in Past Events

Year	Event	Debris Volume	Data Source
2010	Haiti earthquake	estimated 23 - 60 mill tonnes	(Booth, 2010)
2009	L'Aquila earthquake	estimated 1.5-3 mill tonnes	(Di.Coma.C, accessed 2010).
2008	Sichuan, China	20 mill tonnes	(Taylor, 2008)
1999	Marmara Earthquake, Turkey	13 mill tonnes	(Baycan, 2004)
1995	Great Hanshin-Awaji Earthquake (Kobe Earthquake), Japan	15 mill cubic metres	(Baycan and Petersen, 2002)
1994	Northridge earthquake, CA, USA	2 mill tonnes	{USEPA, 1995 #8}.

The aim of this research is to understand the role of waste in disaster management and how to effectively plan for and integrate waste management into both the emergency response/recovery and solid waste management systems. Because of the case-specific nature of an earthquake's waste impacts, a case-study approach is needed to develop generalised insights. This paper looks at the disaster waste management system following L'Aquila earthquake and analyses this case study using a conceptual model of disaster waste management.

2. CASE STUDY: L'AQUILA EARTHQUAKE

On the 6th of April, 2009, a 6.3 magnitude earthquake hit the Abruzzo region in central Italy. The epicentre was near the province capital of L'Aquila causing widespread building damage in the predominantly masonry and reinforced concrete buildings. An estimated 1.5–3 million cubic metres of debris was generated resulting both directly from the earthquake and from demolition and repair works. Approximately 70-80% of debris was estimated to be aggregates / masonry / concrete. Existing solid waste disposal and resource recovery facilities were overwhelmed by the waste volumes and new recovery facilities have been sought (Di.Coma.C, accessed 2010). Disaster waste management activities continue at the time of writing and the city waste contractor ASM estimates the waste management process will take 2 years to complete (personal communication).

A special Environmental Protection function to manage the earthquake waste was established under the Protezione Civile Directorate of Command and Control. The unit established and oversaw the waste management activities, procedures and legislation until waste management responsibility has now been handed back to the municipality (Di.Coma.C, accessed 2010).

Primarily, the demolition and waste management works, are organised into three categories defined by the degree of building damage and body responsible for the works:

1. Demolition works –by National Fire Corps (and eventually the municipality)
2. Repair works –by private firms (approved under an environmental managers' regulation).
3. Minor repair works –by individuals.

Waste from categories 1 and 2 is deposited at regional sorting and disposal sites. Waste from minor repairs (category 3) is deposited at central collection centres for sorting, recycling and disposal by the municipal waste contractor ASM. Recycling was identified early as a key component in debris management to reduce environmental impact and save landfill space. Waste aggregate has been earmarked for building construction, road reconstruction and environmental remediation works (Di.Coma.C, accessed 2010).

Waste management guidelines to outline the technical and logistical running of temporary sites including their effectiveness, efficiency and affordability were established by L'Aquila Provincia. The provincial environmental regulatory bodies (Institute for Environmental Protection and Research

(ISPRA) / Regional Agency for Environmental Protection (ARTA)) approved recovery and disposal sites. Municipalities assessed and established temporary storage sites.

Strict environmental laws in Italy and the European Union, initially crippled the waste management response, in particular the siting of recovery and disposal sites. Neither the European environmental / waste management Directives nor Italy's Decree Law n.152/2006 (Italian Government, 2006) consider environmental procedures and standards in light of an emergency. As a result of this, Protezione Civile was forced to prepare new emergency legislation for waste management (Di.Coma.C, accessed 2010). Eleven months after the earthquake many of the temporary and permanent sites needed to process the large volumes of waste are only just being approved (Nardecchia, 2010) and a large area in the City Centre, referred to as the 'red zone' is still cordoned off and full of debris.

Reimbursement, through various disaster relief funds, was dependent on all waste being separated on site in accordance with European Waste Categories (EWC) on site. This requirement proved time consuming and costly as the waste was often difficult to separate. It was not until a decision was made to categorise all earthquake waste under a single EWC that disaster waste managers could proceed without the concern of not receiving reimbursement if they could not efficiently separate the waste.

3. DISASTER WASTE MANAGEMENT SYSTEM

A conceptual model of disaster response and decision-making has been developed to aid case study analysis. Figure 1 depicts a generic recovery model of decision-making following a disaster. In this paper the model will be applied specifically to earthquake waste.

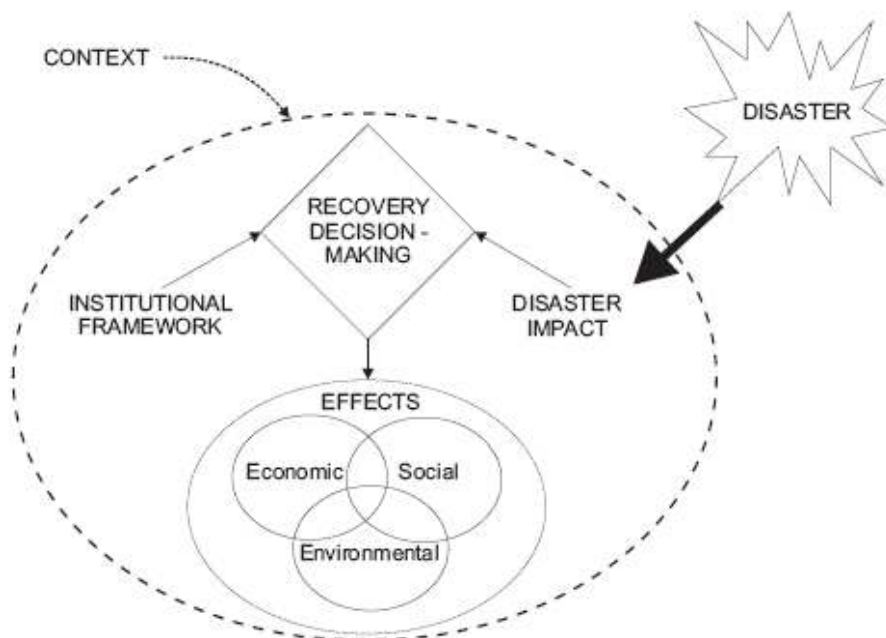


Figure 1 Planning for disaster decision-making model

Disasters are external forces that impact our physical and social environment. The physical and social environment, or *context*, in which a disaster occurs, will underpin any post-disaster decision-making. The *context* includes the built environment, resource availability, culture, governance and security. The *disaster impact* will depend on the size and magnitude of the disaster, the location of

the disaster, and *contextual* factors such as the level of development, and infrastructure of the affected area. In most *contexts*, governments will have established legal frameworks, organisational structures and funding mechanisms to respond to disasters. Where no emergency provisions have been established pre-disaster, they are obliged to either use peace-time institutions or to develop new frameworks specific to the disaster event (collectively these are referred to here as *institutional frameworks*). *Disaster recovery decisions* – or in this case, specifically disaster waste management decisions – are made bounded by these frameworks. Finally these decisions and corresponding actions have varying social, economic and environmental *effects* on the disaster affected area and population. The goal of any post-disaster decision-maker is to manage these potential effects to achieve a positive outcome.

4. L'AQUILA EARTHQUAKE CASE STUDY ANALYSIS

4.1. The institutional framework

Institutional frameworks do not always effectively account for emergency situations. Inappropriate organisational structures, laws/regulations, and emergency funding can severely constrain decision-makers and thus impact the efficiency and effectiveness of a disaster waste management system. In many cases (Hurricane Katrina (Luther, 2008), Victorian Bushfires (lead author's observation)) authorities have made changes to institutional frameworks post-disaster. These changes are made - under time pressure; often with significant social and political pressure; without access to sufficient information; and/or technical expertise to assess potential effects to assist in management of disaster waste.

4.1.1. Organisational structures

In past events, disaster waste has been managed almost entirely independently of other recovery efforts. Roles and responsibilities, even within waste management operations, seem ill-defined and insufficient to cope with the complexities arising from varied stakeholders with differing social, economic and environmental agendas.

The coordination and organisational structure for earthquake waste management in L'Aquila comprised of no less than six major governmental and non-governmental organisations in addition to a number of private demolition and waste management firms. The large number of organisations is aggravated by the split of demolition and debris disposal works into three building damage categories. Many of the companies involved are also not routinely involved in waste management activities. The number of organisations and potential shortage in waste management expertise (identified by ASM as a challenge) will also increase the need for monitoring and oversight to ensure operations are run efficiently and effectively.

There is a plethora of possible organisational structures to manage disaster waste. However a community or governing body decides to manage its emergency and disaster debris programme, clear roles and responsibilities and overall objectives need to be defined and the appropriate technical personnel need to be on board for effective response.

4.1.2. Legislative issues

In many countries, emergency legislation is available to stream-line emergency response and recovery efforts. Many disaster debris management plans or guides highlight the availability of emergency waivers on environmental regulations (Solis et al., 1995, WRCDEMG, 2008) but it is often unclear to what degree and in what circumstances this relaxation is acceptable. Conversely, if no waivers or emergency regulations are provided, rigid laws and regulations can slow the debris process significantly. Such was the case in L'Aquila.

Compliance with rigid regulations in L'Aquila, including processing and disposal facility siting and on-site waste segregation, all but halted waste managers' efforts to clear debris. New post-disaster

emergency regulations had to be developed to permit new facilities and ensure clean-up could proceed expeditiously. The major impacts resulting from the slow debris removal included frustrated residents (as evidenced by occurrences of illegal dumping), delayed rebuild and associated return of economic activity and potential health and safety and environmental hazards of the waste left in the streets / city.

In some other cases, however, liberal use of environmental waivers has led to community disaffection and potential long-term environmental effects. After Hurricane Katrina, authorities expanded existing waste acceptance criteria at Construction and Demolition landfills. An environmental group concerned about the potential for adverse environmental effects from this environmental standard relaxation filed a lawsuit against the US Federal Emergency Management Agency. The result was cessation of activity at one landfill and the specification of management restrictions at another (Luther, 2008).

Emergency legislation needs to be provided to handle disaster waste and should be considered pre-disaster. Strict regulations can severely hamper clean-up efforts with significant social and economic implications and loose regulations can cause public dissatisfaction and potential long-term impacts on the environment. The legislation needs to be flexible enough to suit any disaster situation and but also bounded to avoid undesirable negative effects. If emergency legislation is established pre-disaster significant delays could be avoided.

4.1.3. Funding mechanisms

Disaster response and recovery funding mechanisms vary between contexts. Funding mechanisms include insurance, government or local authority financing, public donations (e.g. monetary or in-kind labour or goods), public and private contributions. The nature of the funding mechanism, scope and procedural requirements can significantly affect the speed and efficiency of the debris removal (and consequently recovery) programme.

In L'Aquila, the initial requirement, for funding eligibility, to categorise all waste prior to collection significantly slowed collection efforts. The decision to categorise all waste into a single EWC category allowed the waste to be transported expeditiously to temporary storage sites where it could be sorted further for recovery or disposal. Speed of removal in turn will minimise public health and environmental hazards of uncollected waste, facilitate rebuilding and economic and social recovery (Di.Coma.C, accessed 2010).

The scope and procedural requirements of funding mechanisms and resultant impact on clean-up activities needs to be considered thoroughly. If not, stringent management requirements have the potential to adversely affect the speed and effectiveness of the clean-up works.

4.2. The effects

Decision-makers are primarily concerned with the potential effects of their decisions. Generally effects can be grouped into environmental, economic and social effects. Working within the given context and institutional framework and responding to the disaster specific impacts, disaster waste managers need to consider the various options for collection, treatment and disposal of waste and weigh-up the likely environmental, economic and social effects of the different options.

In order for waste managers to do this assessment, a realistic waste management and or overall disaster recovery goal, in terms of these effects, needs to be set. For example 'Remove debris as quickly as possible and protect human health and the environment' {USEPA, 2008 #67} may not be achievable as fast debris removal may compromise worker health and safety if there are significant hazards in the debris so a trade-off will need to be made. The inevitable strain on financial, personnel and equipment resources following a disaster means emergency managers also need to prioritise debris management and other relief / recovery activities in these goals.

4.2.1. Environmental Effects

Desired speed of disaster recovery (and at times, cost), often leads waste managers to alter the standard waste management hierarchy of source reduction, recycling and waste combustion/landfilling. Source reduction is generally not possible. Recycling can be slow and cumbersome and is dependent on market availability and so waste combustion and landfilling become the default management options. However, landfill space is often insufficient for the volume of debris generated and combustion is not socially acceptable in many communities. Temporary or sub-standard debris treatment methods and disposal sites (including for hazardous wastes) are often employed with varying environmental effects.

Following the Great Hanshin-Awaji earthquake, Japan, January 1995, open burning of wastes took place in the early stages of the debris management process to reduce debris volumes. While some accepted this management option in the interest of speed, others condemned the action due to potential health risks and environmental concerns (Kobayashi, 1995, Irie, 1995).

The environmental effects from L'Aquila debris management are not yet evident. The delays over selection of temporary and permanent disposal sites have caused dissatisfaction amongst residents but the delays may have also allowed for more thorough environmental assessments on potential sites to be carried out - thus minimising future potential for environmental damage. Recycling efforts too, while again slowing the waste management process, will have positive environmental effects in the long term.

4.2.2. Economic Effects

When assessing costs for debris management direct and indirect costs should be accounted for. The direct costs include management, collection, treatment and disposal costs. Indirect costs, however, are more difficult to account for (UNISDR, 2006) and include disruption of critical infrastructure, delays to rebuilding processes, impacts on local industry such as tourism, reduction in future landfill space, environmental impact remediation resulting from inappropriate and/or illegal dumping, resource depletion by limited resource recovery. FEMA (2007) estimates that for disasters in the US between 2002 and 2007 (predominantly hurricanes and other storm events) debris removal operations accounted for 27% of disaster recovery costs.

The economic impact of debris removal from L'Aquila earthquake is largely unknown at this stage. In terms of indirect costs, the lengthy delays in dealing with debris will severely impact the rejuvenation of the local economy. On the other hand the concerted efforts to handle the waste environmentally sensitively and to maximise resource recovery may save environmental remediation and the recycled materials may reduce raw material use during rebuild.

4.2.3. Social Effects

On a psychological level, disaster waste can serve as a reminder to communities of the losses they have endured. Physically, the poor management of waste can potentially pose a public health hazard and can hinder the rebuilding process and the subsequent return to 'normalcy'.

Following the L'Aquila earthquake, the slow debris removal, particularly in the City Centre, has frustrated residents. On 28 February 2010, almost 11 months after the earthquake, thousands of people, wielding 6000 wheelbarrows (Nardecchia, 2010), staged a demonstration against the presence of debris in L'Aquila town centre (Caporale, 2010). The protest was a call for action – to remove the debris and continue with the rebuilding.

It must be acknowledged, however, that the slow debris response, while not ideal, may be partially vindicated by the desire to protect historic buildings (MiBAC, accessed 2010), allow post-disaster investigations and achieve a long-term positive environmental outcome. A fast response that didn't consider all these factors might also not have been accepted.

ASM reported illegal dumping / debris and waste deposition in the streets by frustrated residents trying to clear their own properties. The hap-hazard dumping exacerbated the clean-up task for ASM and posed both an environmental and public health hazard. Illegal dumping is undoubtedly a combination of poor public understanding of the clean-up process (communication) and general frustration by the slow waste management response.

Public perception, understanding and involvement has long been recognised as the key to successful solid waste management programmes {USEPA, 1995 #72}. Achieving this community engagement and recognising the potential impact of waste management options on a community in a disaster situation is a huge challenge for waste managers.

5. PLANNING FOR DISASTER WASTE MANAGEMENT

The need to plan for disaster debris has only really been recognised within the past 15 years or so. The first and most comprehensive national guidance on disaster debris management was USEPA's "Planning for Disaster Debris" {USEPA, 1995 #8}. Planning documents prepared by governments are generally built from the experience of previous events in the country and are framed around existing legislation, organisational structures and funding mechanisms. There is little or no guidance on establishing appropriate institutional frameworks. The guides also give technical advice but no decision-making or environmental, economic and social assessment guidance is provided. Effective planning for disaster waste management must be built around a model such as the one in Section 3.

The CONTEXT is known. It is likely to change slowly over time (demographics, social structures, landuse, climate etc.) but for medium and long term disaster planning the essential context will remain constant both before and after the disaster. Planning should be carried out with an understanding of the specific context.

The DISASTER and DISASTER IMPACTS are largely unknown. Prediction and modelling of disasters is improving rapidly but there will always be uncertainty in this (size, location, date, time, duration etc). Plans need to account for disaster impact variability and unpredictability.

The INSTITUTIONAL FRAMEWORK can and should be established pre-disaster. In planning for disaster response, the framework (legal, organisational, financial) should be designed specific to the context and should be flexible enough to be readily applied to a spectrum of predicted disaster impacts but bounded enough to ensure appropriate decision-making. As discussed, disaster response decisions are bounded by these institutional frameworks and having appropriate and flexible institutional frameworks in place can improve the efficiency and efficacy of the response. If emergency situations are anticipated prior to a disaster, significant delays could be avoided and the potential for erroneous decision-making (based on inadequate information or poor analysis of information) could be avoided.

The EFFECTS, environmental, economic and social, are what decision-makers in a disaster situation must consider when designing recovery, or in this case, disaster waste management, options. To respond in a disaster, given the unknowns, decision-makers need to be armed with the right tools to expeditiously and confidently assess the likely effects of various recovery options. Disaster assessment tools to measure social impact, environmental impact, risk and cost-benefit analyses are all needed specifically for waste management decisions.

Social and political pressure for a fast and economic recovery can elevate levels of risk taking as speed of recovery reigns over environmentally sustainable and accepted solid waste management practices. If planning is carried out in peace-time, without these post-disaster pressures, and robust assessment tools developed, the efficiency and effectiveness of the overall recovery could be improved.

6. CONCLUSION

Emergency and recovery managers in L'Aquila have cited waste as a significant hurdle on their road to recovery. Complex legal requirements for management of waste in particular have hampered efforts to expeditiously remove, recover and dispose of the waste.

Effective disaster debris management has far wider implications in disaster response and recovery than is currently recognised. There is real social, economic and environmental value in planning for the management of disaster debris. Plans should include flexible institutional frameworks and robust impact assessment tools specific to the context and predicted disaster envelopes. Disaster waste management is not just a logistical exercise – it is an integral part of the disaster recovery process and can be planned for effectively.

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