Safe Disposal and Recycling of Water Disaster Debris in Pakistan

A. Latif[1], T. Sultan[2], A. S. Shakir[3], A. R.Ghumman[4], M. U. Rashid[5]

[1,2]Civil Engineering Department, University College of Engineering & Technology, BZU. Multan, Pakistan
[3]Civil Engineering Department, University of Engineering and Technology, Lahore, Pakistan
[4]Civil Engineering Department, University of Engineering and Technology, Taxila, Pakistan
[5]Senior Engineer, NESPAK, Lahore, Pakistan
Engrabid1997@gmail.com

Abstract-Depending upon the nature, the disaster may produce large masses of debris. Waste masses from single disaster integrate to larger magnitude annually. This will ultimately causes the extra work load on personnel and reflects the poor existing debris management facilities. Besides, it will take longer time to rehabilitate the debris exaggerated regions. The study focuses on 2main cases of disaster i.e. earthquake of 2005 and flood of 2010 in Pakistan. Complete analysis involve two stages: the first stage involve development of "disaster and disaster debris" effects guidance whereas the second stage involves the development of set of criteria to make efficient environment and positive impacts of successful debris managing scheme. Such principles were employed to evaluate efficiency of debris managing scheme for detailed analysis. The discussion of the detailed analysis depicts methodology which assists the disaster managers, planners and researcher to simply multitude of work. Moreover, the "disaster and disaster debris" influence direction, the effect evaluation criterion and managing criteria have been established having the effect they can be virtually put into service for prospect debris managing scheme, planning and retort.

Keywords-Disaster Rubble, Ecosystem Influences, Harmful Waste, Quake, Deluge, Debris Managing Scheme, Removal and Reprocessing.

I. INTRODUCTION

The disaster may come across in many forms: flood, earthquake, civil dissensions, droughts, eruption of volcano, tsunami, tornado, fire etc. All these disasters have different impacts from economic, social and physical impacts.

Disaster is a natural and an unpredictable incident which go beyond the capability of exaggerated region to retort to it so that bring to safety; to keep belonging; and to maintain the communal, financial, environmental and biased firmness of the exaggerated area" [1].

With respect to character and strictness, calamity may make high magnitude of waste. By keeping in view the precedent calamities in the United States (US), [ii] concluded that in few situations produced waste masses approximately five to fifteen times more than yearly waste production rate from a single occasion.

Same results were revealed by [iii] subsequent tsunami of Indian Ocean. Such kind of large masses may effects the existing solid debris management system and human resources.

Major disaster yields large masses of debris in few hours or sometimes even in minutes. The volume of disaster debris depends upon the magnitude of trees ball up, indemnity to houses, business, services etc. The disaster remaining may be equally large in metropolitan and non-metropolitan areas. Debris clearance should begin as soon as possible to ensure the public health and safety. All activities relating to debris management like clearance, removal, and recycling are vivid signs of recovering regularity and ensuring sustainable community.

1.1 Environment and Public Health Safety

Defective disaster management and environmental vulnerability are chief causes of high physical damages. Good environmental standards such recycling, use of open burning and disposal can speed up the revival. Health of public and protective measures is the vital targets in planning and studies of debris management. Following are basically important features in this regard

1- Damage of health of public from debris like pest and sites of vector reproduction and health issues [iv] has to be directed.
2- Intimidation of health and safety from waste management choices e.g. Hurricane Andrew, US, 1992, the health of public was seriously affected by air curtain incinerator units and intimidation from on fire mix waste masses [v].
3- Protective measures of debris handling personnel. The crew involve in the cleanup operation of

debris of World Trade Center (2001) inhaled dust particles during operation and they were strongly affected to health problems [vi].

Disaster waste impacts and their issues are explained in Table No. I.

II. Characteristics of Debris with Respect to Disaster Types

The characteristics and volume of disaster mainly depends upon the disaster types. For example, flood generates vegetation, household debris, mud and soil, sand bags, plastic and demolished material. Basically debris may consist of ashes, wood, vegetation, damaged furniture, metals, concrete, soil, etc. Table No. II summarizes the debris characteristics according to the disaster types.

III. Debris Composition

The composition of debris is well predictable from two important features.

1- Built Environment
2- Kind of calamity [vi]

Construction and demolition (C & D) waste are the major components of urban disaster debris management. Such waste also includes such components that afterward intensify serious health risk to public. They may include; arsenic processed wood, asbestos, [viii], gypsum leaching [ix], [vii] and organic contaminations [x].

Besides, some other kinds of components are also considered here which may be in roundabout way liable to subsequent events, involving: too much surplus aid [xi], high finance of health care [iv], stale and out ride food at power breakdowns [xii] and hold up for urgent situation food packaging [xiii].

Community waste is another component if public is residing in exaggerated regions. The community waste must be kept into the mind when planning a waste managing scheme [xiv]. Otherwise, the community rubble assimilates into the rubble [xv] and liable to serious health risk. Likewise, it is very hard to segregate [xiv] and unable to collect [i].

IV. Debris Management Phase

Normally the debris managing phase further consists of three phase [xvi]

1. Exigency retort
2. Recovery
3. Restructure

TABLE I
Disaster Waste Impact and Their Issues

Issues	Distinctive Homo and Ecological Affects
Ungoverned structure debris from smashed buildings	Hinder entree and restraints restore & restructure actions. The site is also dumping site so it forces more waste.
Removal in unsuitable fields and or development of spread deposit places	Greater impact on potable water supplies and on aquatic life. Increase in vectors which ultimately cause diseases. High destruction of valuable land. Human injury risks from dumping sites. Risks of cuts and from sharp material. Liability of fires.
Crumple of public solid barren work, as well as possible loss of skilled rubbish handlers	Shortage of assortment work and irregular removal of dissipate.
Unrestrained discarding of health care barren from clinics and hospitals	Causes serious danger to health of public and causes breaking out of epidemics and issues regarding odor.
The sheets of asbestos contact in distorted structures or in recycle of asbestos for renovation	Causes health risk while inhaling.

TABLE II
Debris Characteristics with Respect to Disaster Types

Disaster	Debris Characteristics
Earthquake	Structures get collapse and entrapped the waste within damaged building. This causes serious difficulties while separating hazardous and non-hazardous material. Collapsed buildings block the streets and causes difficulties in rescue and relief operation. Since all building content mix with waste therefore causes serious health issues.

Disaster	Debris Characteristics
Flooding	Affects the structural integrity of infrastructure. Timber may get rotten Waste is mixed with hazardous materials like electronic devices and house hold cleaning products. It transports grits which may be merged with harmful matters and require evaluation earlier than disposition.
Tsunami	Strongly damage infrastructures and spread debris over large area. Debris consists of mud, branches of trees and other objects that are very hard to separate.
Volcanoes	Consists of ashes, pumice stone and fused state of rocks or lava. The presence of fine ash particles makes it difficult to remove debris and also it create extra working load and strain on equipment's.
Hurricane Typhoons Cyclones	Building ruined partially or completely due to wind. It completely destroys the low cost houses even bricks and concrete walls may collapse. Debris which yield consists of petty items, roofing sheeting, dust etc. which disperse over streets, roads, market places etc. This causes the problem especially if the debris consists of asbestos. Sea craft are thrown towards shore and destroyed. Telephone and electrical services may be destroyed.
Conflicts-short term	Short term combat missions results in damage of buildings, infrastructure and other modern amenities. Bombing and rockets can greatly damage infrastructure is often burnt, such as stones, bricks and concrete. Communication structures like bridges, highways, and railway lines are often Bridges, highways; railway structures etc. are often destroyed. Clean-up operation is normally performed by heavy machine like excavators and bulldozers. Unexploded ordnance (UXO) which consists of landmines often present in the debris matrix.
Conflict-protracted	Such types of conflicts are similar to short term conflicts but cause damages of buildings and infrastructures on very large extent.

The exigency stage consists of the elimination of all the waste masses that are liable to serious health risk [ii] and it may take only some days and two weeks [xvii], [xviii].

In history, recovery stage has hanged about up till five years [xii]. The exigency stage may also be influenced by many issues that are out of the ascendance of waste management, law enforcement and corner inspection that may abstain place occupying intended for rubble [xi] and native come back [xviii].

Restructuring stage may go up till 10 years [xix]. However, it is very length process and not easy to predict the exact "end" of this phase.

V. Debris Handling and Treatment Interventions

5.1 Provisional Staging Sites

Debris can damage the environment and people's livelihood if unsuitable sites for temporary storage of debris are selected. After Tsunami of Indian Ocean (2004), the rubble was thrown to open grounds, drench etc. [xx]. Many writers suggest impermanent storage sites to overcome the dangerous impacts [xxi].

5.2 Open Burning

Some people recommend that it is good enough under different conditions to openly burn the debris, while other censure it because of harmful impacts on environment. Following the Indian Ocean tsunami [iii], and the Great Hanshin-Awaji earthquake [xxii]. Reference [iv] advocate that such type of technique is essential preference in many situations to eliminate pressing dangers but yields some guidance on the stipulation for convenient open burning.

VI. Debris Disposal and Recycling

If the rubble is disposed off inappropriately then it strongly affects the livelihood, natural schemes and health of public. Recycling and reuse is apparent with the value of improved "clean" concrete rebar being more than 50% of the value of latest rebar, expected to augment additionally and already generating work/cash for effected community.

6.1 Disposal

Sometimes disaster may generate very large volume of debris in such cases the permanent debris disposal sites cannot accommodate debris [iv], [vii]. Provisional waste disposition may be employed, as used after the Marmora quake [xiv]. Writers enlightened the dangerous impacts on environment of these disposition sites but discussed few actual

impacts on environment.

Disposition of harmful matter had caused severe problems as the subsequences of Indian Ocean tsunami [xx]. Such kinds of several dangerous matters are first segregated in some cases and then disposed off.

6.2 Recycling

Sometimes it is convenient to recycle debris instead of disposal. Usually the matrix of debris often consists of coalesce and requires segregation/sorting on the site or off the site. Usually the corporeal that is reprocessed from rubble of building may include timber, roof sheeting, metals, asphalt, concrete, etc.

Moreover, these materials afterward used in land filling, fertilizations, slope stabilization, etc.

The major part of disaster debris obtained from building sites majorly consists of construction and demolition (C&D) debris. The major arrangement includes in the recycling process involves: collecting and processing corporeal; the lack of particular instruments; difficulty to segregate the material [xiv]; difficulty in making up material for rebuilding [xxiii]; lack of disposition places [xxiii]; unavailability of funds for disposition [xiii]; and the deficiency of market to accommodate big measure of material [xxiii].

Greater magnitude may be sold or donated which is collected from rubble and sold, donated, store or used again on the current project. Commonly the materials that are reused in repaired or new works may be appurtenances, window panes, bricks, fittings, console etc. Nearly more than 200 stores are working across the Pakistan that purchase or get donation of these items.

VII. METHODOLOGY

Many disasters may cause severe cause to environment as well as human health such as damages to chemical plants, erosion and landslide risks in hilly areas. Some disaster may also causes obtuse effects on environment and human health, but even so requires attention in early recovery process.

The case studies on two important disasters in Pakistan have been analyzed:

1. Earthquake of 2005
2. Flood of 2010

In both case studies, qualitative facts and figures have been congregated from publicly meetings with staffs engaged straightly in the debris management process comprising solid debris managers, emergency managers and local authorities.

Further data was also collected from before and after tragedy literatures (e.g., Government statements, documents; practitioner reports; newspaper, etc.) and semi-structured consultations with specialized engaged in disaster debris administration.

7.1 Earthquake of 2005

The rubble of earthquake commonly consists of building corporeal, property and sediments. Moreover, it is very hard collect demolished material due to safety reasons.

7.1.1 Characteristics of Earthquake

Pakistan has faced a giant earthquake of 7.6 struck northern Pakistan. The destructive effects spread over nine districts of *Azad Jammu Kashmir* (AJK) and *Khyber Pakhtunkhwa* (KPK). Epicenter of the earthquake was situated 19km towards north-east of Muzaffarabad in AJK having focal depth 26km.The destructive effects of this earthquake were landslides, rock falls damaged, destroy many roads and buildings and breaking up approach to several portion of the area.

7.1.2 Earthquake Debris Management

Quake produces larger magnitude of rubble that was obtained from restoration.

1. Wipe out work done by National Fire Corps or by municipality
2. mend works by firms permitted from ecological manger's rule
3. Petty mend work by entity

Rubble yields from repair and wipeout work was dumped at territorial disposition place whereas the rubble from petty repair operation was dumped at essential compilation centers. Debris aggregates had been used in the construction of building, roads and environmental remedial works.

7.1.3 Disposal and Recycling of Earthquake Debris

The reprocessing and reprocessing of different kinds of disaster waste are carried out by different means.

7.1.4 Disposal of Debris from Infrastructure and destroyed Buildings

Waste from destructed buildings and other structures had great bad impacts on livelihood (agriculture, commerce, reconstruction, roads and other access), human health and other environmental factors.

An inspection is performed before the demolition of any structure took place to assess site utilities and drawbacks (private well, combustible material, asbestos, etc.). Rubble obtained from demolition was dumped to land filling sites. Bitumen shingles, metal roof sheeting, wood, and other similar materials were not separated meanwhile. Concrete and asphalt were squeezed and sold for utilization as sub-base in road building process.

7.1.5 Other Hazardous Material

Besides above, some other dangerous material consists of toxic substances chemical industry, hydrocarbons, ammonia gas from refrigeration, wall

and roof sheeting of asbestos, material from damaged transformer and electric appliances etc. Some appropriate remedies were applied to such type of waste material which includes storage and disposal. If hazardous materials could not safely be removed from other flood debris or no recycling option was available, hazardous materials could be taken to a landfill for disposal. General hazardous debris recycling activities engrossed were the mending of spent solvents (e.g., acetone recovery) or metals (e.g., lead recovery). Metal were recycled and sold by scrap metal dealers.

7.1.6 Homo and Solid Waste

Earthquake destroyed public and household manure system on large extent and resulting in contamination of underground water. It posed serious risk to human health. This was really significant in refugee's camps.

Due to lack of disposal sites debris was being thrown into the rivers which ultimately caused danger to the communities residing to the downstream across the Indus Basin. Alternatively, dead human bodies were taken to a landfill for final disposal.

7.2 Flood During 2010

7.2.1 Flood Characteristics

Pakistan have been faced the worst flood in history since 1929. The flood created as a result of heavy rain of in month of July (2010) of same year which continues up till September (2010). This flood enormously affected the entire range of country.

7.2.2 Flood Debris Management

The flood water was contaminated with human and animal excreta, oil, gasoline, industrial chemicals that potentially causes ill effects on human health.

Government had established a debris management program with certain level of recycling. Debris was collected directly from homes or community. This debris is then afterward dumped to permitted land fill sites or rubbish sites.

7.2.3 Disposal and Recycling of flood Debris

Government establishes three different sorts of cleanup programs.

7.2.4 Sand and Mud Deposited on Roads

Crew collected the sand and mud from roadways and put them into drainage ditches on the road side. This material is afterward cleared up from ditches to recover the drainage. This collected soil was delivered to the farmers, who used it for topsoil. Government invited interested farmers to take debris from roadside. Mud was used as landfill coat or as a soil alteration for the farmers.

7.2.5 House Hold and Hazardous Debris

After the drop down of flood water the house hold debris was collected from town or sites along the river. For this purpose, government placed containers in towns or communities alongside the river. Private company was agreed contract to haul nearly 900 containers of rubble having capacity 40 to 90 tons. The residents individually used to drop their house hold debris into container. The debris from these containers was afterward dumped to landfill sites. Initially, the work effort of crew was 10 hours per day which was afterward enhance up to 24/7as people dropped larger rubble at night in contrast to the day time. Site staff was accountable for isolation of material for recycling and hazardous material. People dropped their house hold debris to collection sites on the land. The crew use high power tractor with bucket on the front, to lift weighty things into the container.

Crew segregated nearly 1/3 of the rubble consists of wood, roofing and flooring, gadgets, tires and other hazardous material etc. It was proscribed to fill land with decaying material like leaves, vegetables etc. If the crew was less assurance that whether the material is hazardous or non -hazardous then it was categorize as special debris. After isolation of material, the non-hazardous material was dumped to the land fill sites. While hazardous materials were placed into sealed containers which was leaked proof. Metals were recycled and sold by the scrap metals dealers.

7.2.6 Building Destruction Debris

Altogether 300 houses destroyed having cost more than 50% of the capital cost. Personnel separated windows, doors, gadgets, wires, pipes, shingles, roofing, insulation etc. The contractor sold or left away partial of these materials before disposition. The rest of the material was dumped to land filling site. Bricks were sold for re-use or used as ground in scenery applications. Recycling of building debris stuffs were as crushing concrete to re-use it as gravel evades using landfill space, diminished the necessitate of quarry rocks and/or cut trees.

VIII. Results and Discussions

8.1 Results

8.1.1 Outline of Earthquake affects

The giant quake of 2005 made massive damage of life and property approximately 73,000 deaths, 128,000 injured and 600,000 houses destroyed. Moreover, infrastructures, telecommunication facilities and others amenities also got affected. Imprecisely, the rough estimate of total envision of scathe was US$5.8 billion [xvii].

8.1.2 Outline of Flood Impacts

The 2010 flood, high rain and landslides largely affected the infrastructures. Entire hamlets were

washed away, several homes and buildings destroyed. Moreover, flood ruined cardinals of acres of cultivated domain and eroded soil on large scale.

According to National Disaster Management Authority (NDMA), the floods and rains exaggerated 20 million refugees, around 1.67 millions houses were damaged and 2.2 million hectares of cultivated land destroyed.

Flood destroyed many houses approximately $1.158 billion cost of damaged is estimated to houses. Nearly 1.6 million homes were ruined by water. Nearly 1.45 million exaggerated houses were kutcha and nearly 850,000 had been damaged entirely. Imprecisely 800,000 homes in Sindh, 375,000 houses in Punjab, 250,000 houses in Khyber Pakhtunkha and 80,000 houses in Baluchistan were either damaged or destroyed completely due to flood water.

Demolished material can be waste off and reprocessed in several methods summarized as Table No. III.

8.2 Discussions

Debris removal technique is a very challenging task after disaster. It may take few months or may finish in years. Debris removal technique after flood in Pakistan has drawn attention from stake holders, as well as statesmen.

Disposal and recycling are basically two important means of treating with debris. Enhancing the recycling can reduce landfill debris. Furthermore, it is a valuable technique for the material which cannot dump to the landfill sites. The inert constituent of debris is considered as good material for landfill.

The debris itself is considered as the good resource for the construction of roads, buildings. Concrete, inert rocks, asphalt road base and the asphalt shingles utilize to the maintenance of damaged road. Likewise, rock, sand, concrete and other material may utilize new concrete. Plants and other compostable material can be aided to soil for fertilization purposes.

Building demolition is a very complicated issue as it yields different sorts of material. Building demolished debris may contain both hazardous and non-hazardous material which includes; asbestos, computer equipments, appliances, furniture, waste water, shingles, flooring etc and results extraordinary opportunity of recycling. So before dismantling, better results may be achieved by pre assessing the building materials.

TABLE III
DISCARDING AND RECYCLING OF DESTRUCTED MATERIAL

Destruction Material	Recycling/Disposal
Bitumen (shingles and paving)	Recycling of bitumen for new construction, dumping into landfill or used as clean filled by keeping in minds state regulations.
Soil	Disposition into landfills and may as it is or after cleaning.
Electrical	Recycling and disposal to sites for solid debris disposition.
Insulation (rigid polystyrene non-asbestos, roofing and fiberglass bat)	Disposal into land fill sites by keeping in mind state regulations in this regard.
Masonry and Rubble	Disposed off to landfill sites. May also be used as clean filled, recycled and crushed into smaller components?
Metal	Sold as scrap and get scrap value. It is further recycled in furnace.
Plastics	Disposition to landfill sites or reprocessed.
Roof Materials	Disposition to land fill sites or reprocessed by using as aggregates in pavements and flooring.
Flooring, siding, windows and doors	It is may be reused if removed integral otherwise disposition to the landfill sites.
Timber (nom-treated and treated)	Reused as structure member or reprocessed and used as fuel and some other building products.
Wall Coverings	May be used as reclamation of soil or a substitute for lime on lawns, or may be dumped to landfill sites.
Glass	Collected and send to glass recycling plant or thrown to landfill.
Asbestos, PCBs, etc.	Collected separately and disposed off to special disposing sites.

IX. Conclusions and Recommendations

This research offers a stout structure and a scheme recognizing which will help to get ready for prospect disaster debris management plots. The devastation and debris elimination retort overall following the two disasters in Pakistan were considered almost successful. While the retort was effectual in these cases the same method cannot be effectual for the other disaster state. Planning is compulsory to provide decision-creators information and the tools needed to make opportune, effectual and coordinated verdicts after any disaster event.

Different types of disaster have different degree of destruction and require different types of efforts for revival. So there must be proper planning to machinate the recovery efforts within certain restrained parameters. The developed plans within restrained parameters must have some level of flexibility to possible disposal and recycling process.

It must be kept into mind that ensure population with basic life amenities, prevent further loss to property/life during disposal and recycling. The scope of debris management comprises of exploring, rescue activities, road clearance and making secure structure. Moreover, during recovery phase, the objectives should be kept flexible that can be changed when needed.

Following are the some vigorous benefits of disposal and recycling process.

Lessened dangerous environmental effects

Reducing landfill load

Economizing the whole exertion

Reducing in transportation for raw material and debris

Fashioning employment opportunities

Reduction in the quantity of raw materials demand

Some propositions are recommended below for future disaster management:

Must ensure economical work to avoid postponing

Planner must coordinate with disposal and recycling coalition

The directive and supporting environment must be structured for recycling disaster debris

Debris management operations should be considered in communal waste managing scheme.

References

[i] FEMA, (2007). Debris Management Guide, Public Assistance, FEMA-325/July 2007, Federal Emergency Management Agency.

[ii] Reinhart & McCreanor, (1999). Disaster Debris Management - Planning Tools, 24 September 1999, Department of Civil Engineering, University of Central Florida.

[iii] B. F. A. Basnayake, C. Chiemchaisri, C. Visvanathan, (2006). Wastelands: Clearing up after the tsunami in Sri Lanka and Thailand. Waste Management World, March-April 2006, 31-38.

[iv] M. Petersen, (2004). Restoring Waste Management Following Disasters. 2004 International Conference and Student Competition on post-disaster reconstruction "Planning for reconstruction" Coventry, UK, April 22-23, 2004.

[v] USEPA, (1995). Planning for Disaster Debris.

[vi] J. H. Lange, (2004). The WTC Disaster and Asbestos Regulations. Environmental Health Perspectives, 112:11, A606-607.

[vii] USEPA, (2008). Planning for Natural Disaster Debris EPA530-K-08-001, Office of Solid Waste and Emergency Response, Office of Solid Waste, USEPA.

[viii] B. Dubey, H. M. Solo-Gabriele, & T. G. Townsend, (2007). Quantities of Arsenic-Treated Wood in Demolition Debris Generated by Hurricane Katrina. Environmental Science & Technology, 41(5), 1533-1536.

[ix] Y. C. Jang & T. Townsend, (2001). Sulfate leaching from recovered construction and demolition debris fines. Advances in Environmental Research, 5:3, 203-217.

[x] Y. C. Jang & T. Townsend, (2001). Occurrence of organic pollutants in recovered soil fines from construction and demolition waste. Waste Management, 21:8, 703-715.

[xi] S. Ekici, D. A. McEntire, & R. Afedzie, (2009). Transforming debris management: considering new essentials. Disaster Prevention and Management, 18:5, 511-522.

[xii] L. Luther, (2008). Disaster Debris Removal after Hurricane Katrina: Status and Associated Issues, Order Code RL33477, Congressional Research Service.

[xiii] G. Y. Solis, H. C. Hightower, J. Sussex & J. Kawaguchi, (1995). Disaster Debris Management. The Disaster Preparedness Resources Centre. The University of British Columbia for Emergency Preparedness Canada.

[xiv] F. Baycan, & M. Petersen, (2004). Disaster Waste Management C and D Waste. Annual Conference of the International Solid Waste Association, Istanbul, Turkey, 8-12 July 2002.

[xv] N. M. Jackson, (2008). Cleaning up after Mother Nature. WasteAge, July 2008, 3.

[xvi] JEU, (2010). Initial clearing of debris and solid waste. JointUNEP/OCHA Environmental Unit, Geneva.

[xvii] J. Cosgrave, & M. Herson, (2008). Perceptions of crisis and response: A synthesis of evaluations of the response to the 2005 Pakistan earthquake. In M. Herson, J. Mitchell & B. Ramalingam

(Eds.), ALNAP Seventh Reivew of Humanitarian Action (pp. 177-224). London: Overseas Development Institute.

[xviii] J. E. Haas, R. W. Kates, & M. J. Bowden, (1977). Reconstruction following disaster, The MIT Press.

[xix] T. Cook, (2009). Cleaning up New Orleans: The impact of a missing population on disaster debris removal. Journal of Emergency Management, 7(3).

[xx] S. Pilapitiya, C. Vidanaarachchi & S. Yuen, (2006). Effects of the tsunami on waste management in Sri Lanka. Waste Management, 26 (2006), pp 107-109.

[xxi] E. Johnston, L. Dolan, B. Glavovic, R. V. Schalkwyk, C. Killeen, J. Cousins, (2009). Disposal of debris following urban earthquakes: guiding the development of comprehensive pre-event plans GNS Science Report 2009/33, Institute of Geological and Nuclear Sciences Limited.

[xxii] T. Irie, (1995). Lessons from the Hanshin-Awaji Earthquake - Final Disposal of Solid Waste. Earthquake Waste Symposium, Osaka, 12-13 June 1995.

[xxiii] E. K. Lauritzen, (1998). Emergency construction waste management. Safety Science, 30(8).