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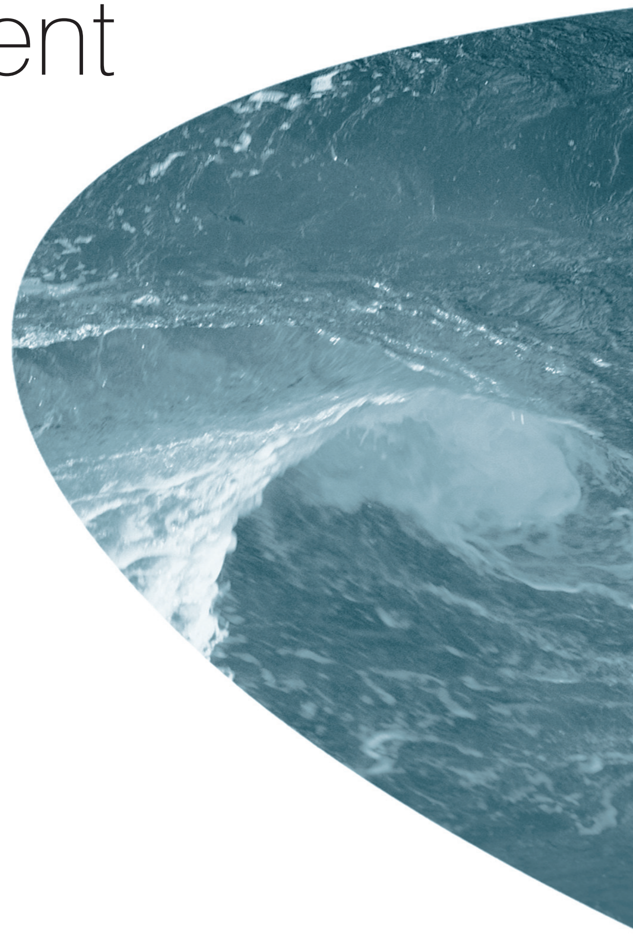

Disaster management and the built environment

Guest Editors: Professor Dilanthi Amaratunga and Dr Richard Haigh

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Guest editorial

About the Guest Editors *Professor Dilanthi Amaratunga currently holds a chair at the School of the Built Environment at the University of Salford, UK and currently leads research in the field of capability and capacity building in the built environment, with a particular interest in disaster management. She has nearly 200 published papers, and has successfully managed several research projects. She is the Coordinator of CIB International Task group TG53, which aims to improve the availability of skilled researchers in building education and research through the development of researchers' capacity to produce, transfer and utilise knowledge. (CIB - International Council for Research and Innovation in Building and Construction (www.cibworld.nl/website/) CIB was established in 1953 as a UN associated association whose objectives were to stimulate and facilitate international cooperation and information exchange between governmental research institutes in the building and construction sector, with an emphasis on those institutes engaged in technical fields of research. CIB has since developed into a worldwide network of over 5000 experts from about 500 member organisations active in the research community, in industry or in education, who cooperate and exchange information in over 50 CIB Commissions covering all fields in building and construction related research and innovation. CIB Members are institutes, companies and other types of organisations involved in research or in the transfer or application of research results). She was the Conference Co-Chair of CIB W89 CIB BEAR 2008 (International Conference on Building Education and Research) (www.bear2008.org) held in Sri Lanka in February 2008 in bringing together world-leading experts in education and research and capability building in disaster management. Details of her profile are available at: www.seek.salford.ac.uk:80/pp.jsp?AmaratungaDilanthi248. She currently leads, together with Dr Richard Haigh, CIB/United Initiative on Disaster management and the Built Environment.*

Dr Richard Haigh is the Programme Director of the MSc in Disaster Mitigation and Reconstruction Degree Programme at the School of the Built Environment, University of Salford, UK and an active researcher in disaster management with a particular interest in capacity building and corporate social responsibility. Richard is also the Coordinator of CIB Task Group 63: Disasters and the Built Environment, a network of 58 Higher Education Institutes across 27 countries. This CIB Task Group aims to stimulate ideas for future research by exploring the range of perspectives from which the construction industry is able to contribute towards improved resilience to disruptive challenges and by facilitating the dissemination of the existing knowledgebase. Richard is joint principal investigator of EURASIA, an EU Asia-Link funded network project that aims to enhance the capacity of the partner institutions for training, teaching and research activities required for the creation and long-term management of public and commercial facilities and infrastructure associated with disasters. Details of Richard's profile are available at: www.seek.salford.ac.uk:80/pp.jsp?HaighRichard509

Details of disaster management research led by Professor Amaratunga and Dr Haigh are available at: www.buhu.salford.ac.uk/research_centres/capacity_building_disaster_mgt/

Disaster management and the built environment

In recent years, there has been increasing recognition of the contribution that built environment related professionals can make towards increasing a community's resilience to disasters. The "built environment" encompasses a wide variety of professional expertise including design, construction management, quantity

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surveying, building surveying, and property management. Their contribution occurs beyond the traditional cycle of feasibility analysis, planning, design, construction, operation, maintenance and divestiture, to encompass the built environment professional's ability to anticipate and respond to unexpected events that damage or destroy a building or infrastructure project, and reflect an ongoing responsibility towards the host community.

The role of built environment professionals and local communities in developing resilience to disasters can be viewed as two separate yet interrelated aspects:

(1) To create a built environment that is not vulnerable to a disaster or disruptive challenge. This relates to the resilience of the physical state of infrastructure, buildings and cities as well as developing policies, legal and regulatory controls, and practices that govern the building industry to build safe structures. Essentially this means building cities or infrastructure that will not be affected by a disaster.

(2) To develop organisational structures, capacities through education and training, and construction systems, that can react in the event a disruptive challenge does occur. This means responding to the immediate after effects of a disaster to restore operational conditions of infrastructure or the built environment as quickly as possible. This means also to aid in the speedy recovery of the region through sustainable reconstruction, post-disaster building or other related projects.

In February 2008, the Building, Education and Research (BEAR) Conference was held in Sri Lanka, with over 160 papers accepted for publication and presentation. The Conference was organised by the School of the Built Environment, University of Salford, in conjunction with the CIB (Conseil International du Bâtiment, in English this is: International Council for Building), a worldwide network of over 5,000 experts from about 500 member organisations active in the research community, in industry or in education, who cooperate and exchange information in over 50 CIB Commissions covering all fields in building and construction related research and innovation. The Conference was also held in association with EURASIA, a three year EU Asia-Link programme funded project that aimed to improve capacity in training, teaching and research activities associated with the creation and long-term management of public and commercial facilities and infrastructure in selected HEIs in Asia and Europe. The EURASIA partners included the University of Moratuwa and University of Ruhuna in Sri Lanka, Tallinn University of Technology in Estonia, and Vilnius Gediminas Technical University in Lithuania.

The theme of the 2008 conference was to promote built environment related education and research towards preparing for, responding to, and recovering from disasters. Like other affected countries, post-Tsunami rehabilitation in Sri Lanka is operating in a difficult context; among the most important factors is the pre-existence of very high densities of unplanned settlements in the Southern part of Sri Lanka with the majority of construction not observing some of the critical building standards. To add to this, the post-Tsunami rehabilitation operation has been affected due to weak local government institutions with poor response capacities to address the needs of such a magnitude. This is mainly because, before the Tsunami, Sri Lanka was known to be a safe haven where outrages of nature scarcely occurred except for occasional floods and landslides during the rainy seasons. The response to these challenges from the CIB community was not disappointing. Alongside the BEAR Conference's traditional themes of building education and research, in excess of 45 papers were published and presented on the themes of disaster mitigation, post-disaster recovery, post-disaster reconstruction, sustainability and environmental management. The conference programme also included five key note addresses that contributed to the debate on how the built environment community can assist society in developing resilience to disruptive challenges, including natural and man-made disasters, as well as the more traditional themes of advancing built environment education and research. The speakers brought with them knowledge and understanding from HEIs in four countries, as well as practical experience in Tsunami affected areas. The Conference also included a cross-theme discussion on the built environment community's role in disaster preparedness and reconstruction, which in examining the revised lifecycle, focused upon the associated themes of: capacity building, education, research and training; law and regulatory systems; the needs of developing countries; and, sustainable reconstruction. The discussion identified challenges and opportunities, helped to develop synergy, and identify areas for collaborations. It was evident that the CIB network of experts and member organisations active in the research community, in industry and in education, has a wide range of expertise to offer in addressing disaster related challenges. However, the attendees also recognised a need to fully engage with relevant stakeholders in order to address this challenging and complex problem, and working towards socially and environmentally sustainable human settlements.

The present volume of *Disaster Prevention and Management (DPM)* draws on the wide range of expertise that built environment professionals can contribute towards increasing resilience to disasters. It compiles original papers which were prepared for a panel of the Building Education and Research Conference, held in Kandalama, Sri Lanka, between 11 and 15 February 2008. The papers address different stages of the disaster management lifecycle, from pre-disaster risk reduction, through to post-disaster response and relief, and finally, long term sustainable reconstruction.

Lee Bosher and co-authors focus on the mitigation for flood hazards in the UK; particularly in understanding the extent of the problem, collating key guidance and legislation related to flood hazard mitigation, and identifying who the key construction decision makers are and the most opportune stages of the Design-Construction-Operation Process when they need to make their key decisions. Bosher et al. conclude that despite the publication of a range of guidance on flood hazard mitigation in the UK there is still insufficient evidence that key construction stakeholders are playing an active role in mitigating flood risk.

Also looking at risk reduction, Kanchana Ginige and co-authors highlight the vulnerability of women in many disasters and emphasise the importance of gender mainstreaming as an element in disaster reduction policy, and to integrate a gender equality perspective in all policies, and at all levels. Ginige et al. conclude by discussing the ways in which women's specific needs may be captured and incorporated at the disaster management planning stage.

Moving on to the recovery phase, Zeeshan Aziz examines how mobile computing support can be used by professionals involved in a disaster response and recovery operation to facilitate better assessment of the damage caused to buildings and to make this assessment information available to personnel within the disaster response arena so as to expedite a safe, efficient and effective disaster response process. The paper describes a Radio Frequency Identification (RFID) enabled mobile devices and tags system deployed and trialled at Illinois Fire Services Institute (IFSI). They conclude that the system can be used for posting, gathering, storing and sharing building assessment information in an efficient manner with lesser errors, leading to improved efficiency and effectiveness in the emergency response process.

Nicole Becker shows how a risk index can be developed to investigate the distribution and the reasons for post-disaster homelessness. Henerichs goes on to present options for an insulated tent floor with enhanced thermal properties that will not only raise the immediate post-disaster living conditions of the affected, but also enhance the overall sheltering process and create more time for good reconstruction to become available.

The final two papers focus on the longer term reconstruction requirements. Milinda Pathiraja and Paolo Tombesi contend that in fast urbanizing economies such as Sri Lanka, the construction industry tends to fragment into almost separate spheres of production with little or no reciprocal connection in training, know-how and career development paths. Set against this background, the paper presents the results of a technical review of a small sample of ideal-type projects in Sri Lanka, developed with the intention of forming an empirical basis to address: whether strategic planning of specific building technologies could lead to professional frameworks capable of narrowing the gap between high-quality architectural production, middle-quality commercial building and low-quality shelter supply; and, whether architecture can act as an engine of social and economic growth for those involved in its production. Based on government statistics and building output analysis, the paper argues that the above should and can indeed be the case, provided that such an agenda is developed strategically.

Finally, Rajendram Thanurjan and Indunil Seneviratne investigate the concept of knowledge management in the context of post disaster housing reconstruction in Sri Lanka. Their study found inadequate compiling and synthesising of accumulated data, information and knowledge, and that storing and organising knowledge was a major challenge faced by the donors and consultants. The study also found that although most organisations are aware of the importance of knowledge management to improve performance, most organisations engaged in post-disaster reconstruction of housing have not formally implemented knowledge management practices.

This special issue of Disaster Prevention and Management is our contribution to increasing the resilience of communities affected by disasters. It contributes to increasing our understanding of the built environment professions' role in disaster mitigation, response and reconstruction. Hopefully many more studies will build on this contribution and encourage the built environment community to engage with relevant stakeholders in order to address this challenging and complex problem.

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Attaining improved resilience to floods: a proactive multi-stakeholder approach

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Abstract

Purpose – There is a need to proactively address strategic weaknesses in protecting the built environment from a range of hazards. This paper seeks to focus on the mitigation for flood hazards in the UK; particularly in understanding the extent of the problem, collating key guidance and legislation related to flood hazard mitigation, identifying who the key construction decision makers are and the most opportune stages of the Design-Construction-Operation Process when they need to make their key decisions.

Design/methodology/approach – A pluralistic research design was adopted for the study, which included a UK-wide questionnaire survey and a set of semi-structured interviews involving a range of professionals from construction, planning, insurance, emergency management and local/national government agencies was undertaken.

Findings – Despite the publication of a range of guidance on flood hazard mitigation in the UK there is still insufficient evidence that key construction stakeholders are playing an active role in mitigating flood risk. The pre-construction phase of a building's life cycle is identified as is the most critical stage when key stakeholders need to adopt flood hazard mitigation strategies. The socio-institutional constraints to the proactive attainment of built-in resilience are highlighted as are recommendations as to how these constraints can be addressed.

Research limitations/implications – The paper reports on the provisional findings of an ongoing project but these findings nonetheless provide essential foundations for the latter development of the PRE-EMPT toolkit and also raise some important considerations about flood resilience in the UK.

Originality/value – The findings presented reveal how stakeholders should be better involved, and what issues they need to address, regarding the integration of built-in resilience into construction decision making.

Keywords Decision making, Floods, United Kingdom, Risk analysis

Paper type Research paper

Introduction

The floods during June and July 2007 were a wake-up call. The three months from May to July were the wettest since records began and the events that followed have been linked to the deaths of 13 people. They also resulted in damage to approximately 48,000 homes and 7,000

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> businesses. Power and water supplies were lost, railway lines, eight motorways and many other roads were closed and large parts of five counties and four cities were brought to a standstill (Cabinet Office, 2007, p. 3).

Threats to society and the built environment, are diverse and include extreme natural hazards (such as windstorms and floods) and human induced hazards (such as terrorist attacks). The "Stern Review" (Cabinet Office/HM Treasury, 2006) warns of a bleak future for the planet if societies and the built environment do not adapt to address the implications of a changing climate and the report goes as far as stating that the benefits of strong and early action far outweigh the economic costs of not acting.

Typically, natural and human induced hazards cause minor disruption to the economy, infrastructure and residents of the United Kingdom (UK) but it has been argued that the magnitude and frequency of these extreme events are increasing due to the implications of climate change (Cabinet Office/HM Treasury, 2006) with the result that the nation's built environment is likely to become increasingly vulnerable. Ofori (2008) states that the immutable nature of built assets, the inability to accurately test them for resilience, the legislative and socio-economic requirements of development, requirements for ongoing maintenance, adaptation and redevelopment, and potential appropriation by the end user all render built assets vulnerable to a wide range of hazards which will change over time. It would also appear that with socio-economic progress, society becomes more vulnerable as urban areas become reliant on their increasingly extended supply lines (Menoni, 2001), and ever-expanding and vital distribution networks of water, power, gas and telecommunication systems. Moreover, with globalisation, major urban settlements are also inter-connected; an extreme event in one of them can precipitate widespread disruption in many others.

Given this backdrop, this paper will discuss why it is important to embed flood hazard mitigation into pre-construction decision making. However, for this to occur, a wide range of stakeholders (such as engineers, designers, and urban planners) need to be consulted and actively involved in more informed decision making.

Towards a more proactive approach to resilience

The observed shift in the way disasters are being managed has been illustrated by the move away from the reactive attributes of Disaster Management towards the more proactive Disaster Risk Management (DRM) paradigm that should be "mainstreamed" into developmental initiatives (DFID, 2006). The United Nations' International Strategy for Disaster Reduction (UN/ISDR, 2004) has adopted a concept of DRM that can be summarised into four mutually interconnected phases (Figure 1), being:

1. hazard identification;
2. mitigative adaptations;
3. preparedness planning; and
4. recovery (short-term) and reconstruction (longer-term) planning.

DRM should be concerned with people's capacity to: manage their natural, social and built environments; and take advantage of it in a manner that safeguards their future and that of forthcoming generations. DRM needs to be holistic; it must ensure that associated strategies are viewed as a shared responsibility towards the attainment of resilience that includes issues such as hazard mitigation (Pelling, 2003; Trim, 2004) and

Figure 1.
The interconnected phases of the DRM framework

land-use planning (Burby *et al.*, 2000; Wamsler, 2004). Part of the shared responsibility that is required could be achieved by embedding construction professionals, who possess the knowledge and experience of how to design, build, retrofit and operate what are typically bespoke built assets, into the DRM framework (Bosher *et al.*, 2007b). The construction sector should play an important role in the structural[1] elements of mitigation (and adaptation), while developers and planners should be able to positively influence the non-structural[2] elements (Wamsler, 2006). However, there is little evidence of DRM being a priority for construction professionals, which may explain the apparent inability of the industry to mitigate the effects of natural and human-induced threats (Bosher *et al.*, 2007a). Thus, integrating the multitude of disciplines responsible for how the built environment is delivered is critical to the mainstreaming of DRM into long-term development (Dainty and Bosher, 2008).

The importance of resilience

In recent years the concept of "resilience", the capacity of human and physical systems to cope with and respond to extreme events, has become an increasingly prominent issue that complements the "sustainability" agenda. Indeed the concept has largely supplanted the concept of "resistance" with its focus on pre-disaster mitigation (Tierney and Bruneau, 2007). This may reflect the realisation that the changing nature of natural and human-induced threats are such that a nation's built environment can never really be future-proofed to be totally resistant (Dainty and Bosher, 2008).

The contemporary focus therefore, has shifted to ensuring the capability of the built environment to both resist and recover rapidly following extreme (but arguably more regularly occurring) events. Despite the theoretical attractiveness of this proposition however, the structure of the construction industry and the nature of the interaction between those who plan, design, construct, operate and maintain the built environment provides a problematic context within which resiliency considerations can be integrated. The socio-political landscape of the industry and professions arguably act as fundamental impediments to the achievability of this goal (Dainty and Bosher, 2008). Attaining more resilient infrastructure will therefore demand a paradigm shift in the way that built environment professionals integrate their activities and interact with the communities within which built assets reside. It is also important to appreciate that resilience is a multi-faceted concept which includes physical, social, economic and institutional components; the socio-institutional aspects are arguably as important to the attainment of resilience as the physical aspects because "resilient engineering" also demands a more resilient infrastructural context with regards to the professions, the structures and processes which govern construction activity. As Godschalk (2003, p. 42) notes:

> . . . if we are to take the achievement of urban resilience seriously, we need to build the goal of the resilient city into the everyday practice of city planners, engineers, architects, emergency managers, developers and other urban professionals. This will require a long-term collaborative effort to increase knowledge and awareness about resilient city planning and design.

Such knowledge is likely to come from several areas of inquiry all of which will form a new synthesis for achieving more resilient built environments. Bosher (2008) points to a number of key actions required to address systems in the built environment that are at risk from natural and human induced hazards. These actions are categorised as broadly relating to: Innovation and knowledge (new technologies, trans-disciplinary training and hazard awareness); Operations (information exchanges between a wide range of stakeholders such as planners, designers, engineers and the emergency services); Planning (well designed and suitable locations), and; Legislation and regulatory incentives (building codes and good practice guidance) (Bosher *et al.* (2007a). However, at present in many countries developing resilience against natural and human induced threats is an agenda which has been developed almost exclusively by politicians and emergency planning professionals with little if any discussion with citizens, the business community, town planners, urban designers and other built environment professionals (Coaffee, 2008). Little (2004, p. 55) acknowledges that a fully inclusive strategy for urban resilience is required because it:

> . . . will be neither holistic nor effective if it is restricted to narrow professional or disciplinary stovepipes or if interactions among government officials, security professionals, program and financial staff, and emergency responders occurs only on a product by product basis.

Riverine flooding hazards

Approximately 10,000 km^2 (or 8 percent of the total area) of land in England is at risk from fluvial (river) flooding, including tidal rivers and estuaries (DTLR, 2001). An estimated five million people, two million homes and 185,000 businesses are at risk from flooding in England and Wales every year, with total exposed property, land and assets amounting to £214 bn (Crichton, 2005). The risk of flooding in the UK can be increased to a certain extent due to changes in river hydrology caused by human activity and partly from the increase of development in areas at risk. It is expected that climate change will increase the risk of coastal and river flooding as a result of sea-level rise and more intense rainfall events. The "Foresight Report" (Office of Science and Technology, 2004) suggested that annual average damages could increase from £1 bn to between £2 bn and £21 bn if no action is taken to manage the increased risk. These figures are particularly germane as house-building rates are anticipated to increase to the level recommended in the Barker report (Barker, 2004) that has suggested that over the next 10 years almost 200,000 homes would be built each year on previously developed land. Development to this level would require over 70,000 hectares of land that was previously used for industrial or residential purposes, much of which will be located in the floodplain (DEFRA, 2004). This is a particular concern because there are already "over 2,000 schools and 80 hospitals in flood hazard areas in England" (Crichton, 2008, p. 125).

It should also be noted that pluvial flooding (typically associated with abundant rainfall in a localised area, and exacerbated by insufficient capacity of urban drainage systems) has also increased in prominence on the flood risk agenda in light of the Summer 2007 floods. For instance the flooding that inundated the coastal city of Hull affected 8,600 homes and 1,300 businesses and has now largely been attributed to the city's drainage network being totally overwhelmed by heavy and prolonged rain (Coulthard *et al.*, 2007). The implications of the flooding that was experienced in Hull on hazard mitigation strategies will be discussed later in this paper.

The research

There is a need to pro-actively address strategic weaknesses in protecting the built environment from a range of hazards. This component of the research is focused on the mitigation for flood hazards in the UK; particularly understanding the extent of the problem, collating key guidance and legislation related to flood hazard mitigation, identifying who the key construction decision makers are and the most opportune stages of the Design-Construction-Operation Process when they need to make their key decisions. Through this, the paper will also highlight some of the socio-institutional constraints to the proactive attainment of built-in resilience and provide some suggestions as to the approaches that may be required to address these constraints.

Methods

A pluralistic research design was adopted for the study using a complementary range of datasets and research methods. A state of the art literature review; including academic papers, governmental and non-governmental reports, UK legislation and regulations, governmental, institutional and industrial guidelines and policy documentation was undertaken to identify key guidance, standards and legislation related to flood hazard mitigation in the UK. The EM-DAT database (EM-DAT, 2007) of global emergency events was searched and analysed to assess the most prevalent and high impact (regarding financial costs and the loss of human life) disasters in the UK. Between July and November 2007, 50 questionnaire surveys were also completed by a selective range of experts involved with construction, risk and emergency management, local and national government and urban planning. These questionnaires were designed to elicit perspectives and opinions about hazard and threat awareness and knowledge of available governmental and non-governmental guidance for hazard mitigation and emergency preparedness. These data were augmented by 11 semi-structured in-depth interviews with experts from the construction sector, engineering, emergency planning, and urban planning.

Preliminary research findings

The findings raise some important issues about the construction sector's role in hazard mitigation, with a specific focus on the mitigation of riverine flood hazards. The datasets have been combined below in relation to the type of threats apparent, the efficacy of current guidelines and the role and input of various stakeholders.

Evaluation and prioritisation of identified threats

An analysis of the data[3] obtained from the EM-DAT database (EM-DAT, 2007) of global emergency events indicates that, from an historical perspective, the greatest threats to the built environment in the UK are from flooding (riverine, pluvial and coastal) and severe windstorms. The perspectives and opinions of key threats to the built environment were sought from the respondents and these were found to be very much in-line with the historical data with pluvial and riverine flooding considered as the key threats (Table I).

The respondents' awareness of the threat from flooding events (riverine, pluvial and coastal) was high and supports the findings from previous research (see Bosher *et al.*, 2007c) that found the majority of over 100 respondents from the construction sector in the UK perceived flood risk to be the most prominent threat to the built environment. A particularly interesting observation from the questionnaires was that according to the respondents, none of the threats associated with the key identified hazards have been significantly reduced in the last decade (Table II). This observation is somewhat unexpected because it is in spite of numerous efforts (by government and business) to address such hazards; through for instance, flood defences, Sustainable Urban

Table I.
Perceptions of major threats to the built environment in the UK

Threats	Responses (%) Agree/strongly agree	Neither agree or disagree	Disagree/strongly disagree
Coastal flooding	88	6	6
Earthquakes/tremors	16	26	58
Flooding (pluvial)	94	2	4
Heat waves	67	25	8
Industrial explosions	44	34	22
Landslides subsidence	66	24	10
Transportation emergencies	50	40	10
Riverine flooding	92	8	0
Terrorist bombs	78	10	12
Tornadoes	22	48	30
Windstorms	76	12	12

Table II.
Perceptions of whether threats from hazards have increased or decreased in the last decade

Threats	Responses (%) Increased	Neither increased nor decreased	Decreased	Do not know
Coastal flooding	80	18	0	2
Earthquakes/tremors	6	84	2	8
Flooding (pluvial)	92	4	0	4
Heat waves	68	28	0	4
Industrial explosions	14	56	28	2
Landslides subsidence	36	52	6	6
Transportation emergencies	44	42	12	2
Riverine flooding	90	10	0	0
Terrorist bombs	90	10	0	0
Tornadoes	32	50	0	18
Windstorms	46	50	2	2

Drainage Systems, increased spending and resources on intelligence to counter terrorism and rafts of legislation and guidance to improve the safety of industrial sites. One of the interviewees posited a suggestion as to why the apparent increase in the scale of the threats might be occurring:

> Many people I work with feel that the UK has sat on it's laurels for far too long now and that the flooding and windstorm damages experienced in the last couple of years are merely the sour fruits of the government's and the construction sector's short-termism and procrastination. We are doing too little too late to proactively mitigate for an ever increasing range threats (Interview with National Security consultant).

Current guidelines. This study has found that while there is an ever increasing range of guidance, information and legislation, there is a lack of suitable guidance that is specifically focused on proactive flood mitigation measures that are targeted for use by key stakeholders in the construction sector. When suitable guidance is available, awareness of when and how to best use it is poor. The list below provides a non-exhaustive list of key guidance, standards and policy related to riverine flooding in the UK; the few documents that were used by a majority of the respondents are shown in italics. The findings of earlier research (see Bosher *et al.*, 2007b) also revealed that the lack of coherent guidance on how hazard mitigation considerations should be integrated into the Design-Construction-Operation Process is likely to inhibit the ability of the construction industry to proactively design and build a more resilient built environment and also constrain appropriate re-construction (and resilient reinstatement) of flood affected properties.

Selection of guidance available to construction professionals for addressing riverine flooding in the UK

Details of available guidance for riverine flooding in the UK (from Governmental and private sector sources) follow. Documents that were identified and used by a majority of the respondents are shown in italics:

(1) Pre-design and design stages:
- BS EN 752-4:1998 Drain and sewer systems outside buildings. Hydraulic design and environmental considerations;
- BS EN 13564: Anti-flooding devices for buildings;
- PAS 1188-2:2003 Flood protection products. Specification. Temporary and demountable products;
- PAS 1188-1:2003 Flood protection products. Specification. Building apertures;
- PAS 64:2005 Professional water mitigation and initial restoration of domestic dwellings;
- *Approved Document C of the Building regulations*;
- *CLG, (2006), Planning Policy Statement 25: Development and Flood Risk (PPS25), Department of Communities and Local Government, London*;
- CLG, (2007), Improving the Flood Performance of New Buildings, Department of Communities and Local Government, London;
- Environment Agency Flood risk mapping website;

- Scottish Environmental Protection Agency Flood risk mapping website;
- *DEFRA, (2005), Making space for water, March 2005, DEFRA, London*;
- *EA, (2004), Catchment Flood Management Plans: Policy Guidance*;
- National Flood Forum website and documentation;
- CIRIA Designing for exceedance in urban drainage - good practice (C635);
- CIRIA Low-cost options for prevention of flooding from sewers (C506);
- CIRIA Development and flood risk - guidance for the construction industry (C624);
- CIRIA Infiltration drainage - manual of good practice (R156);
- CIRIA Scope for control of urban runoff, Volume 1 – overview (R123); and
- BRE Climate change – impact on building design and construction.

(2) Post-construction:

- *CIRIA Standards for the repair of buildings following flooding (C623)*; and
- BRE Repairing flood damage.

The flooding events in the UK in 2007 (and 2005) have underscored the importance of achieving a more informed and joined up multi-stakeholder approach to attaining a resilient built environment. The recent publication of the "Improving the Flood Performance of New Buildings"[4] document by the Department of Communities and Local Government is a move in the right direction as it is targeted at the developers and designers that are "keystones" in the "built-in resilience" agenda espoused in this paper:

> From a business point of view we need to ensure that we do not "scare off" the developer or client by saying we will be considering hazard mitigation issues. Nine times out of ten the developer or client will assume these "resilience" measures will cost them more money; so they may ditch us and go for the company that they perceive as being better value for money, or in other words is the "cheapest" option. The developers and clients are the "keystones" to the attainment of built-in resilience. I am confident that this construction company has the skills and knowledge required to attain built-in resilience, we just need stakeholders such as the developers and clients to start looking past short-term profits (Interview with Technical Manager – Large construction company).

This comment suggests that developers and clients may be central to either helping or hindering the "resilience" agenda. However, while it is pertinent to acknowledge that these are indeed key stakeholders, it is also important to appreciate that there is a wider range of stakeholders that need to be engaged with the resilience agenda; therefore a range of strategies will need to be utilised. For instance, the pluvial flooding that occurred in Hull illustrates an important aspect of hazard mitigation; Who is to blame? Or rather, who is in charge? Many organisations are responsible for different parts of drainage systems and other water courses in the UK and this makes overall management extremely difficult. This is a problem that was highlighted by the Independent Review Body of the floods which stated:

> In short no single agency accepts responsibility for any elements outside their terms of reference. This is a recurring theme – one of inadequate consultation, co-operation and unity between the agencies. These practices must end (Coulthard *et al.*, 2007, p. 34).

The experiences of Summer 2007 demonstrate that a more coordinated approach to dealing with not only the consequences of floods but also the mitigation of flood hazards needs to be high on the Government's agenda.

Identification of key stakeholders

A review by Sir Michael Pitt into the 2007 summer floods in the UK concluded, amongst numerous other issues, that a lack of clarity in the responsibilities of government agencies and non-governmental stakeholders was one of the key factors that contributed towards the extent of the flooding (Cabinet Office, 2007). Appropriately informed stakeholder decision making is therefore an important aspect of how disastrous events can be reduced and managed. Previous research has demonstrated which stakeholders should be involved in DRM activities and also at what stages of the Design-Construction-Operation Process (DCOP) these stakeholders should be involved (for details see Bosher *et al.*, 2007b). The pre-construction phase was identified as the critical phase in the DCOP when DRM activities, and specifically hazard mitigation, can be (and need to be) integrated. It is during this phase in particular that hazard mitigation considerations should be made by architects/designers, structural and civil engineers, urban planners, specialist contractors and emergency/risk managers (Table III).

Discussion

This research has so far revealed that while there is an ever increasing range of guidance, information and legislation for stakeholders in the construction sector, there is a lack of suitable guidance that is specifically focused on proactive mitigation measures that are targeted for use by key stakeholders in the construction sector.

Phase of DCOP	Formal specified input required by...	Formal unspecified input required by...
Pre-construction		
Stages of this phase include:	Architects/designers	Emergency services
Outline proposals/outline conceptual design	Engineering consultants	End users
Scheme design/full conceptual design	Structural engineers	Government agencies
Detail design/coordinated design	Specialist contractors	Insurers
Production information	Urban planners/designers	
Tender documentation	Civil engineers	
Tender action	Emergency/risk managers	
	Local authorities	
	Developers	
	Contractors	
	Materials suppliers	
	Clients	
	Utilities companies	
	Quantity surveyors	

Notes: Formal specified input: Essential structured input that may need to be driven by legislation. Formal unspecified input: Essential input that may be driven by "best practice" guidance rather than legislation

Source: Bosher *et al.* (2007b)

Table III. The key stakeholders that need to make flood hazard mitigation inputs into the pre-construction phase

When suitable guidance is available, awareness of such guidance by key construction related decision makers is poor. It is also important to not only know about the guidance but it is also essential that the key decision-makers are aware that the pre-construction phase is the critical stage of the Design-Construction-Operation process when flood hazard mitigation should be undertaken by architects/designers, structural and civil engineers, urban planners, specialist contractors and emergency/risk managers.

Reaching out to this wide array of stakeholders and integrating their inputs suggests that a complementary range of strategies will be required to address the issue of building-in flood resilience (as well as resilience to other hazards) into the decision-making of construction stakeholders. It is likely that these strategies will include, "innovation and knowledge", "operations", 'planning' and "legislative and regulatory" initiatives that will need to be driven by developers, construction firms, planners and governmental agencies (amongst others).

Innovation and knowledge

Achieving built-in resilience will demand that traditional demarcations in roles and responsibilities are reconstituted in order to propagate the free-flow of knowledge between the stakeholders (Dainty and Bosher, 2008). This strategy should therefore include developing new more resilient technologies and materials and initiating trans-disciplinary training and hazard awareness programmes for construction professionals. Threats to the built environment should not be seen as problems but as opportunities to develop and provide niche products and solutions related to hazard mitigation.

Operations

Professional fragmentation is a hallmark of the construction industry, with architects, surveyors and engineers usually employed from outside construction firms as independent consultants (Morton, 2002). Therefore, the difficulties of trying to facilitate this information exchange in an environment with fragmented relationships between the various actors renders this a problematic notion (see Trim, 2004; Lorch, 2005). Facilitating information exchanges between stakeholders such as planners, designers, engineers and the emergency services will be an important requirement (possibly one that could be achieved by encouraging the involvement of construction stakeholders in Local and Regional Resilience Forums).

Planning

The publication of "Planning Policy Statement 25: Development and Flood Risk" (PPS25) by the UK Government has helped to incorporate flood risk into the planning process. However, PPS25 (DCLG, 2006) has been criticised because it continues to permit development in flood plains if there is nowhere safer to build. Therefore, improved guidance that is targeted at planning and urban design practitioners will need to be developed to support well designed developments that are not located in flood risk areas.

Legislation and regulatory incentives

At present in many countries developing resilience against natural and human induced threats is an agenda which has been driven almost exclusively by politicians and emergency planning professionals with little, if any, discussion with citizens, the business community, town planners, urban designers and other built environment professionals (Coaffee, 2008). One of the strategies required to help attain improved resilience to riverine flooding is likely to include the revision of building codes and developing good practice guidance on a number of measures (such as the resilient reinstatement of flood affected buildings, see Soetanto *et al.*, 2008 for details). It is therefore important that built environment professionals are consulted and actively involved in the revisions that will undoubtedly be required to make built assets in the UK more resilient to an ever increasing flood risk.

Engaging with key stakeholders

Little (2004) acknowledges that a fully inclusive strategy for urban resilience is required. Therefore, one of the key challenges in attaining built-in resilience will be in sufficiently engaging with key stakeholders from the construction sector and increasing their awareness of not only appropriate hazard mitigation approaches, but also the important roles they can play in proactively mainstreaming the principles of "resilience" into long-term development. A top down approach to achieving stakeholder engagement is likely to be constrained by the aforementioned problems of traditional demarcations in roles and responsibilities and the fragmented relationships between the myriad construction professions; a bottom up and multi-disciplinary approach may be the way forward.

Charrette workshops are a technique used by practitioners to involve various individuals and organisations directly in the planning, programming, or design of a project. The charrette is often used in community planning to encourage involvement from local stakeholders; multi-disciplinary charrettes were used as part of the ongoing PRE-EMPT Project to explore the issues of creating resilient buildings. During the charrette, a design scenario was tabled, with supporting documentation; the design actions of the invited group of key stakeholders were the focus for a set of predominantly qualitative research instruments to analyse differences in process, actions, conflicts and resolutions. These charrettes[5] have enabled a review of current decision making processes during project briefings whilst also identifying how decisions have been informed. This process has been a key component in the ongoing development of user defined decision support tools[6] that will enable stakeholders to integrate "resilience" options into how they plan, design, build, operate, maintain and reconstruct the built environment. The charrettes have also been an important research tool in not only obtaining rich qualitative data for the research team on decision making processes, but also in aiding the collaborating organisations to understand the strengths and weaknesses in their approaches to hazard mitigation and in stimulating informed decision-making for built-in resilience.

Conclusions

The pre-construction phase of a building's life cycle is the most critical for incorporating flood hazard mitigation strategies that should be undertaken by stakeholders such as architects/designers, structural and civil engineers, urban planners, specialist contractors and emergency/risk managers. However, despite the publication of a range of guidance on flood hazard mitigation in the UK there is little evidence to suggest that key construction stakeholders are playing an active role in mitigating flood risk. It is argued that the construction sector is currently ill-prepared to build-in resilience to flooding in the UK. Resilience is a multi-facetted concept which includes physical, social, economic and institutional components; the socio-institutional aspects are arguably as important to the attainment of resilience as the physical aspects because "resilient engineering" also demands a more resilient infrastructural context with regards to the professions, the structures and processes which govern construction activity. This paper has argued that fundamental institutional change and the provision of better guidance and training are required if the "innovation and knowledge", "operations", "planning" and "legislative and regulatory" initiatives towards built-in resilience are to be successful. These underlying institutional conditions will be difficult to obtain in a short period of time so other, possibly more discrete, approaches may be required in the meantime.

One of the approaches could include the development of decision-support tools that could be applied during the pre-construction, construction and post-disaster reconstruction phases. The development of a decision support tool could enable construction stakeholders, such as civil and structural engineers and architects, to make informed decisions regarding the proactive integration of flood hazard mitigation (and the mitigation of other hazards) during the design, planning, construction, operation and maintenance of existing and future construction projects.

Notes

1. Structural mitigation includes the strengthening of buildings and infrastructure exposed to hazards (via building codes, engineering design and construction practices, etc.).
2. Non-structural mitigation includes directing new development away from known hazard locations through land use plans and regulations, relocating existing developments to safer areas and maintaining protective features of the natural environment (such as sand dunes, forests and vegetated areas that can absorb and reduce hazard impacts).
3. The indicative list of hazards in the UK that was provided to the respondents did not include hazards such as earthquakes, volcanoes, tsunamis and meteorites as these (in the present context) were not considered by the authors to be key threats to the UK. In addition fire hazards were omitted from the survey because fire related hazards are already encompassed by existing building and design, and a raft of other, regulations.
4. It should be noted that the guidance contained within the document is limited to), new properties in low or residual flood risk areas), (CLG, 2007, p. 8).
5. For more information about the charrette workshops and how they are being used to stimulate informed decision making on resilience considerations, please refer to Glass *et al.*, 2008.
6. It is anticipated that the toolkit may consist of a range of tools such as a CD-ROM based software package, guidance manuals and a matrix to signpost decision makers at the most appropriate stages of their projects to key regulations, guidance and best practice literature. It is important to emphasise that it is not feasible to be too prescriptive about what solutions will be required as these will inevitably be contingent upon the types of built asset and the nature of the hazards that have been identified.

References

Barker, K. (2004), *Review of Housing Supply: Delivering Stability: Securing Our Future Housing Needs*, Office of the Deputy Prime Minister, HMSO, London.

Bosher, L.S. (Ed.) (2008), *Hazards and the Built Environment: Attaining Built-in Resilience*, Routledge, London.

Bosher, L.S., Carrillo, P.M., Dainty, A.R.J., Glass, J. and Price, A.D.F. (2007a), "Realising a resilient and sustainable built environment: towards a strategic agenda for the United Kingdom", *Disasters*, Vol. 31 No. 3, pp. 236-55.

Bosher, L.S., Dainty, A.R.J., Carrillo, P.M. and Glass, J. (2007b), "Built-in resilience to disasters: a pre-emptive approach", *Engineering, Construction and Architectural Management*, Vol. 14 No. 5, pp. 434-46.

Bosher, L.S., Dainty, A.R.J., Carrillo, P.M., Glass, J. and Price, A.D.F. (2007c), "Integrating disaster risk management into construction: a UK perspective", *Building Research and Information*, Vol. 35 No. 2, pp. 163-77.

Burby, R., Deyle, R.E., Godschalk, D.R. and Olshansky, R.B. (2000), "Creating hazards resilient communities through land-use planning", *Natural Hazards Review*, Vol. 1 No. 2, pp. 99-106.

Cabinet Office (2007), *The Interim Conclusions of The Pitt Review – Learning Lessons from the 2007 Floods*, London.

Cabinet Office/HM Treasury (2006), *Stern Review on the Economics of Climate Change*, Cabinet Office/Her Majesty's Treasury, London.

Coaffee, J. (2008), "Security planning in the resilient city: stimulating integrated emergency planning and management", in Bosher, L.S. (Ed.), *Hazards and the Built Environment: Attaining Built-in Resilience*, Routledge, London, pp. 300-16.

Coulthard, T.J., Frostick, L., Hardcastle, H., Jones, K., Rogers, D., Scott, M. and Bankoff, G. (2007), *The 2007 Floods in Hull, Final Report by the Independent Review Body*, Hull City Council, Hull, 21 November.

Crichton, D. (2005), "About floods", working paper, Benfield Hazard Research Centre, UCL, London.

Crichton, D. (2008), "Role of insurance in reducing flood risk", *The Geneva Papers*, Vol. 33, pp. 117-32.

Dainty, A.R.J. and Bosher, L.S. (2008), "Afterword: integrating resilience into construction practice", in Bosher, L.S. (Ed.), *Hazards and the Built Environment: Attaining Built-in Resilience*, Routledge, London, pp. 357-72.

DCLG (2006), *Planning Policy Statement 25: Development and Flood Risk*, Department of Communities and Local Government, London.

DEFRA (2004), *Study into the Environmental Impacts of Increasing the Supply of Housing in the UK*, DEFRA Statistics, April, Department for Environment, Food and Rural Affairs, London.

DFID (2006), *Reducing the Risk of Disasters*, Department for International Development, East Kilbride.

DTLR (2001), *Planning Policy Guidance 25: Development and Flood Risk*, December, Department for Transport, Local Government and the Regions, HMSO, London.

EM-DAT (2007), *The OFDA/CRED International Disaster Database*, Université Catholique de Louvain, Brussels.

Glass, J., Dainty, A.R.J., Bosher, L.S., Carrillo, P.M. and Price, A.D.F. (2008), "Stimulating informed decision making for built-in resilience through the use of Charrette workshops", *Proceedings of the Building Abroad Conference: Procurement of Construction and Reconstruction Projects in the International Context, Université de Montréal, Montréal, Canada, 23-25 October*.

Godschalk, D. (2003), "Urban hazard mitigation: creating resilient cities", *Natural Hazards Review*, Vol. 4 No. 3, pp. 136-43.

Little, R. (2004), "Holistic strategy for urban security", *Journal of Infrastructure Systems*, Vol. 10 No. 2, pp. 52-9.

Lorch, R. (2005), "What lessons must be learned from the tsunami?", *Building Research and Information*, Vol. 33 No. 3, pp. 209-11.

Menoni, S. (2001), "Chains of damages and failures in a metropolitan environment: some observations on the Kobe earthquake in 1995", *Journal of Hazardous Materials*, Vol. 86 Nos 1-3, pp. 101-19.

Morton, R. (2002), *Construction UK: Introduction to the Industry*, Blackwell Publishing, Oxford.

Office of Science and Technology (2004), *Foresight Flood and Coastal Defence Project*, Office of Science and Technology, London.

Ofori, G. (2008), "Construction in developing nations: towards increased resilience to disasters", in Bosher, L.S. (Ed.), *Hazards and the Built Environment: Attaining Built-in Resilience*, Routledge, London, pp. 39-60.

Pelling, M. (2003), *The Vulnerability of Cities: Natural Disaster and Social Resilience*, Earthscan, London.

Soetanto, R., Proverbs, D., Lamond, J. and Samwinga, V. (2008), "Residential properties in England and Wales: an evaluation of repair strategies towards attaining flood resilience", in Bosher, L.S. (Ed.), *Hazards and the Built Environment: Attaining Built-in Resilience*, Routledge, London, pp. 124-49.

Tierney, K. and Bruneau, M. (2007), "Conceptualizing and measuring resistance: a key to disaster loss reduction", *TR News 250*, May-June, pp. 14-17.

Trim, P. (2004), "An integrated approach to disaster management and planning", *Disaster Prevention and Management*, Vol. 13 No. 3, pp. 218-25.

UN/ISDR (2004), *Living with Risk: A Global Review of Disaster Reduction Initiatives*, United Nations International Strategy for Disaster Reduction, Geneva.

Wamsler, C. (2004), "Managing urban risk: perceptions of housing and planning as a tool for reducing disaster risk", *Global Built Environmental Review (GBER)*, Vol. 4 No. 2, pp. 11-28.

Wamsler, C. (2006), "Mainstreaming risk reduction in urban planning and housing: a challenge for international aid organisations", *Disasters*, Vol. 30 No. 2, pp. 151-77.

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Mainstreaming gender in disaster reduction: why and how?

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Abstract

Purpose – The purpose of this paper is to highlight the importance of gender mainstreaming into disaster reduction decision making as a way of reducing disaster vulnerabilities of women, a highly vulnerable group to disasters.

Design/methodology/approach – The paper builds a discussion around disaster reduction, the importance of gender mainstreaming in disaster reduction and the ways of mainstreaming gender based on a literature review. It reviews academic literature as well as papers and reports produced by the United Nations International Strategy for Disaster Reduction (UN/ISDR) and various other institutions.

Findings – The paper highlights the importance of the role of gender mainstreaming in disaster reduction as a means of reducing disaster risk through considering women's needs and concerns in particular. Further, on the basis of the literature reviewed, the paper emphasises the need for enhancing gender balance in disaster reduction decision making in order to understand the possible effects of policies and measures developed for disaster reduction on gender roles.

Practical implications – The paper paves the way forward to identify how gender mainstreaming could be achieved in the context of construction as construction has a significant relationship with development that could create or reduce disaster risk.

Originality/value – The paper attempts to contribute to disaster reduction through emphasising the need for mainstreaming gender into the disaster reduction decision-making process and also towards reducing disaster vulnerabilities of women. In this context, the paper brings an insight into the necessity for mainstreaming gender in disaster reduction in construction.

Keywords Disasters, Gender, Women

Paper type Literature review

1. Background

1.1 Introduction

"Disasters, one of man's oldest concerns, reach back to periods of pre-history and myth, yet strangely enough, are hardly an area of critical scrutiny" (Jaya Kumar, 2000, p. 66). Disasters are known as sudden events, which bring serious disruption to society with massive human, material and environmental losses and these losses always go beyond the capacity of the affected society to cope with its own resources (Kelman and Pooley, 2004; Shaluf and Ahmadun, 2006). According to McEntire (2001), any disaster is a combination of a triggering agent and a set of vulnerabilities – and it is these vulnerabilities, the conditions, which affect the capacity of a society to respond to the triggering agent which is the controllable component of a disaster. Since disasters cause large-scale damage to human life, their livelihoods, economic and social infrastructure and environment (International Strategy for Disaster Reduction, 2002; Shaluf *et al.*, 2003) and these damages have shown a significant increase in the last one and a half decades (Shaluf *et al.*, 2003), the world is in serious need of a sustained and

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comprehensive disaster reduction strategy. In achieving this, the needs and concerns of all social groups such as poor, rich, men, women, young, old, indigenous or non-indigenous must be necessarily integrated into the disaster reduction policies and measures because the level of vulnerability depends on these social aspects (International Strategy for Disaster Reduction, 2002). The Secretariat of the United Nations International Strategy for Disaster Reduction (2002) emphasises that the vulnerability of women to disasters is greater mainly because of the social values.

The main aims of this paper are to highlight the importance of gender mainstreaming in disaster reduction policymaking and to discuss ways of mainstreaming gender. In order to make the path of achieving this aim clearer, this paper gives an account of the nature and types of disasters and the world's movement towards disaster reduction in its early sections. The next section characterises and classifies disasters as a preface to the disaster reduction trend and practices, which are described later. The third section focuses on gender mainstreaming, its importance and proposed means of integrating it into disaster reduction policies and measures. This paper is based on a review of academic literature, papers and reports produced by the United Nations International Strategy for Disaster Reduction (UN/ISDR) and various other institutions.

1.2 The way disasters are seen

1.2.1 Defining disasters. Historically, disasters were known as acts of god, or events outside human control, which brought massive disruption to society (McEntire, 2001). However, subsequently, with the expansion of scientific knowledge, disasters became synonymous with disaster agents or more specifically, they were seen as natural hazards (McEntire, 2001). UN/ISDR defines a disaster as a serious disruption of the functioning of a community or society causing widespread human, material, economic or environmental losses, which exceed the ability of the affected community or society to cope using its own resources (Kelman and Pooley, 2004). However, disasters are interpreted in different ways by scholars and institutions. Weichselgartner (2001) argues that natural disasters are a social phenomena because the overall damage due to natural hazards is the result both of natural events that act as a "trigger" and a series of societal factors. According to Jaya Kumar (2000), the term is used to indicate a whole range of distress situations both individual and communal and that disasters are events in time, which have distinct phases of onset, climax and withdrawal. Ariyabandu and Wickramasinghe (2003) view disasters as sudden events, which require immediate, emergency relief. McEntire (2001) puts forward a different perspective by indicating that disasters as the disruptive outcome or human-induced triggering agents when they interact with and are exacerbated by vulnerabilities from diverse but overlapping environments. Apropos, as Shaluf *et al.* (2003) indicates none of these definitions of disasters are universally accepted yet. The way that the disasters are explained varies according to the discipline in which they have been defined. Generally, there are four main bases for defining disasters as technical, sociological, political and medicinal (Siriwardena *et al.*, 2007). However, almost all the definitions describe a disaster as an event, which disturbs the social structure or the environment, causes a significant loss and needs external assistance in recovery.

1.2.2 Types of disasters. Disasters are often divided into two main categories - as natural or man-made according to their cause (Shaluf *et al.*, 2003; Kelman and Pooley, 2004; Osorio and Hurych, 2004; Shaluf and Ahmadun, 2006). Figure 1 illustrates this. In addition to the two main categories of disaster, Shaluf *et al.* (2003) and Shaluf and Ahmadun (2006) indicate that there can be a third category of disasters as hybrid disasters, which occur as a combination of natural and man-made disasters. Further, Shaluf and Ahmadun (2006) show that natural and/or man-made disasters can trigger subsequent disasters as well.

Disasters are classified into three groups by Jaya Kumar (2000) referring to the spatial dimensions of disasters as small, localised or large and regional disasters. On the other hand, disasters can be categorized into two, based on their spatial and socio-economic characteristics as exogenous disasters and endogenous disasters (Jaya Kumar, 2000, p.75):

(1) *Exogenous disasters* – which relates to an energy that is external to society and which injure, destroy and affect everyone trapped within the spatial or temporal dimension. This can be defined as an event concentrated in time and space in which a community or a society experiences and shares severe danger, injury and destruction or disruption of the social structure and essential function of the society.

(2) *Endogenous disasters* – which emerge from forces within society and which injure one group while enrich other or which distress is suffered by one section of the community while material gains and social satisfaction accrue to another.

1.2.3 Occurrence of disasters. Initially, scholars and policy makers gave attention to disasters concentrating mainly on hazards giving an implication that the hazard agent was the disaster (McEntire, 2005). UN/ISDR (International Strategy for Disaster

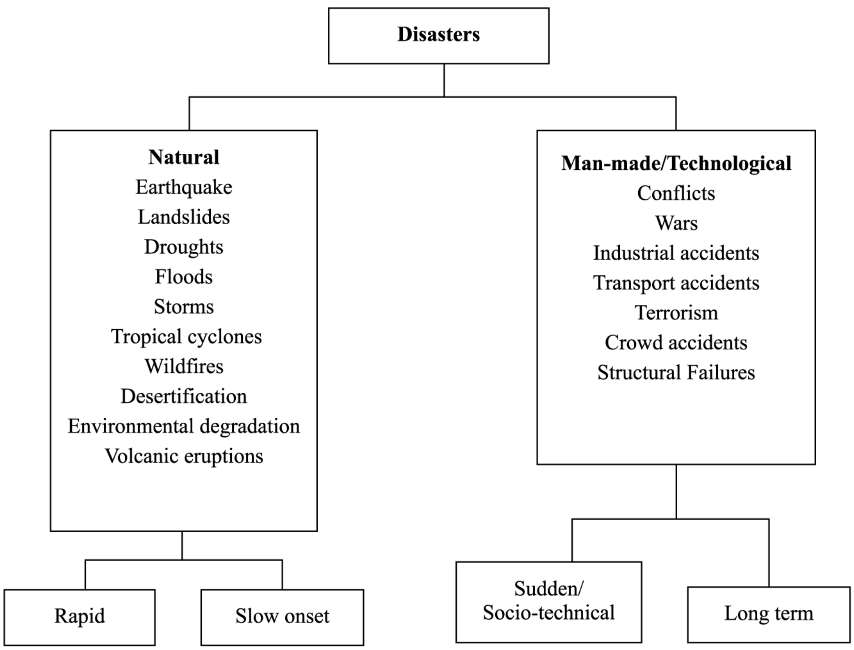

Figure 1.
Categorization of disasters according to their cause

Reduction, 2004) describes hazard as a potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Furthermore, hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydro-meteorological and biological) or induced by human processes (environmental degradation and technological hazards) (International Strategy for Disaster Reduction, 2004). However, this initial perspective on disasters was problematic because natural occurrences such as tornados in uninhabited plains may not be seen as a disaster and some hazards such as floods and fires can even be beneficial for the environment (e.g. providing rich, fertile soils for farming and forest rejuvenation) (McEntire, 2005). Therefore, the subsequent viewpoint that all disasters irrespective of whether they are natural or man made emerge as a combination of a triggering agent/hazard and vulnerabilities (McEntire, 2001), Sahni and Ariyabandu (2003) is more rational. With the establishment of the latter view, the emphasis on vulnerabilities in the context of disasters was raised gradually.

1.2.4 Vulnerabilities. Vulnerability is known as a set of conditions that affect the ability of countries, communities and individuals to prevent, mitigate, prepare for and respond to hazards (Ariyabandu and Wickramasinghe, 2003). It is seen that all individuals and communities are to varying degrees vulnerable to hazards and all have intrinsic capacities to reduce their vulnerability (Working group on Climate Change and Disaster Risk Reduction of the Inter-Agency Task Force on Disaster Reduction, 2006). Apropos, vulnerability is given various definitions in disaster research since 1980 (Weichselgartner, 2001). Similarly the disaster definitions vary according to the discipline they are based on and the way in which vulnerability is seen depends on the respective discipline (McEntire, 2005). UN/ISDR (International Strategy for Disaster Reduction, 2004) defines vulnerability as the conditions determined by physical, social, economic, and environmental factors or processes which increase the susceptibility of a community to the impact of hazards. Based on the above explanation, the Working Group on climate change and disaster risk reduction of the Inter Agency Task Force on Disaster Reduction (2006) illustrates the different dimensions of vulnerabilities as follows:

- physical vulnerability refers to susceptibilities of the built environment and may be described as “exposure”;
- social factors of vulnerability include levels of literacy and education, health infrastructure, the existence of peace and security, access to basic human rights, systems of good governance, social equity, traditional values, customs and ideological beliefs and overall collective organisational systems;
- economic vulnerability characterises people less privileged in class or caste, ethnic minorities, the very young and old, the disadvantaged, and often women who are primarily responsible for providing essential shelter and basic needs; and
- environmental vulnerability refers to the extent of natural resource degradation.

On the other hand, McEntire (2001) categorizes the variables, which interact to produce a future of increased vulnerabilities under physical, social, cultural, political, economic, and technological headings as given in the following list. This classification splits the social vulnerability in the earlier categorization into three separate groups as social, cultural and political dimensions of vulnerabilities. In addition, the environmental dimensions are brought under the physical variables here in contrast to the earlier division:

(1) *Physical*:
   - the proximity of people and property to triggering agents;
   - improper construction of buildings;
   - inadequate foresight relating to the infrastructure; and
   - degradation of the environment.

(2) *Social*:
   - limited education (including insufficient knowledge about disasters);
   - inadequate routine and emergency health care;
   - massive and unplanned migration to urban areas; and
   - marginalisation of specific groups and individuals.

(3) *Cultural*:
   - public apathy towards disaster;
   - defiance of safety precautions and regulations;
   - loss of traditional coping measures; and
   - dependency and an absence of personal responsibility.

(4) *Political*:
   - minimal support for disaster programmes amongst elected officials;
   - inability to enforce or encourage steps for mitigation;
   - over-centralisation of decision making; and
   - isolated or weak disaster related institutions.

(5) *Economic*:
   - growing divergence in the distribution of wealth;
   - the pursuit of profit with little regard for consequences;
   - failure to purchase insurance; and
   - sparse resources for disaster prevention, planning and management.

(6) *Technological*:
   - lack of structural mitigation devices;
   - over-reliance upon or ineffective warning systems;
   - carelessness in industrial production; and
   - lack of foresight regarding computer equipment/programmes.

McEntire (2001) explains that vulnerability acts as the dependant component while the triggering agent stands as the independent component of a disaster. This dependant component is determined by the degree of risk, susceptibility, resistance and resilience

(McEntire, 2001). Therefore, vulnerabilities should be managed in order to mitigate disasters. McEntire (2001) shows invulnerable development or vulnerability management as a process whereby decisions and activities are intentionally designed and implemented to take into account and eliminate disaster to the fullest extent possible.

2. An overview of disaster reduction

Disaster preparedness through minimising vulnerabilities has been identified as a better approach to face disasters than post-disaster responsiveness (International Strategy for Disaster Reduction, 1994; Sahni and Ariyabandu., 2003). According to Goodyear (2003), creating a culture of prevention is essential to address everyday hazards and the consequences of a disaster. Disaster risk reduction is defined as the conceptual framework of elements considered with the possibilities to minimise vulnerabilities and disaster risks throughout society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards, within the broad context of sustainable development (International Strategy for Disaster Reduction, 2004). Therefore, disaster risk reduction must be more decisively incorporated as an essential component of all development strategies, policies, programmes and investments for national and local governments (Secretary-General, 2006). In other words, disaster reduction incorporates taking measures in advance, addressing risk reduction, involving environmental protection, social equity and economic growth, the three cornerstones of sustainable development, to ensure that development efforts do not increase the vulnerability to hazards (International Strategy for Disaster Reduction, 2002).

The United Nations International Strategy for Disaster Reduction (UN/ISDR) is a pioneer in disaster reduction movement in the international context. ISDR aims at building disaster resilient communities by promoting increased awareness of the importance of disaster reduction as an integral component of sustainable development and it promotes following four objectives for disaster reduction:

(1) increase public awareness to understand risk, vulnerability and disaster reduction globally;

(2) obtain commitment from public authorities to implement disaster reduction policies and actions;

(3) stimulate interdisciplinary and intersectoral partnerships, including the risk reduction networks; and

(4) improve scientific knowledge about disaster reduction.

A close inter-relationship is shown between disaster reduction and sustainable development in disaster management research. Stenchion (1997) determines that a number of development activities have a great responsibility and inter-relationship with disaster risk reduction because both development and disaster management are aimed at vulnerability reduction. Further, it is indicated that development can increase and/or decrease disaster vulnerability (McEntire, 2004). It is essential, therefore, to take measures of disaster risk reduction into consideration in all development activities. The framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters states, “there is now international acknowledgement that efforts to reduce disaster risks must be systematically integrated into policies, plans and programmes for sustainable development and poverty reduction, and supported through bilateral, regional and international cooperation, including partnerships. Sustainable development, poverty reduction, good governance and disaster risk reduction are mutually supportive objectives. In order to meet the challenges ahead, accelerated efforts must be made to build the necessary capacities at the community and national levels to manage and reduce risk" (International Strategy for Disaster Reduction, 2005).

3. Gender mainstreaming and disaster reduction

3.1 Gender and disasters

"Disasters affect women and men differently because of the distinct roles they occupy and the different responsibilities given to them in life and because of the differences in their capacities, needs and vulnerabilities" (Ariyabandu and Wickramasinghe, 2003, p. 51). Inter-agency Secretariat for the International Strategy for Disaster Reduction (2002) indicates that women are more vulnerable in disasters and they are the most affected. The poor and predominantly female and elderly populations are characterised by higher economic vulnerability as they suffer proportionally larger losses in disasters and have limited capacity to recover (Working group on Climate Change and Disaster Risk Reduction of the Inter-Agency Task Force on Disaster Reduction, 2006). Enarson (2000) identifies the following points as the reasons for women's higher vulnerability in disasters:

- women have less access to resources;
- women are victims of the gendered division of labour;
- women are primarily responsible for domestic duties such as childcare and care for the elderly or disabled and they do not have the liberty of migrating to look for work following a disaster;
- as housing is often destroyed in the disaster, many families are forced to relocate to shelters; and
- when women's economic resources are taken away, their bargaining position in the household is adversely affected.

In addition to the above factors, Enarson (2000) points out that disasters themselves can increase women's vulnerability not only because they increase female headed households but sexual and domestic violence are also increased following a disaster.

According to, Enarson (2000) and Khatun (2003), although women are at greater risk than men in disasters, it is the women who make it possible for the community to cope with disasters because their social role is central to the management of a disaster coping strategy. However, women's abilities to mitigate hazards and prevent disasters and to cope with and recover from the effects of disasters have not sufficiently been taken into account or developed (Ariyabandu and Wickramasinghe, 2003). As Ariyabandu and Wickramasinghe (2003) indicate, in current practice of disaster reduction women are seen as helpless victims and their capacities, knowledge and skills in each stage of the disaster cycle are not recognised. The gender differences in the disaster mitigation have been discussed primarily in the context of vulnerability or community involvement. The absence of women in decision making positions in emergency and recovery planning is not effectively addressed. Therefore, a gender perspective should be integrated into all disaster reduction policies and measures in order to decrease women's susceptibility in disasters. However, gender equality in disaster reduction requires empowering women to have an increasing role in leadership, management and decision making positions because women are not only victims of disasters but they can act as agents of change in disaster reduction planning (International Strategy for Disaster Reduction, 2002).

3.2 Gender mainstreaming

The Platform for Action (PfA) at the Fourth World Conference on Women in Beijing in 1995 brought up the concept of gender mainstreaming, the commitment to integrate gender perspective in all forms of development and political processes of governments (Office of the Special Adviser on Gender Issues and Advancement of Women, 2001a, 2001b). International Strategy for Disaster Reduction (2002) elaborates gender mainstreaming as the process of bringing a gendered perspective into the mainstream activities of governments at all levels, as a means of promoting the role of women in the field of development and integrating women's values into development work. Although, the ultimate aim of gender mainstreaming is to achieve gender equality, it is not for promoting equality to the implementation of specific measures to help women; it is to achieve equality in all general policies and measures by actively and openly taking the possible effects on the respective situation of men and women into account at the planning stage (European Commission, 1996).

According to the Employment and European Social Fund (2005), gender mainstreaming means a partnership between women and men to ensure both participate fully in society's development and benefit equally from society's resources. Gender mainstreaming covers the following aspects:

- policy design;
- decision making;
- access to resources;
- procedures and practices;
- methodology;
- implementation; and
- monitoring and evaluation.

Therefore, gender mainstreaming is necessary to incorporate in the policies and programmes related to disaster reduction mainly because "gender shapes capacity and vulnerability to disasters" (Childs, 2006) as discussed earlier. As the United Nations Office of the Special Adviser on Gender Issues and Advancement of Women (2001a, 2001b) explains, gender mainstreaming can promote gender equality and women's empowerment, particularly where there are glaring instances of persistent discrimination of women and inequality between women and men. Gender mainstreaming can be used as an effective tool to reduce the vulnerability of women, which arise due to various factors including less access to resources and to bring more women in to disaster reduction policy making process.

However, promoting gender mainstreaming is a long, slow process requiring inputs on many fronts over a long period of time, including advocacy, advice and support, competence development, development of methods and tools and vigilance in following up and evaluating progress (Office of the Special Adviser on Gender Issues and Advancement of Women, 2001a, 2001b).

3.3 Gender mainstreaming in disaster reduction

According to the definition given by the International Labour Organisation (n.d.) for gender mainstreaming, it is bringing the experience, knowledge, and interests of women and men to bear on the development agenda and identifying the need for changes in that agenda in a way which both women and men can influence, participate in, and benefit from development processes. Accordingly, mainstreaming gender perspectives into disaster risk reduction should concern women in development processes as equal partners to men as both decision makers and beneficiaries (Ariyabandu and Wickramasinghe, 2003).

According to Carolyn Hannan, Director of the UN Division for the Advancement of Women (International Labour Organisation (n.d.), the following basic principles should be set up for mainstreaming gender:

- adequate accountability mechanisms for monitoring progress need to be established;
- the initial identification of issues and problems across all area(s) of activity should be such that gender differences and disparities can be diagnosed;
- assumptions that issues or problems are neutral from a gender-equality perspective should never be made;
- gender analysis should always be carried out;
- clear political will and allocation of adequate resources for mainstreaming, including additional financial and human resources if necessary, are important for translation of the concept into practice; and
- efforts to broaden women's equitable participation at all levels of decision-making should be taken.

Therefore, mainstreaming gender in to disaster reduction policies and measures translates into identifying the ways in which women and men are positioned in society (International Strategy for Disaster Reduction, 2002). In other words, in the context of disaster risk reduction, gender mainstreaming refers to fostering awareness about gender equity and equality, etc, to help reduce the impact of disasters, and to incorporate gender analysis in disaster management, risk reduction and sustainable development to decrease vulnerability (International Strategy for Disaster Reduction, 2002). Gender mainstreaming can be used to bring equality into disaster management through considering the specific needs and interests of vulnerable women before, during and after disasters.

The United Nations International Strategy for Disaster Reduction (2002) shows gender mainstreaming in disaster reduction as a parallel but inter-linked process to the mainstreaming of disaster reduction into sustainable development policies and activities while recommending to integrate gender, development and environmental management and disaster risk reduction both in research and practice. It further recommends that efforts should be made to increase a gender balance in decision-making positions to deal with disaster risk management. There is a need for a focus on the disaster and sustainable development planning processes and ensure a participatory approach and involvement of non-traditional/non-conventional ideas and partners.

4. Conclusions

Disasters, which disrupt society with enormous damage to the human life, environment and economic resources treat women and men differently. Women are more vulnerable to the consequences of disasters because of their social role. This emphasises the need to achieve gender equality in disaster reduction and integrate a gendered perspective to all policies and measures implemented in disaster management context.

Gender mainstreaming in disaster reduction allows women to decrease their vulnerability through identifying their specific needs at the disaster management planning stage. Women are empowered by gender mainstreaming to reach equality in decision making roles in disaster reduction and to utilise their skills in planning and implementation of policies and measures. After identifying the existing roles of men and women through gender analysis, gender mainstreaming helps to achieve equality in disaster reduction by giving a comprehensive understanding of the possible effects of policies and measures developed for disaster reduction on gender roles. However, since disaster reduction and development have a close inter relationship, gender mainstreaming in disaster reduction is a parallel and inter-linked process to mainstreaming disaster reduction into sustainable development policies.

5. The way forward

This paper focused to give an account for the importance of gender mainstreaming in disaster reduction through a discussion of literature findings on disasters, the types of disasters, different categories of disaster vulnerabilities and gender mainstreaming and its role in disaster reduction process. Apropos, gender mainstreaming in disaster reduction facilitates non-traditional ideas and parties to participate in disaster reduction and sustainable development planning while empowering women to develop their leadership qualities and other special skills in the decision making process.

Therefore, the study which was the basis for this paper aims to continue researching in the future on:

- establishing a relationship among disaster reduction, construction and gender;
- demonstrating the importance of gender in the context of disaster reduction construction;
- understanding the need for mainstreaming women in construction in disaster reduction; and
- identifying the ways of mainstreaming women in construction in the disaster reduction decision making process.

References

Ariyabandu, M.M. and Wickramasinghe, M. (2003), *Gender Dimensions in Disaster Management – A Guide for South Asia*, ITDG South Asia, Colombo.

Childs, M. (2006), "Not through women's eyes: photo-essays and the construction of a gendered tsunami disaster", *Disaster Prevention and Management*, Vol. 15 No. 1, pp. 202-12.

Employment and European Social Fund (2005), *Equal-Guide on Gender Mainstreaming*, European Communities, Luxembourg.

Enarson, E. (2000), "Gender and natural disasters", IPCRR Working Paper No.1, International Labour Organisation (available at: www.ilo.org/public/english/employment/recon/crisis/publ/index.htm (accessed 2 June 2007).

European Commission (1996), "Gender mainstreaming", (available at: http://ec.europa.eu/employment_social/equ_opp/gms_en.html (accessed 10 June 2007).

Goodyear, E.J. (2003) in Sahni, P. and Ariyabandu, M.M. (Eds), *Disaster Risk Reduction in South Asia*, Prentice-Hall of India Private Limited, New Delhi.

Inter-agency Secretariat for the International Strategy for Disaster Reduction (2002), *Women, Disaster Reduction and Sustainable Development*, UN/ISDR, Geneva.

International Labour Organisation (n.d.), "Definition of gender mainstreaming", available at: www.ilo.org/public/english/bureau/gender/newsite2002/about/defin.htm (accessed 26 June 2007).

International Strategy for Disaster Reduction (1994), "Yokohama strategy and plan of action for a safer world – guidelines for natural disaster prevention, preparedness and mitigation", paper presented at World Conference on Natural Disaster Reduction, Yokohama, 23-27 May.

International Strategy for Disaster Reduction (2002), *Gender Mainstreaming in Disaster Reduction*, UN/ISDR, Geneva.

International Strategy for Disaster Reduction (2004), "Terminology: basic terms of disaster risk reduction", available at: www.unisdr.org/eng/library/lib-terminology-eng%20home.htm (accessed 18 June 2007).

International Strategy for Disaster Reduction (2005), "Hyogo framework for action 2005-2015: building the resilience of nations and communities to disasters", Final Report of the World Conference on Disaster Reduction, Kobe, Hyogo, 18-22 January.

Jaya Kumar, G.S. (2000), "Disaster management and social development", *International Journal of Sociology and Social Policy*, Vol. 20 No. 7, pp. 66-81.

Kelman, I. and Pooley, S. (Eds) (2004), *Disaster Definitions*, available at: www.ilankelman.org/miscellany/DisasterDefinitions.rtf (accessed 20 October 2007).

Khatun, H. (2003), "Livelihood strategies in disaster risk reduction in Bangladesh", in Sahni, P. and Ariyabandu, M.M. (Eds), *Disaster Risk Reduction in South Asia*, Prentice-Hall of India Private Limited, New Delhi.

McEntire, D.A. (2001), "Triggering agents, vulnerabilities and disaster reduction: towards a holistic paradigm", *Disaster Prevention and Management*, Vol. 10 No. 3, pp. 189-96.

McEntire, D.A. (2004), "Development, disasters and vulnerability: a discussion of divergent theories and the need for their integration", *Disaster Prevention and Management*, Vol. 13 No. 3, pp. 193-8.

McEntire, D.A. (2005), "Why vulnerability matters – exploring the merit of an inclusive disaster reduction concept", *Disaster Prevention and Management*, Vol. 14 No. 2, pp. 206-22.

Office of the Special Adviser on Gender Issues and Advancement of Women (2001a), "Gender mainstreaming – concepts and definitions", available at: www.un.org/womenwatch/osagi/gendermainstreaming.htm (accessed 26 June 2007).

Office of the Special Adviser on Gender Issues and Advancement of Women (2001b), "Supporting gender mainstreaming – the work of the Office of the Special Adviser on Gender Issues and Advancement of Women", available at: www.un.org/womenwatch/osagi/pdf/report.pdf (accessed 26 June 2007).

Osorio, N.L. and Hurych, J. (2004), "Literature of disasters from the human factors point of view: a descriptive analysis", *Collection Building*, Vol. 23 No. 2, pp. 64-72.

Sahni, P. and Ariyabandu, M.M. (2003), "Introduction", in Sahni, P. and Ariyabandu, M.M. (Eds), *Disaster Risk Reduction in South Asia*, Prentice-Hall of India Private Limited, New Delhi.

Secretary-General (2006), *Implementation of the International Strategy for Disaster Reduction: Report of the Secretary-General to the UN General Assembly*, available at: www.unisdr.org/eng/about_isdr/basic_docs/SG-report/SG-report-61-229-eng.pdf (accessed 26 June 2007).

Shaluf, I.M. and Ahmadun, F. (2006), "Disaster types in Malaysia: an overview", *Disaster Prevention and Management*, Vol. 15 No. 2, pp. 286-98.

Shaluf, I.M., Ahmadun, F. and Said, A.M. (2003), "A review of disaster and crisis", *Disaster Prevention and Management*, Vol. 12 No. 1, pp. 24-32.

Siriwardena, N.U., Haigh, R. and Ingirige, M.J.B. (2007), "Disaster! In search of a definition: specific to construction industry", *Proceedings of the 7th International Postgraduate Research Conference in the Built and Human Environment, University of Salford, 28-29 March 2007*.

Stenchion, P. (1997), "Development and disaster management", *Australian Journal of Emergency Management*, Vol. 12 No. 3, pp. 40-4.

Weichselgartner, J. (2001), "Disaster mitigation: the concept of vulnerability revisited", *Disaster Prevention and Management*, Vol. 10 No. 2, pp. 85-94.

Working group on Climate Change and Disaster Risk Reduction of the Inter-Agency Task Force on Disaster Reduction (2006), *On Better Terms – A Glance at Key Climate Change and Disaster Reduction Concepts*, UN, Geneva.

Further reading

International Strategy for Disaster Reduction (1999), "Mission and objectives", available at: www.unisdr.org/eng/about_isdr/isdr-mission-objectives-eng.htm (accessed 22 May 2007).

McEntire, D.A., Fuller, C., Johnson, C.W. and Weber, R. (2002), "A comparison of disaster paradigms: the search for a holistic policy guide", *Public Administration Review*, Vol. 62 No. 3, pp. 267-81.

Schmidt-Thome, P. and Schmidt-Thome, K. (2007), "Natural hazards and climate change: stakeholder communication and decision-making processes – an analysis of the outcomes of the 2006 Davos Conference on Disaster Reduction", *Management of Environmental Quality: An International Journal*, Vol. 18 No. 3, pp. 329-39.

Stanganelli, M. (2007), "A new pattern of risk management: the Hyogo framework for action and Italian practice", *Socio-Economic Planning Sciences*, Vol. 42 No. 2, pp. 92-111.

United Nations Development Programme (2007), *United Nations Development Programme A Global Review: UNDP Support to Institutional and Legislative Systems for Disaster Risk Management*, UNDP, New York, NY.

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Supporting urban emergency response and recovery using RFID-based building assessment

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Abstract

Purpose – The purpose of this paper is to focus on improving mobile computing support for professionals involved in a disaster response and recovery operation to facilitate better assessment of the damage caused to buildings and to make this assessment information available to personnel within the disaster response arena so as to expedite a safe, efficient and effective disaster response process.

Design/methodology/approach – The research method involved the use of scenario-based user needs analysis for studying end-user needs and requirements and use of Rational Unified Process for software design and implementation. An IT-supported collaboration platform was developed to enable first responders to communicate using handheld devices and laptops and share critical building evaluation information using a mobile *ad hoc* network. The deployed system was trialled at Illinois Fire Services Institute (IFSI).

Findings – Radio Frequency Identification (RFID)-enabled mobile devices and tags can be used for posting, gathering, storing and sharing building assessment information in a efficient manner with fewer errors, leading to improved efficiency and effectiveness in the emergency response process.

Originality/value – The key research contribution includes analysis of the information needs of first responders, development of a collaborative framework for supporting urban preparedness and emergency response, demonstration of developed concepts in realistic disaster scenarios, and implementation and validation of the prototype system to demonstrate the concepts.

Keywords Radio, Buildings, Disasters, Mobile communication systems, Information exchange

Paper type Research paper

1. Introduction

With the total number of natural disasters worldwide now averaging 400 to 500 a year, up from an average of 125 in the early 1980s (Oxfam, 2007), there is a need for robust systems to deal with such disasters. However, recent research and surveys show that our society as a whole is not adequately prepared for and capable of responding to large scale disasters in the best possible manner (UN/ISDR, 2005; Oxfam, 2007; EM-DAT, 2007). Current disaster relief operations are characterized by numerous shortcomings that inhibit optimal decision making during disaster management

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operations. Obstacles in the disaster response process include "no communication, miscommunication and misleading information" (IAFF, 2005) and the inability to access information and the lack of standardization, collaboration, coordination, and communication (NRC, 1999). The 9/11 Commission Report (2004) reported that during emergency response operations effective decision making was hampered by problems in command and control and in internal communications to an extent that "incident commanders from responding agencies lacked knowledge of what other agencies and, in some cases, their own responders were doing" resulting in "command, control, and communications" problems. The report recommended the need to "enable first responders to respond in a coordinated manner with the greatest possible awareness of the situation". Similar recommendations were made by Select Bipartisan Committee (2006) analyzing response to Hurricane Katrina, which specifically recommended that an information system be designed which allows users to track and share information more openly and efficiently. All of the aforementioned problems points towards the need for an integrated framework which expedites communication and data transfer procedures in the field during disaster events.

First responders including civil engineers are often at the forefront of disaster response and recovery operations (Aldunate *et al.*, 2006) reporting on the extent of the disaster, victim evacuation, initial assessment of the affected buildings and casualties and an assessment of any further threat. Thus, they become a primary link in a chain of information exchanges that lead to critical, perhaps lifesaving, decisions (Sawyer *et al.*, 2004). Civil engineers support the disaster response process by securing and monitoring the built environment for the search and rescue operations to be conducted and by providing precise and accurate information to support the decision making, resource allocation, and risk assessment processes during disaster relief efforts involving Critical Physical Infrastructure (CPI) (Aldunate *et al.*, 2006). This paper presents the work done as part of the CP2R (Collaboration for Preparedness, Response and Recovery during Disaster) project at the University of Illinois at Urbana-Champaign, which aims at establishment of a conceptual framework and development of an IT-supported platform to improve the collaboration among the key actors involved in preparedness against (i.e. before disaster), response to (i.e. during disaster) and recovery from (i.e. after disasters) extreme events involving CPI.

This paper is organised as follows. Section 2 introduces related work and the impetus for this paper. Section 3 presents the research methodology while Section 4 discusses a scenario which has guided the development of the proposed architecture and subsequent implementation. Subsequently system architecture and implementation (Section 5) and evaluation (Section 6) are discussed. Finally, conclusions are discussed regarding the possible impact of research on future urban emergency response (Section 7).

2. Motivation and related work

A key challenge in emergency response operations is to assess the condition of buildings/infrastructure in the aftermath of a disaster. Different building marking schemes are used (Table I) to assess structural damage and/or facilitate search and rescue operations.

Lessons learned from building assessments during past incidents highlight issues regarding information flow, standardization, data coordination and integration,

Building Marking Systems (BMS)	Organization(s) using the BMS	Description of the BMS
National Urban Search and Rescue (US&R) Response System (FEMA/US&R, 2005)	FEMA US Army Corps of Engineers (USACE) Local/regional responders	Four categories of structural marking including identification, structure/hazards evaluation and victim location marking are used. It uses International Orange Spray Paint for marking
International Search and Rescue Response (INSAR, 2005)	United Nations INSAR Advisory Group International USAR teams	This includes building marking for structure/hazards assessments, victim location, general hazards, facility/vehicle, identification of potential voids and team and function marking
Applied Technology Council (ATC) (ATC, 2003, 2004)	ATC FEMA USACE International USAR teams	ATC has developed different manuals detailing procedures for assessing buildings in disaster areas including ATC-45 for Evaluation of Buildings after Wind Storms and Floods and ATC-20 for Post-earthquake Building Safety Evaluation

Table I. Brief description of various building marking systems

paper-based and error-prone forms, and information update issues between assessed buildings and the Incident Command Post affecting the disaster response operation. Use of different marking systems at different levels of government (i.e. local, state, and federal) lead to confusion because of incompatibility and often results in remarking and reworking of the building assessment. Occasionally, there is a need for reassessment as new information becomes available. Furthermore, poor visibility of building marks because of smoke, debris or the location of the marking may delay the search and rescue operation. All the aforementioned factors affect emergency response operation and could delay the process of undertaking the most expedient emergency rescues while minimizing the risk to responders. As discussed below, some attempts have been made in addressing part of these problems but the approaches used have not been holistic. Much effort remained focused on adapting off-the-shelf commercial products to meet the post-disaster building assessment requirements.

Currently there are various commercially available products intended to facilitate the collection and management of building data from disaster sites. For instance, the ATC-20i PDA application (Figure 1) enables engineers to document structural inspection results using electronic input screens that duplicate the ATC-20 rapid and detailed evaluation forms and upload the data via CDMA/GSM wireless networks to a server where the data can be reviewed, summarized, and managed by the user and by building departments in jurisdictions affected by the earthquake (ATC, 2008). The application is based on Palm Operating System and it allows inspectors to print the Inspected (green), Restricted Use (yellow), and Unsafe (red) placards in the field using a wireless printer. Another commercially available system, the PacketHop Communications System (PocketHop, 2008) uses proprietary wireless networking

Source: ATC (2008)

Figure 1.
ATC-20 PDA implementation for supporting disaster recovery

technologies to enable peer-to-peer communication without the requirement for infrastructure or servers. This allows field personnel to share applications and securely access the internet over range spanning one kilometer.

Various research projects have also focused on addressing information needs of first responders. For instance, the coordinators project (Wagner *et al.*, 2004) focused on decision support provision to first responders by clear role allocation. The system implementation included PDAs, wireless communication technologies, and a proprietary location tracking system for tracking resources and people. Also, various emergency agencies are using Geographic Information Systems (GIS) in support of disaster management operations. Application of other emerging technologies such as mobile GIS, high-resolution digital remote sensing imagery, global positioning systems, computer models, databases and digital video are also being considered to improve the emergency response operation (Montoya, 2003).

Many of the commercially available applications to support post-disaster assessment are based on proprietary hardware and software with a limited capability of information sharing and data exchange and lack flexibility and scalability. Very often, these applications are deployed to support a specific high-end objective such as provision of communications infrastructure, supporting disaster-site data capture, information provisioning or location tracking. Specific needs of professional groups such as civil engineers undertaking building assessment are not adequately addressed. From a technological viewpoint, there is a need to consider improvement of existing processes using emerging technologies such as RFID, Mobile Ad-hoc Wireless Networks, and Mobile Computing within the disaster response environment. Also, existing products to support first responders rely on fixed wireless infrastructure such as public cellular systems to support emergency communications (Jones *et al.*, 2005). If these connections broke or if the dispatch center became inoperable because of a natural disaster, communication between mobile units could become very difficult. Thus, there is a need to explore the potential of mobile *ad hoc* wireless networks to support disaster management teams. While some initiatives have addressed some of the aforementioned limitations there is a need for an integrated framework and a holistic approach for urban disaster response.

3. Methodology

The research methodology adopted involves the use of "Scenario-based User Needs Analysis" (SUNA) (Helvert and Fowler, 2003) to develop and validate scenarios and to establish user needs. The scenario (Section 4) describes a realistic building collapse situation and was derived through interaction with IFSI personnel. It was described as chain of events and was analyzed by bringing together perspectives of experts from different backgrounds (disaster response, communications, construction and technology). The analysis was further used to obtain user requirements for the prototype development. Unified Modeling Language (UML) was used for project modeling. Given the complex nature of the problem being solved, a standardized development process, i.e. Rational Unified Process (RUP), was used for the software design and implementation. It describes a set of guidelines for the entire life cycle of application development and supports iterative software development. To ensure software quality, rigorous testing procedures were adhered to. NUnit.NET (NUNIT, 2008) testing software was used and unit tests for different modules of code were developed. In the platform, two separate functionalities were developed and integrated into one software application. The first part enables first responders to systematically evaluate buildings, save this information into their handheld devices and transfer this information to the incident command centre via an *ad hoc* network. Information was also stored in on-site RFID tags. The second part of the project deals with retrieval of building information from a black box placed in the building and enables the transfer of this information by first responders through the established network (Tsai *et al.*, 2008).

4. Implementation scenario and requirements analysis

This section describes the scenario, which has guided the development of the proposed architecture and subsequent implementation. It describes assessment of buildings a high intensity earth quake. First responder teams consisting of fire-fighters, police, medical personnel and civil engineers were notified and they quickly moved to the incident site. First responders use an IT-based collaborative platform for building assessment. They acquire critical building data such as building evacuation plans, design records, drainage, sewage and HVAC system layout, from a building black-box (Tsai *et al.*, 2008) installed inside the building (Figure 2a). Subsequent building assessment based on the ATC-20 procedure is undertaken in two steps (i.e. rapid and detailed). During the rapid evaluation, the preliminary damage assessment of buildings are recorded in RFID tags. According to the damage level, they flag the building green (indicating safe), yellow (indicating restricted access) or red (indicating

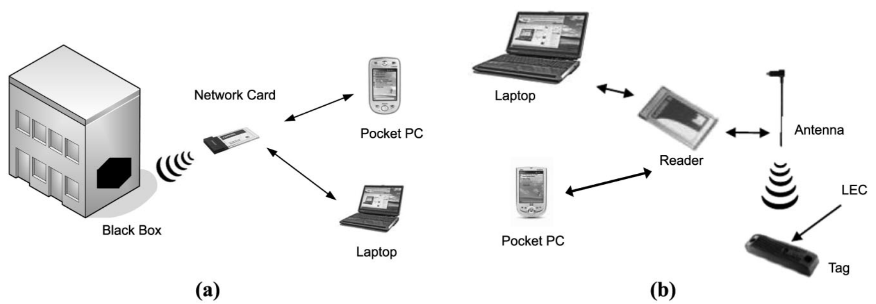


Figure 2. (a) Building Black Box framework; and (b) RFID technology and IT-based collaboration system

unsafe). With the help of a mobile *ad hoc* peer to peer network building assessment information is transferred to the Incident Command Centre and to other nodes concurrently. This information is also stored on RFID tags attached to buildings (Figure 2b). Use of *ad hoc* mobile wireless network reduces dependence on communication infrastructure. Once the rapid evaluation is completed, a second team of engineers perform a detailed evaluation of buildings marked "restricted" and "unsafe" during the rapid evaluation. In this scenario, the underlying IT infrastructure provides first responders with correct and reliable information to effectively and systematically manage disaster relief operations. Use of mobile *ad hoc* networks automated the information transfer process and ensured a better communication flow between first responders.

Based on the preliminary study and the scenario analysis with first responders from IFSI and US Army Corps of Engineers the following user needs for a building assessment system were identified (Table II).

5. System architecture and implementation

To meet user requirements presented in Section 4, this Section presents the multi-layered system architecture and key application packages (Figure 3). Presentation Tier provides users with access to the system. The UI (User Interface) and UIFramework layer renders windows forms to enable users to interact with the system. The Business Logic Tier translates the user input to the functional parameters and then invokes functions present in the lower layers. The Data Access Tier contains the Shared Memory Manager code which provides an interface to access data for the Application Logic layer. Resource Interface tier provides a medium of communication between the Data Layer and the External Resources layer deals with operating system calls, networking components and the local database. In order to capture the system requirements as accurately as possible key class diagrams for various system features such as the user interface, user interface framework and the building evaluation forms (Figure 4) were developed.

The Deployment diagram (Figure 5) shows the hardware for a system, the software that is installed on that hardware, and the middleware used to connect the disparate machines to one another. The boxes in Figure 6 represent hardware nodes of the system including PDAs, laptops, block box servers and *ad ho*c network to support wireless connectivity. The black box database contains building documents such as building drawing, evacuation plans, and other relevant information. PDAs and laptops can access the database on the black box. PDAs and laptops can read and write data from RFID tags using a "RFIDInterface." "NetworkInterface" on the hardware nodes is used to access the *ad hoc* network. The "SharedMemoryManager" uses the local database interface to save the data locally and uses the messaging subsystem to create an object data message and broadcast it on the local area network.

The system implementation provides a means for first responders to perform building assessments on damaged buildings via hand-held devices, store this information on RFID tags attached to the buildings and transmit this data across a local area or mobile *ad hoc* network set up at the disaster site. A GPS extension of the software enable automatic updating and visualization of the location of first responders as they comb the disaster site for victims and make assessments of the existing disaster situation. Both PC (Windows 2000/NT/XP/Vista/Tablet-PC) and

Identified needs and problems	Brief description	Derived user requirements
Variations in building marking systems	Involvement of multiple organizations and professional groups with different priorities and use of different marking systems resulting in overlaps/confusions	System should allow for differences in marking schemes at different levels (e.g. at local, state and federal levels)
Need to communicate information up the information chain	Building assessment data captured on-site are not communicated in real-time up the supply chain	Building assessment data captured from site should be communicated in real-time up the information chain
Need for real-time data	Current approaches rely on paper-based communication methods. Assessment information is transferred to the ICC using crew operational rotation, which may take up to 24 hours	Real-time data transmission of captured building data to ICC
Poor visibility of building marks using spray-based paints	Building marks are often not visible in poor visibility conditions such as smoke and debris	Using non-line of sight-based approaches for on-site data recording
Limited data capture using existing building marking schemes	There is a need to capture related information beyond existing building marking system such as ability to capture all sorts of damage and details such as building plan details, who developed it, how the shore needs were determined, progress on implementing the plan, changes. This may include more detailed information for response such as detailed description of victim location	Ability to capture wide array of data
Ease of integration with other application	Interoperability with other applications	Ability to integrate with other applications using an XML-based approach
Usability	Intuitive interface and easy to use in harsh environments	Systems should meet usability goals
Disaster-proof networking	Ability to communicate with other units when central dispatch is not available	Ability to support peer-to-peer communication
Scalability and flexibility	Ability to add additional hardware	Ability to be scalable
Portability	Given the mobile nature of emergency response work, the system should be portable enough to support field workers	System must support data requirements of both fixed and mobile network client

Table II.
Functional requirements for a building assessment system

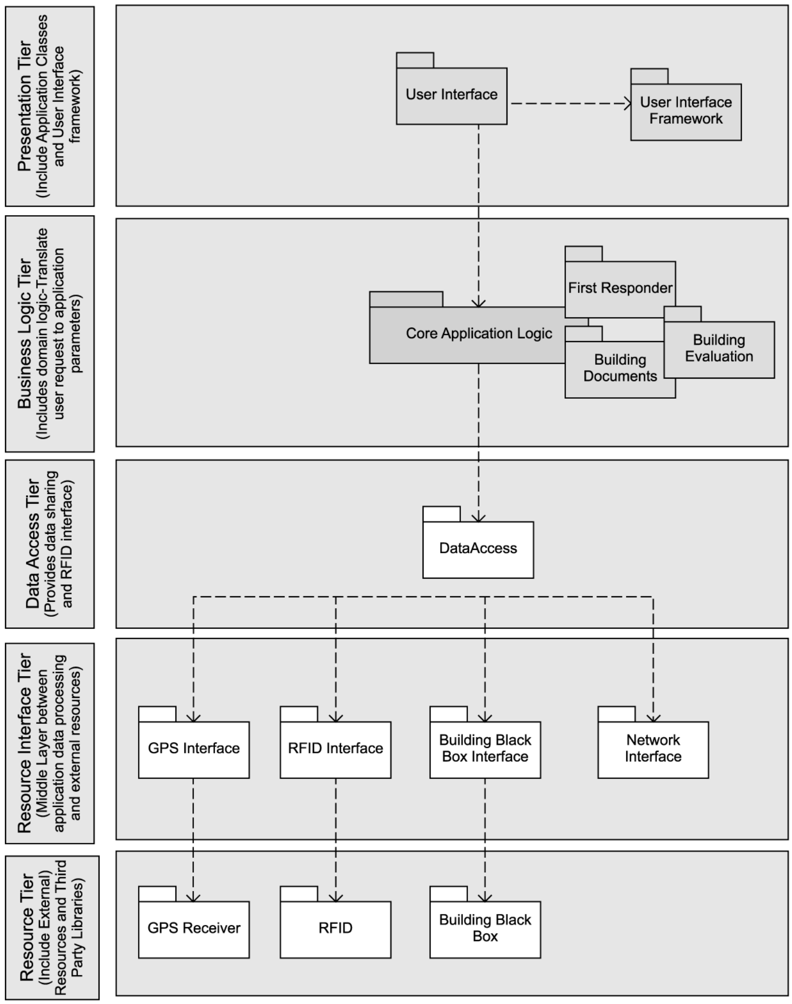


Figure 3.
System architecture and key application packages

Pocket-PC (WinCE) platforms were supported. RFID tags from IDENTEC Inc. (2008) were used. After a successful log-in users have an option to undertake a rapid or detailed evaluation for building assessment (Figure 6).

The system provides user with an option of a detailed or rapid evaluation. If the user selects a "Rapid Evaluation" option, the system will lead user to a tabbed user control (Figure 7). The forms were based on ATC-20 procedures to ensure that responders can use the system without the need for additional training. Some of the key forms in the "Rapid Evaluation" section are discussed here. The user first completes the "Building Identification" (Figure 7b) section of the "Rapid Evaluation" form which involves filling in details such as "evaluation name", "Building ID", "Latitude" and "Longitude" (obtained through GPS). Key fields in the "Inspection" tab of the Rapid Evaluation Form include "Inspector Id", "Affiliation", and "Inspection

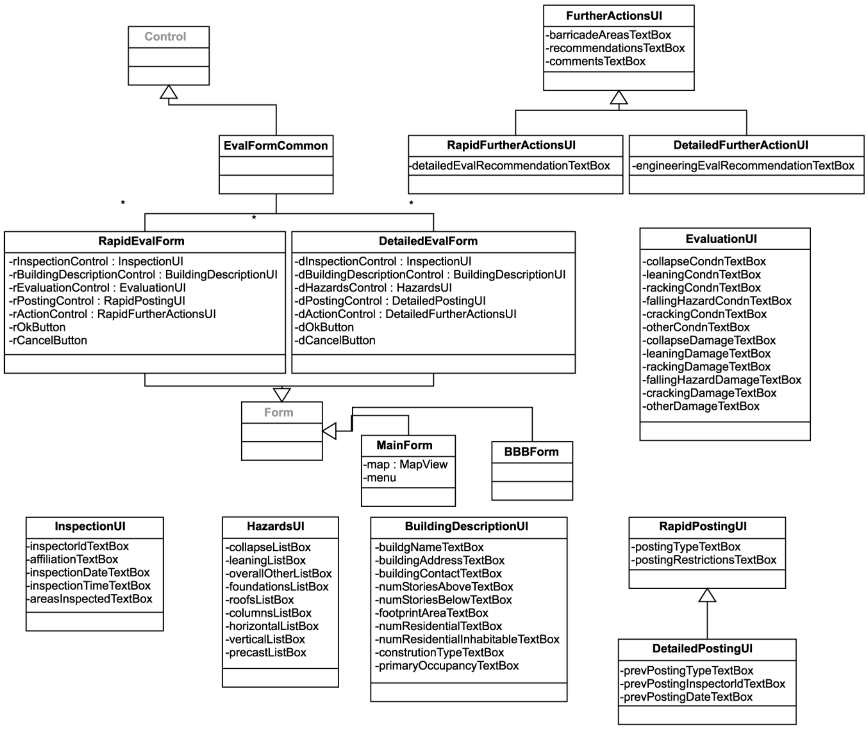


Figure 4.
Class diagram for building evaluation form

Time" and "Areas Inspected". Data for the "Inspection Time" field is obtained automatically through the system clock. In the "Posting" tab, the user selects the types of posting such as Inspected (Green Placard), Restricted (Yellow Placard) and Unsafe (Red Placard). Other forms in rapid evaluation include "Building Description", "Further Actions" and "Evaluation" tab.

Once "Rapid Evaluation" is saved users can see the evaluation data on the geo-coded interactive area map which is automatically and continually updated with RFID tags within range.

6. Testing and evaluation

Field trials of the system were conducted in several iterations at IFSI training arena. The testing operation resulted in successful assessment of an assortment of five totally and partially collapsed buildings surrounded with simulated fire and smoke with firefighters being trained alongside. The exercises were held by the IFSI involving graduate students working in parallel with first responder trainers and professional firefighters. A key objective of the aforementioned field trials was to compare process improvement using tools discussed in this paper to existing processes. To ensure an effective comparison "The Charrette Test Method" was used, which is intended to provide increased reliability and validity for exploratory research in comparison to other commonly used research methods. During the field trials data was drawn from interviews, observations, and time diaries. Field trials also served as a technology

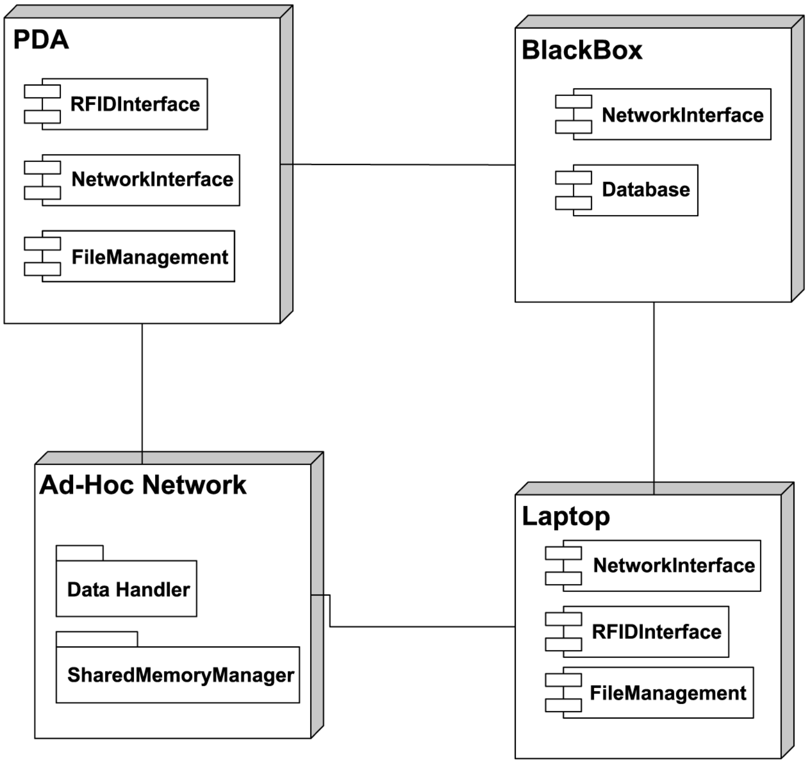


Figure 5.
System deployment diagram

demonstrator, to help identify and discover information needs in realistic disaster situations that were difficult to discover in a laboratory environment. As a result of using mobile *ad hoc* networks, the efficiency and performance of architecture is highly dependent on the number of nodes (e.g. PDAs, Laptops). A large number of nodes will lead to network congestion resulting in a single network device handling a large number of *ad hoc* packets. Because of limited computational capabilities of a device this may lead to inefficient performance.

During the field trials, a keen interest was shown in the CP2R collaboration framework by the professionals. At the same time, many barriers such as cost, organizational, technology-adoption and usability were identified. Major usability concerns included difficulties in operating Tablet-PC/PDA while wearing gloves, difficulty in reading computer screen in sunshine, consistency issues in range of RFID tags and readers. Software adjustments were made iteratively based on the feedback generated from trials. Identified technology-related barriers included issues such as lack of available hardware, limited battery life, high deployment costs, security concerns, *etc*. These are valid points; however, with the fast pace of technology change, it is hoped that many of these technology related barriers will be addressed in due course. Aforementioned barriers also highlight the fact that for successful implementation of such a technology, it is important to satisfy the constraints introduced by technological complexity, cost, user-acceptability and organizational

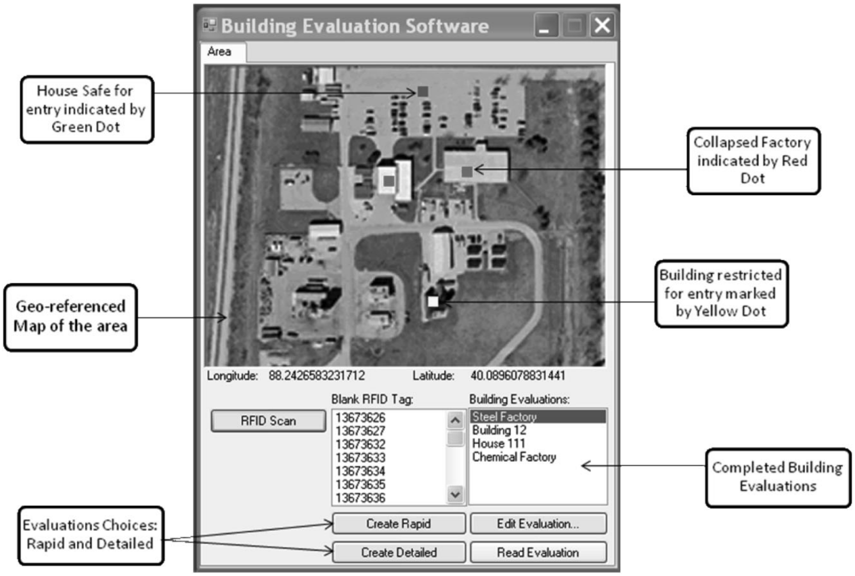
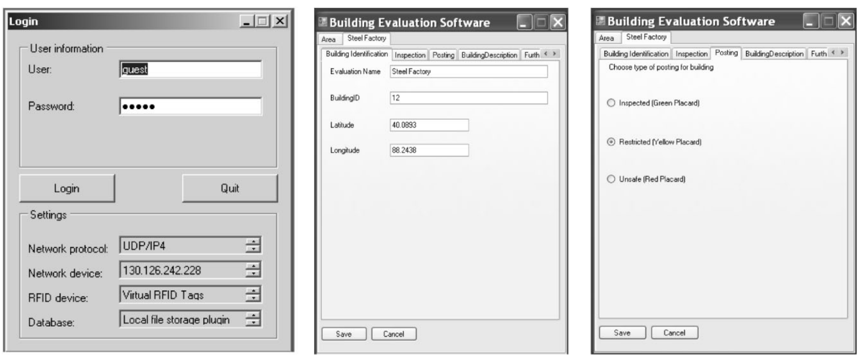


Figure 6.
Description of key features of the user interface



(a) **(b)** **(c)**

Figure 7.
(a) Log in screen; (b) Building identification; and (c) Posting forms

and group dynamics. A few evaluators also expressed a desire to see additional mobility/information support for first responders. Such features are useful and are being addressed as part of a parallel research initiative in CP2R group. In summary, field trials and demonstrations at IFSI helped to better analyze requirements for the collaboration framework. Future tests are also planned to iteratively improve the system in collaboration with different levels of public emergency management agencies.

7. Discussion and future work

Our future work involves the study, development and testing of tools and methodologies to support the work performed by emergency response teams, and facilitate the processes they are engaged in, such as planning, strategic decision making, and on-demand virtual team formation. To enable this we are currently working on developing a "Incident Command Centre" (Figure 8), which will be equipped with a state of the art equipment including sophisticated communication, visual surveillance, data analysis capabilities, real-time location tracking and satellite connectivity and a video conferencing communication system. It will provide the electronic infrastructure, telecommunications, computing, mapping, wireless LAN, GIS, GPS, intra-team capabilities, visualization, remote sensing and related support that engineering-construction responders will need in the field during any large-scale incident involving CPI otherwise achieved through disperse individual equipment. Furthermore, it will eliminate a significant portion of the logistical hurdles for civil engineers' undertaken works in an actual incident and will reduce the need to rely on supporting agency equipments for communications, power and shelter.

A parallel research initiative in CP2R group is directed towards the development of a Geographic Information System (GIS)-based application focusing on enhanced use of geographical information for resource allocation, supported by decision-making algorithms. Future work will involve the integration of the RFID-based building evaluation system with the GIS-based application to display, visualize and analyze spatial data related to buildings after the major events. First responders will also be supported using wearable computers with on-board data processing capabilities and a personal mobile platform to enable first responders to be extremely mobile and deployable in difficult terrain.

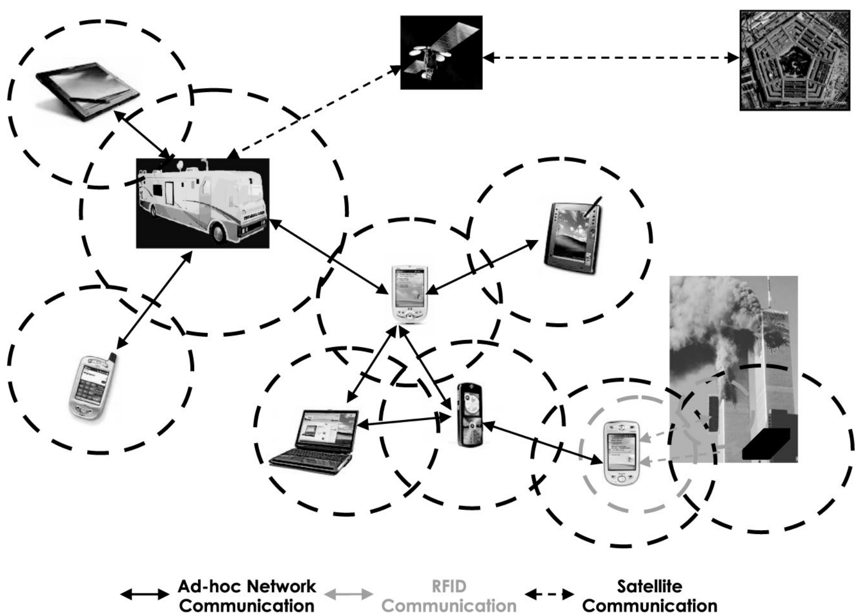


Figure 8.
Visualised framework for information sharing

References

9/11 Commission Report (2004), *Final Report of the National Commission on Terrorist Attacks upon the United States – Executive Summary*, available at: www.9-11commission.gov/report/index.htm (accessed 7 May 2008).

Aldunate, R., Ochoa, S.F., Peña-Mora, F. and Nussbaum, M. (2006), "Robust mobile *ad-hoc* space for collaboration to support disaster relief efforts involving critical physical infrastructure", *Journal of Computing in Civil Engineering*, Vol. 20, pp. 13-27.

Applied Technology Council (2003), *Users Manual: Mobile Post-Earthquake Building Safety Evaluation Data Acquisition System*, available at: www.atcouncil.org/pdfs/ATC20i.pdf (accessed 7 May 2008).

Applied Technology Council (2004), *ATC-45 Field Manual: Safety Evaluation of Buildings after Wind Storms and Floods*, available at: www.atcouncil.org/ATC45.shtml (accessed 7 May 2008).

EM-DAT (2007), *The International Emergency Disasters Database*, available at www.emdat.be (accessed 7 May 2008).

FEMA/US&R (2005), *Urban Search & Rescue Structures Specialist Field Operations Guide*, 4th ed., US Army Corps of Engineers, Washington, DC.

Helvert, V. and Fowler, C. (2003), "Scenario based user needs analysis", working paper 2003-02-SUNA, University of Essex, Colchester.

IAFF (2005), "Fire fighters doing their jobs and the jobs of others", available at: www.iaff.org/Comm/Katrina/Center0903Press.asp (accessed 7 May 2008).

IDENTEC Inc. (2008), "IDENTEC RFID", available at: www.identec.com (accessed 7 May 2008).

INSAR (2005), "International search and rescue response: guidelines", available at: www.reliefweb.int/undac/documents/insarag/guidelines/Id-mark.html (accessed 7 May 2008).

Jones, V.M., Karagiannis, G. and Heemstra de Groot, S.M. (2005), Ad hoc *Networking and Ambient Intelligence to Support Future Disaster Response*, Technical Report TR-CTIT-05-70, Centre for Telematics and Information Technology, University of Twente, Enschede.

Montoya, L. (2003), "Geo-data acquisition through mobile GIS and digital video: an urban disaster management perspective", *Environmental Modelling & Software*, Vol. 18, pp. 869-76.

National Research Council (NRC) (1999), *Reducing Disaster Losses through Better Information*, National Academic Press, Washington, DC.

NUNIT (2008), available at: www.nunit.org/index.php (accessed 17 April 2008).

Oxfam (2007), "Climate alarm: disasters increase as climate change bites", Oxfam Policy Papers, available at: www.oxfam.org/en/policy/2007/

PocketHop (2008), PocketHop Communication Systems, available at: www.packethop.com/products/communications/index.php

Sawyer, S., Tapia, A., Pesheck, L. and Davenport, J. (2004), "Mobility and the first responder", *Communications of the ACM*, Vol. 47 No. 3, pp. 62-5.

Select Bipartisan Committee (2006), *A Failure of Initiatives, Final Report of the Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina*, US Government Printing Office, Washington, DC.

Tsai, M.H., Liu, L., Peña-Mora, F. and Arboleda, C. (2008), "A preliminary design of disaster-survivable building blackbox system for urban disaster response", *ITcon*, Vol. 13

(special issue), “Sensors in construction and infrastructure management”, pp. 179-92, available at: www.itcon.org/2008/13

UN/ISDR (2005), “Hyogo Framework for Action 2005-2015: building the resilience of nations and communities to disasters”, available at: www.unisdr.org/eng/hfa/docs/Hyogo-framework-for-action-english.pdf

Wagner, T., Phelps, J., Guralnik, V. and Van Riper, R. (2004), “An application view of coordinators: coordination managers for first responders”, paper presented at 19th Conference on Artificial Intelligence, AAAI, San Jose, CA, July 24-26, pp. 908-15.

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Raising preparedness by risk analysis of post-disaster homelessness and improvement of emergency shelters

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Abstract

Purpose – The purpose of this paper is to contribute to the development of a winterised tent for emergency shelter use in cold climate regions. As in any risk management process the risk analysis and evaluation are of major importance. First, a risk analysis of post-disaster homelessness is presented. Second, a number of feasible floor insulations for tents will be dealt with.

Design/methodology/approach – The risk analysis was undertaken evaluating the homelessness data of the EM-DAT (Emergency Disasters Data Base) database. For the development of a floor insulation the literature on past-disasters was reviewed and experts in the field of emergency shelters were consulted. Furthermore, a transfer of knowledge from other fields was undertaken, e.g. from build materials.

Findings – It was found that beside the endangerment the human development status is of major importance for the number of people left homeless by a natural disaster. A number of floor insulations were developed which allow for thermal comfort of the tent occupants up to a ground temperature of $-10^{\circ}C$.

Research limitations/implications – Having investigated analytically various options for a floor insulation, consequently field testing becomes necessary.

Practical implications – The paper demonstrates that thermal comfort is not possible without an appropriate floor insulation and therefore highlights the need to consider it as an integral part of tent winterisation.

Originality/value – Within the scope of tent winterisation this paper widens the view from the usual restriction on roof insulation towards a fully winterised tent and addresses thereby all persons working in the field of emergency shelters.

Keywords Risk analysis, Emergency measures, Thermal insulating properties, Homelessness, Disasters

Paper type Research paper

1. Background

Owing to natural disasters every year hundreds of thousands of residential buildings are destroyed leaving their inhabitants for a certain period of time homeless and in need of both intermediate shelters (such as emergency and temporary shelters) and long term housing reconstruction. Especially in cold climate regions it is important to provide adequate emergency shelters quickly, in order to prevent post-disaster illnesses or even death from the cold. However, the Pakistan earthquake in 2005 with its 3.1 million (mio.) homeless showed once more that appropriate tents for cold climate regions are not available. With no other emergency shelter option than tents feasible this earthquake underlined again the necessity to develop winterised tents.

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2. Risk analysis of post-disaster homelessness

For the undertaken risk analysis the data on post-disaster homelessness of the database EM-DAT was used (EM-DAT, n.d.). It was shown that the distribution of homelessness over disaster types varies with the largest number of homeless generated by floods (672 homeless per year per mio. inhabitants), followed by windstorms (266) and earthquakes (71). Analysing the reasons for the observed homelessness it was found out that for earthquakes the number of homeless increases with higher Richter scale magnitude while, considering the human development index (HDI), the highest homelessness is registered for medium human development (Figure 1). This can be explained by an increase in vulnerability in the transition from low to medium human development, e.g. by rural exodus and the formation of large urban slums while for high human development the vulnerability decreases, e.g. due to larger financial means for preventive measures. Finally, assigning to each country a risk class depending on its Mercalli scale zoning and combining this with the human development status a risk index for earthquakes was formulated (NATHAN, n.d.).

Analysing the post-disaster shelter situation the dependency between socio-economic boundary conditions, vulnerability and shelter need could be identified (Figure 2). In each of the three parts of the diagram the different options which exist depending on the socio-economic boundary conditions are depicted with an increase in vulnerability from the left to the right. Initially the socio-economic conditions such as building quality and site location influence the structural vulnerability of the individual's home, e.g. poor people settling on endangered land (part I of Figure 2). In this way the socio-economic conditions affect the total number of

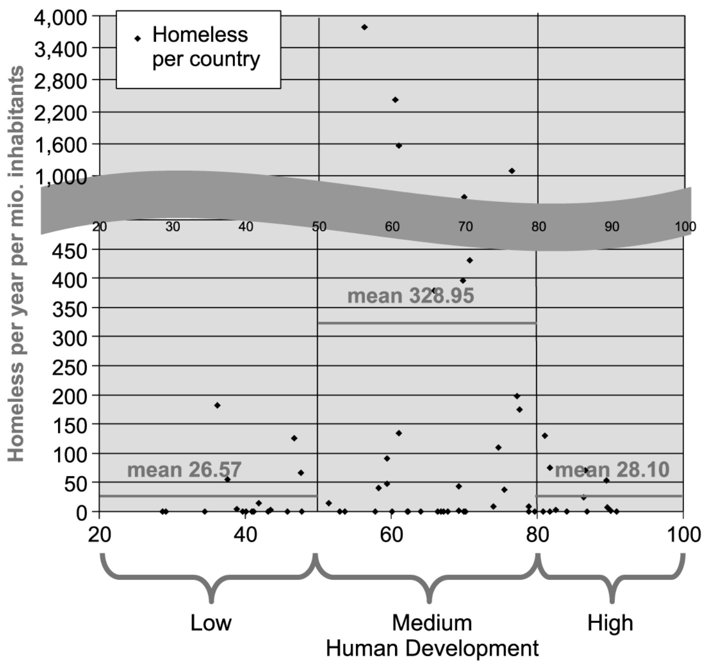

Figure 1.
Homelessness by earthquakes depending on Human Development Index

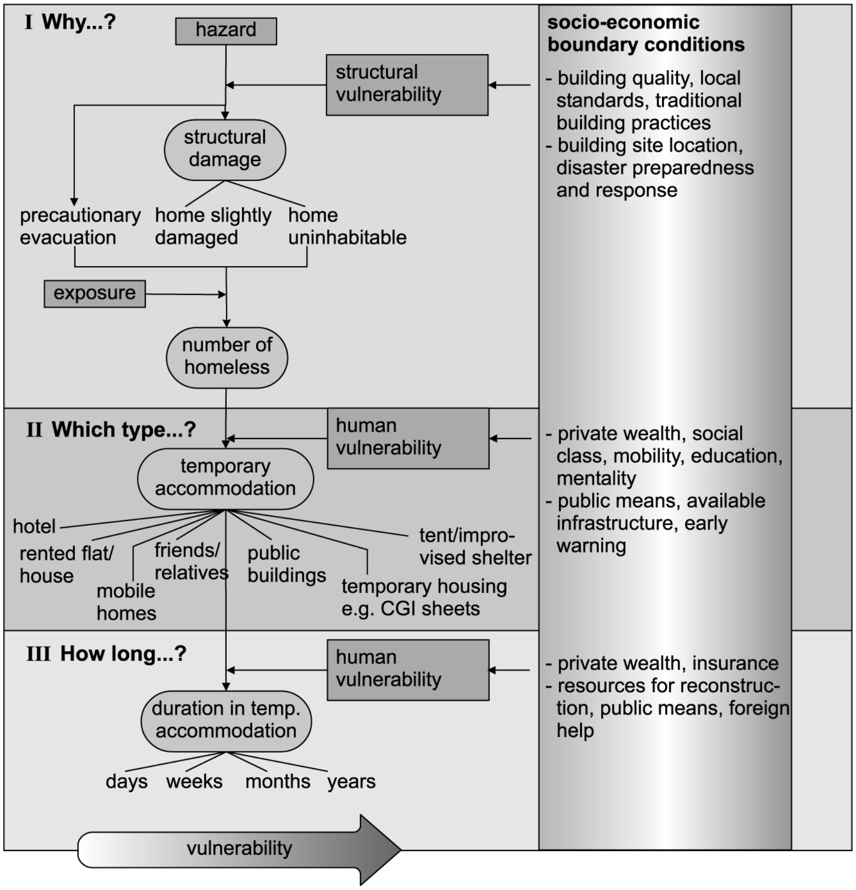

Figure 2.
Influence of vulnerability on post-disaster shelter situation

homeless which corresponds with the above demonstrated relation between human development status and the number of homeless due to earthquakes.

Furthermore, the socio-economic conditions contribute to human vulnerability which influences the availability of emergency shelter options (part II of Figure 2) as well as the duration in temporary housing until reconstruction is finished (part III of Figure 2). For example a wealthy person in a highly developed country can rent a hotel room and quickly return to a reconstructed home paid for by insurance whereas a poor person in a developing country will be compelled to wait for the delivery of tents and external help for reconstruction. From past disasters it can be shown how with increasing human vulnerability the emergency shelter options change from renting a hotel room over mass accommodation in schools towards tents. This signifies that the availability of emergency shelter options is not arbitrary but depends on the socio-economic context. At the same time this means that adequate shelter can only be provided if it is designed in correspondence with the given socio-economic situation.

3. Winterisation of emergency shelter tents

Owing to the observed lack of sufficient winterisation of emergency shelter tents the UNHCR (United Nations High Commissioner for Refugees) defined the development of cold climate tents as a pressing task. Within this task the provision of an insulated tent floor is of major importance as it not only restricts the overall heat loss from the tent but reduces the heat loss of the occupants while they are sitting or sleeping on the ground (The Sphere Project, 2004). Especially during the night the heat loss from the body is critical as less heat is produced and hence freezing is more likely. Therefore, different options for the floor insulation have been investigated using insulation materials from the building industry like Expanded Polystyrene (EPS) as well as locally available materials such as straw. Beside the conformity with the specific requirements from the use as emergency shelter material, e.g. low cost, ease of transport the thermal properties of the solutions were evaluated using calculation methods from the building codes.

In Table I the heat loss of an uninsulated tent floor consisting of two layers of plastic sheeting is compared with two insulated options. The solid system is formed by 2 cm of rigid Styropor or Styrodur lying between two plastic sheetings. For the second option a 2 cm air layer is constructed by a rectangular grid of supporting beams and a top tile both of High Density Polypropylene (HDPP). The thermal properties of the air layer are additionally improved by an infrared reflecting coating on the underside of the top tiles. Table I shows for a ground temperature of −10°C how the heat loss during sleeping can be reduced from 157 W to 59 W by the installation of a stove and the provision of an insulated floor. The achieved value is well below the heat produced by the body during sleeping (85 W) so that the occupants do not chill. Similarly the overall heat loss for an internal tent temperature of 20°C can be reduced drastically. This is important for the heating up of the tent as the heat produced by a standard stove is restricted to 5-7 kW. Furthermore, the thermal comfort which depends largely on the radiation of the surrounding surfaces is raised by a significant increase in the inner surface temperature of the floor (T_{si}).

Summarising the results of the research on insulated tent floors, an easy to apply tool for the shelter aid sector has been developed indicating adequate floor insulations options depending on the local climate (Table II). All depicted options beside the air layer system are designed with two plastic sheetings: one on top of the insulating layer to protect from daily wear and tear and one underneath to protect against water etc. Beside the two options discussed above the specifications of the options are as follows:

- *Acoustic floor mat*. Quiet Zone Acoustic Floor Mat of 9.5 mm closed cell, extruded polyethylene foam.

Type	Basic winterisation	Solid system	Air layer system
Standard	2 tarpaulins, 3 blankets p.p.		
Additions		2 cm EPS/XPS, stove	2 cm air layer, stove
R_{tot}	0.21 m^{2}K/W	0.78 m^{2}K/W	0.80 m^{2}K/W
$Q_{sleeping}$	157W	59 W	59 W
Q_{floor}	2,273 W (heated)	613 W	603 W
T_{si}	−4.1°C (heated)	13.5°C	13.6°C

Table I. Thermal properties of different options for tent floor

- *Pallet with/without IR-reflec.* Standard wooden pallet with min. height of 134 mm; area between top boards of pallets filled with additional boards to form a closed wooden cover of min. 18 mm wood; with IR-reflection: aluminium foil fixed to underside of wooden cover.
- *Straw.* ~10 cm thick layers from bales of dried straw.

The applicability of the different options depends on the inner surface temperature as this is the most critical requirement for thermal comfort. The minimum acceptable inner surface temperature was set to 15°C (case () or providing less thermal comfort to 13.5°C (case (()). With these temperatures as boundary conditions the following other thermal properties are fulfilled:

$Q_{floor} < 485$ W resp. 631 W
(i.e. overall heat loss through floor)

$Q_{sleep,down} < 34.1$ W resp. 33.2 W
(i.e. heat loss from body downwards during sleeping for bed clothing +1 layer of medium thermal resistance blankets resp. 2 layers of medium thermal resistance blankets).

It can be summarised that an insulation of the tent floor is possible both with imported or locally available materials and that thermal comfort can be achieved even under severely cold conditions.

4. Conclusions

Much work has been undertaken to identify the risk of death or monetary damage due to natural disasters. However, the significance of shelter for a fast recovery of the affected population and the large financial expense for both temporary shelter and reconstruction necessitate as well an analysis of the risk of post-disaster homelessness. The undertaken risk analysis shows how a risk index can be developed using the endangerment and the human development status as indicators.

With respect to an improvement of the disaster response the presented options for an insulated tent floor demonstrate that an enhancement of the thermal properties of emergency shelter tents is possible. This will not only raise the immediate post-disaster living conditions of the affected but as well enhance the overall sheltering process. With adequate emergency shelters to hand and a thereby raised preparedness for the disaster case, more time for good reconstruction becomes available and potentially temporary shelters become abundant leaving additional money for a better reconstruction. However, much effort is still required to ensure the completion of fully winterised tents.

Min temperature	10°C	5°C	0°C	−5°C	−10°C
EPS/XPS	✓	✓	✓	(✓)	(✓)
Air layer	✓	✓	✓	(✓)	(✓)
Acoustic floor mat	✓	(✓)			
Pallet without IR-reflec.	✓	✓	(✓)		
Pallet with IR-reflec.	✓	✓	✓	✓	✓
Straw	✓	✓	✓	✓	✓

Table II. Options for insulated tent floor depending on local climate

References

EM-DAT (n.d.), EM-DAT (Emergency Disasters Data Base): Disaster Profiles Database, available at: www.em-dat.net/disasters/profiles.php (accessed 17 September 2007).

NATHAN (2007), Munich Re: Natural Hazard Maps, NATHAN (NATural Hazards Assessment Network), available at: http://mrnathan.munichre.com/ (accessed 17 September 2007).

(The) Sphere Project (2004), *Humanitarian Charter and Minimum Standards in Disaster Response*, Oxfam Publishing, Oxford.

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Towards a more "robust" technology? Capacity building in post-tsunami Sri Lanka

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Abstract

Purpose – In fast urbanizing economies such as Sri Lanka, the construction industry tends to fragment into almost separate spheres of production with little or no reciprocal connection in training, know-how and career development paths, and consequent limitations in internal knowledge dissemination and technology transfer. This type of industrial compartmentalization is detrimental to the social acquisition of skills, and restricts the operational frameworks of given technologies, especially in low-cost sectors. Against this backdrop, this paper sets out to speculate on how design can act as an engine of social and economic growth for those involved in its production.

Design/methodology/approach – Based on government statistics and building output analysis, the paper argues that architects can build labour policy-making into the design of their buildings, provided that such an agenda is developed strategically, by examining the industrial base of the region, and by defining a design and technological vocabulary that feeds off the analysis of place-specific conditions, limitations, and ambitions.

Findings – The integration of technological development and broad socio-economic growth can be facilitated by "open" (or "incremental") industrial design strategies aimed at connecting construction markets rather than keeping them separate. To this end, it is posited that technological contamination and compromise can help the labour force to increase its own skills progressively.

Research/limitations implications – In practical terms, this objective translates in the definition of building implementation techniques that can adapt to the level of complexity required and the level of expenditure possible without penalizing the expected performance of the building – i.e. they must be inherently "robust" as opposed to precise and therefore more "sensitive".

Originality/value – The paper is the first result of a thesis-in-progress that, on the basis of a technical review carried out on a small sample of ideal-type projects in Sri Lanka, is considering ways to create and link labour development opportunities through architectural design.

Keywords Urban economies, Construction industry, Design management, Sri Lanka, Natural disasters

Paper type Research paper

1. Reconstruction challenges in Sri Lanka: the post-tsunami situation

The tsunamis that hit Sri Lanka in late 2004 caused an unprecedented natural disaster with huge loss of lives and severe devastation to infrastructure such as housing, roads, railways and bridges. According to the World Health Organization (TAFREN, 2005), up to one million Sri Lankans were displaced by the tidal waves. In the aftermath of the disaster, Central Bank sources predicted that the rebuilding cost of housing and townships alone would amount to US$2 billion (IPS, 2005). There were initial pledges for assistance by the world community and United Nations-assisted groups, although many feared that such relief may not reach the displaced due to entrenched political graft and mismanagement. Others, however, believed that the sheer amount of aid pledged by donor countries, combined with the reconstruction effort, would spur the

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economy and give a fillip to the stagnant construction industry battered by the country's 20 years of war (TAFREN, 2005).

A more structural question however lingers as to the Sri Lankan construction industry's ability (or maturity) to absorb and put to effective rebuilding use all the assistance received. After almost three years from the day of the disaster, the people who have been made homeless are still residing in refugee camps or temporary structures built closer to their destroyed settlements. The townships are still plagued by damaged buildings and ruined infrastructure. Most of the new buildings that replaced the destroyed ones have failed in quality and character. Above all, the opportunity offered by the disaster to re-think and re-develop the coastal belt to a better vision and substance has been lost in the process.

These reflections gain further resonance when considering that the plight of tsunami refugees cannot be treated as an isolated problem; indeed, it is part of an increasing (and increasingly larger) phenomenon of people displacement, which is particularly pronounced in developing and transitional economies. Reasons vary. The 20-year old civil war in Sri Lanka, for example, has transformed a particular section of the population into what the international community now calls "internally displaced people", or IDPs. According to 1995 estimates, there were about 85,000 IDPs in Sri Lanka; by 2004 this number was expected to have doubled (Pathirana, 2002).

Natural disasters and war conflict combine with economic restructuring and urbanization pressures. In Sri Lanka, the extremely limited opportunities offered by the dying economies of internal towns and villages have triggered large migration flows of rural population to Colombo and other significant towns. As a result, the form of many urban centres is losing its traditional shape and functional hierarchy to become part of continuous, over-stretched urban corridors characterized by noise, congestion, formless growth, and massive shortage of housing and infrastructure. A recent survey of the city of Colombo, for instance, suggests that 52 per cent of its night population lives in under-served, informal settlements (De Silva, 2000). This is a staggering figure given that, out of a total population of 20 million in the country, more than 4 million live in the Colombo Metropolitan Region (CMR), and well over 2 million in the Colombo District alone. By 2010, the CMR population is projected to increase up to 6.4 million, placing even more pressure on the demand for building and services in residential areas. Demand for infrastructure by both local and foreign investors within the CMR is also likely to increase in the future (UDA, 1998).

Responding to these challenges is not going to be easy. If one looks at the whole spectrum of activities carried out within the building industries of developing economies, the relationship between product supply and product demand varies highly in social efficiency. Sri Lanka is no exception. Institutional and professional responses to urbanization and population pressures have largely ignored the spatial needs of the poor, and allowed the proliferation of informal settlements as a social pressure-release mechanism. The planning and implementation of social housing and infrastructure – the supply of which was seen as a government prerogative in the immediate post-colonial period – have not risen to the challenge. Market-based commercial development, by contrast, is being strongly encouraged by the government, and facilitated through zoning, land use concessions and tax cuts. Architectural design, for its part, has been limited to few individual buildings identified mostly by high patronage or top-end tourism uses.

This paper is the first result of a thesis-in-progress that, on the basis of the type and amount of building work carried out in Sri Lanka at the moment, is considering ways to overcome the inherent misallocation of intellectual energy behind it.

2. Organizational structure of the industry: institutional networks and labour pools

The point to start is informal labour. In Sri Lanka, in fact, the formation of construction labour and the consequent transfer of knowledge across the industry occur largely through informal relationships. This is essentially so for two reasons.

The first reason is that the majority of construction work is still organized via traditional networks led by a small-scale, one-man contractor and craftsmen manager, conventionally known as the "baas". These individual contractors establish informal organizations of limited size, assemble a small workforce, and obtain contracts through social contacts which supply them with steady work. They usually rely on a few skilled workers competent in all the aspects of traditional building construction, with a larger team, or work gang, usually formed around them. The acquisition of skills takes place informally on the job, through the relationship between stable and temporary employment, thus generating a tacit working knowledge of building. Although the institutional training of construction workers has grown in recent years, its numbers still remain substantially low compared to informal training.

The second reason is that rural-urban migration has led to a progressive growth of the informal sector by generating a steady supply of unofficial workers, characterized by low capital-labour ratio, lack of job protection, dominance of self-employment, easy entry, and low productivity (Ukwatta and Boyagoda, 2000). The minimum levels of income earned by these workers contribute to entrench their social status and position in the industry: in fact, without spending access to housing and land, they become further confined to the informal sector. In Colombo, squatter residents constitute practically all the informal labour utilized in the building industry, the port and the municipality.

The informal nature of the construction sector can also be explained in light of the large prevalence of self-building activities, where a considerable part of the investment is non-monetised and reliant on sweat-equity. According to The MARGA Institute (1986), most of the semi-permanent and improvised housing in Sri Lanka is constructed through family labour and the assistance of informal groups whose members offer help to one another. Within such a process, required materials are obtained locally, and construction work can be extended over long periods according to the availability of labour and resources. In the 1980s and 1990s, this model was even promoted by government under the banner of "aided self-help programmes" as a reliable mechanism for low-cost housing. Yet the lack of support for users' access to basic resources and knowledge has resulted in the cloning of sub-standard structures all over the island.

It is not difficult to understand why, in such conditions, the evaluation of the true capacity of the construction industry in Sri Lanka has proven to be a difficult task. According to 2003 figures from the Colombo-based Institute of Construction Training and Development (ICTAD), the construction industry provides direct employment to around 300,000 people, who become more than 1,000,000 when considering the informal linkages serving the construction process. These numbers include the staff of around 2,000 ICTAD-registered building contractors, and 100 consultancy/design organizations belonging to state and private sectors. There are also approximately 200 private-sector property development entities, the majority of which, again, operate informally (Rajasiri and Dayananda, 2004). In addition, over a dozen major institutions provide assistance on construction industry issues (ICTAD, 2003). Yet, the industry's involvement in public-sector development has been minimal in recent times, especially when compared to the scale of construction work required to upgrade the battered socio-physical conditions in many parts of the country.

3. Pigeonholing labour by building markets: fragmentation of construction activity into separate production spheres

The informal nature characterising the social structure of building production in the country combines with the failure of the industry as a whole to respond appropriately to current challenges to suggest that new analytical models of the sector may be needed, not only to appreciate the structural limitations of the present situation but also to delineate adequate policy responses that could help Sri Lanka take advantage of the situation rather than becoming a victim of its own opportunities.

Workforce dynamics are likely to occupy a central place in this discussion. With regard to internal migration patterns, a model introduced by Lewis in the early 1990s foresees a one-stage process of labour transfer where, with unlimited human supply, migrant workers from low-productivity rural jobs are absorbed into high-productivity urban industrial jobs (Lewis, 1990). Other authors, on the other hand, are more inclined to envision a two-stage migration process, whereby migrants first enter the "urban traditional sector" (informal sector) due to their limited access to the "modern sector" (formal sector), and then acquire the necessary skills that will eventually enable them to graduate to the formal sector (Todaro, 1976).

Yet the research conducted for this thesis in Sri Lanka shows that both positions lack the necessary dose of realism under actual market conditions. The reason is simple: the construction industry is fragmented into almost separate spheres of production, with little connection in training, know-how and career development paths, and consequent limitations in cross-system application of technology transfer. In such a context, the advance of labour from entry-level informal workers to skilled workers does not occur as smoothly as labour scholars may have implied: construction workers tend to find themselves confined to insular activity pockets, characterized by the building markets they serve and the original social status that brought them there in the first place.

In order to arrive at making this assertion, the research employed over a dozen ideal-typical case-studies to examine the way specific building systems – concrete block-work walls, pre-cast concrete beam and column structural systems, and steel structural and roof framings – are developed and erected in Sri Lanka, depending on the building markets in which they are used. Due to space limitations, only concrete block-work will be considered in the following text.

4. The gap between ambitions and reality

To start with, the relationship between particular building markets and the skill base of their labour pool was analysed from a socio-technical viewpoint (Figure 1).

Construction workers for low-cost residential and commercial building activities in Sri Lanka are sourced predominantly from social networks characterized by the use of local materials and processes as well as manual tools, where empirical and "conventional" knowledge constitutes the basis for action and decision-making, and where informal labour structures are built around "self-builders" or small-scale contractors (baas).

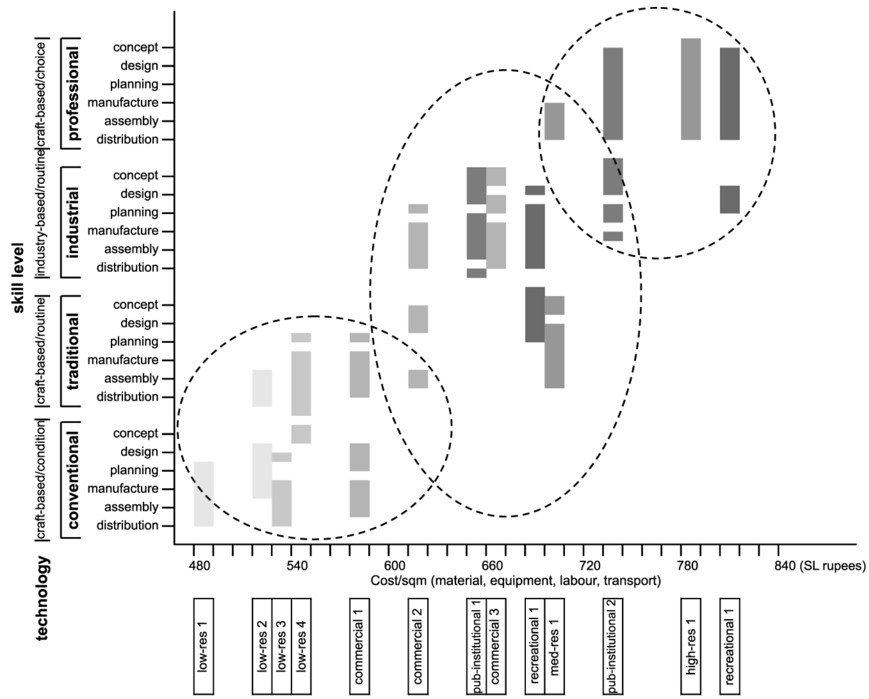

Figure 1.
Application of block work: socio-technical economics

The limited level of building know-how available to such construction activities has a direct bearing on the formal, environmental and mechanical performances of the finished products. For example, the formation of roughened surfaces and irregular edges in concrete blocks due to errors in manufacture, assembly and handling are common to most block-work walls built in low-skilled construction sites. High porosity of blocks as a result of irregularities in the concrete mixture and curing process is also commonplace, thus creating failure chains in water proofing and thermal insulation. The mortar joints between blocks often appear ragged, untidy and irregular, and most walls have stained surfaces due to droppings of mortar and bad weathering. Moisture penetration through shoddily built joints is a major concern, while structural failure due to the use of sub-standard blocks is also common.

For most large-scale commercial and industrial buildings, however, industry-based routine processes provide the basis for construction know-how and labour organization. Work in such building markets is often carried out by ICTAD-registered commercial builders or construction companies, supported by a pool of skilled/semi-skilled masons and plasterers. Block-work modules are mostly factory-produced by large-scale manufacturers, using skilled block-makers at their plants. There is a reasonable emphasis here on the use of proper block-laying techniques, although routine production protocols can also give rise to inflexible, and thus potentially compromised, technical solutions. Exposed block-work, for example, is rarely used for higher-end commercial buildings in Sri Lanka; plastering of walls is generally considered essential to cover shoddy junctions and ragged joints.

In buildings of high patronage such as resort hotels, museums or high-end residences, the involvement of design professionals and the set up of a highly craft-based socio-technical framework is deemed necessary, thus implicitly generating a demand for highly honed labour skills and efficient planning of work at the site. Since the architectural ethos informing most of this work finds its inspiration in a picturesque paradigm defined and achieved through high craftsmanship, the lack of precision that characterises building artefacts in low-skilled labour environments is aggressively rejected. Common techniques employed in these more "cultivated" markets include the laying of blocks to different compositional strategies, forms and bonding patterns, and the use of custom-designed block-work that requires special instructions both at the factory and on site. The employment of skilled masons, plasterers and carpenters is seen as both natural and essential to carry out such jobs, thus depriving entry-level informal labour the opportunity to be contracted for higher-end work even as apprentices.

As Figure 1 shows, when construction activity takes place within areas with such dramatic differences in capital expenditure ability, access to materials and systems, and standards of use, technology itself gives rise to separate socio-technical pockets. This make it difficult for the workforce employed within each pocket – particularly the lower ones – to move across boundaries, learn from others, and improve their technical and economic status.

5. From technology to "sensitive" technology: consequences of industrial compartmentalization

After looking at product characteristics as a result of labour skills and material resources, the analysis focused on the socio-cultural definition of acceptable (or expectable) building parameters. In Figure 2, particular technological decisions taken by various parties involved in the construction processes observed – e.g. self-builders, commercial builders, funding agencies, planning and building regulators, design professionals, social activists, etc. – are associated to a set of measurable factors, or "values", which define the complex of surrounding circumstances, conditions or influences in which a person lives or operates. These factors are collectively identified as "environmental parameters", and organized in the diagram under six sub-headings: cost, space, environmental protection, comfort, life-cycle performance, and ecological behaviour.

For the actors performing in the lower-end markets, the parameters related to cost of production – such as quantity, availability and supply of materials and labour, or easy constructability of chosen building systems – seem to be the most crucial and achievable at the same time. The actors involved in the process have neither the economic capacity nor the technical knowledge to respond to higher aesthetic and environmental product concerns. In other words, the environmental parameters pertaining to cost and constructability define the technological framework within which builders, users and facilitators of low-end residential and public projects operate. Even more so, these parameters form a combination of semi-independent constrains that define the real choice available to decision-making subjects in that particular building process. Groak (1990) calls the result of this combination the "feasible set of available technological decisions" of a given building program, and argues that attempts to stretch this boundary will result in "sensitive" technological applications that may lead to building failures. For example, the construction of commercial and

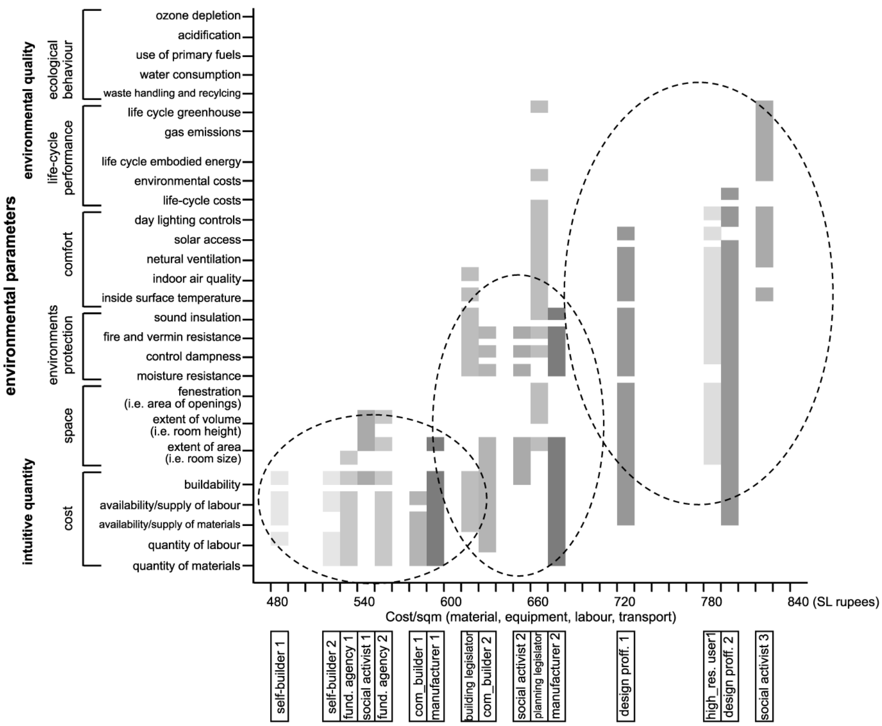

Figure 2.
Application of block work: socio-cultural economics

institutional buildings in Sri Lanka requires the provision of determinate levels of fire and sound resistance to comply with the occupational health and safety parameters set up by planning and building authorities. Due to lack of knowledge, skill and capacity, the lower-end building markets do not adhere to such regulations, thus exposing their buildings to potential failures. On the other hand, attempts to stretch their "feasible set" to accommodate such concerns may result in failures elsewhere – i.e. lack of funds to spend on a proper waterproofing mechanism due to the different allocation of a very tight budget.

By contrast, larger "feasible sets" are available for building markets with higher spending capacity and cultural ambitions. High-end commercial buildings, for example, have both the capacity and the need to facilitate proper response to regulatory requirements such as fire and sound resistance. Yet, concerns for life-cycle embodied energy in buildings, or for their impact to the ecological footprint, are not embraced by commercial builders and manufacturers.

What happens, in other words, is that the stated objectives of construction activity, be they physical, commercial or cultural, differ greatly according to the market. It is therefore unlikely that the knowledge required to respond to those objectives is produced outside the market where it is needed. Attempts to import the objectives without importing the work structure or the resources, then, may result in sub-standard results or relative failures.

The industrial compartmentalization of labour can be further understood in relation to the production systems in use amongst building component suppliers. As explained in

Figure 3, concrete block-work wall production in Sri Lanka spans different industrial models. If one adopted Winch's taxonomy of production systems (Winch, 2003), the supply of block-work walls for low-end construction (in both residential and commercial buildings) is generally organized under "make to order" or "assemble to order" provisions, where pre-configured systems or sub-assemblies end up being used almost as raw (and thus imperfect) materials, with the understanding that they will be inevitably altered to adapt to the "feasible set" of technological options. In other words, the "order" for a standard exposed block-work wall system already allows for construction irregularities that come from both the manufacturing and the application context. The inevitability of formal and mechanical errors is almost accepted as part of it.

For construction activities based on routine re-production – i.e. commercial, institutional and industrial projects – off-the-shelf procurement is more widely used. Building components are produced for stock and sold after or during manufacture; the final product is always a reasonably well-built, plastered block-work wall.

High-end architectural creations for cultural programs, on the other hand, depend mostly on a supply chain where the client's involvement from early conceptual and design stages appears to be essential. In such a 'designed to order' process, significant design work – for example the laying of blocks to a particular pattern, or the manipulation of wall texture through the exposure of aggregates or particular pigmentation – is required even to conceptualise the basic product.

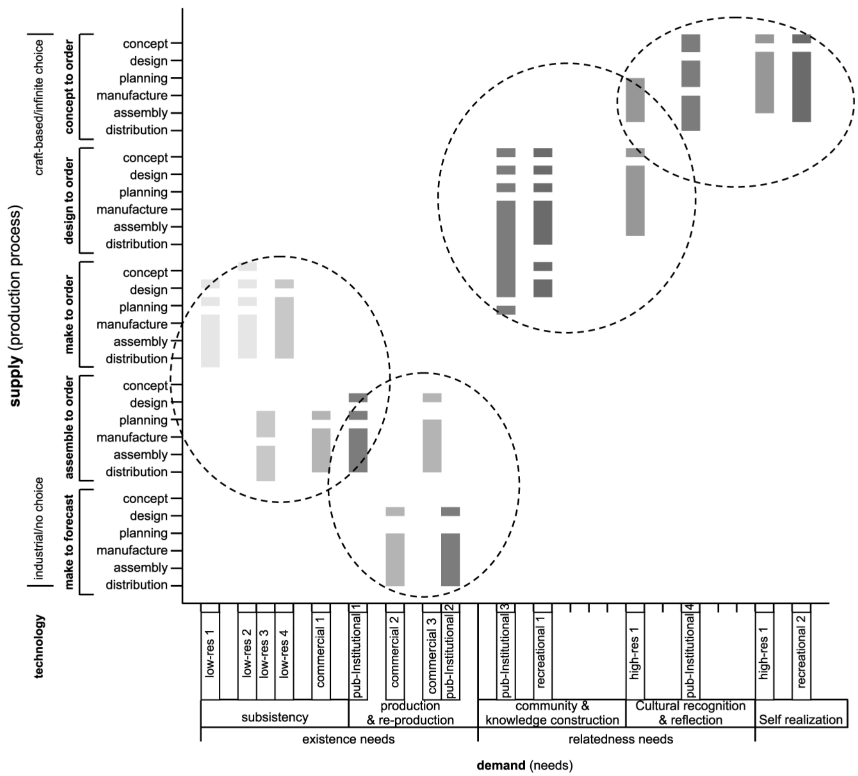

Figure 3.
Application of block work: demand-supply behaviour

6. Planning for controllable failure

Succinct tough it has to be, the description highlights the contradictions that pervade construction activity in socio-economic environments such as Sri Lanka's, with a large portion of the workforce employed in the sector officially unaccounted for and yet central to the operations, and ultimately the outcome, of many of its sub-markets. The technical review undertaken of different projects depicts an industrial landscape, even at building system and component level, characterized by highly diverse demands, labour skills, achievable objectives, and conception-and-implementation horizons, which is structured and functions essentially as a series of separate socio-technical environments. The more internally efficient (or optimised) each of these environments becomes in terms of product definition and delivery, the less permeable its boundaries will turn out to be for the productive passage of labour force from other environments, particularly lower-end ones. This may not be critical to the ultimate realization of building structures (although it can lead to both better and worse construction results depending on actors' understanding of the requirements); but it is certainly critical to the building of technical capacity and, ultimately, the existence of social development paths.

The theoretical conclusion arrived at in the thesis, and currently under investigation through a series of pilot projects, is that the integration of technological development and broad socio-economic growth can be facilitated by "open" (or "incremental") industrial design strategies: rather than planning for design solutions and structures of production perfectly self-contained in their limitations and potential, from emergency shelter-relief work to sophisticated iconic hotels, it would be advisable to recognize that technological contamination and compromise can increase the rate of participation of the labour force to their own progressive training. What is proposed, in other words, is the definition of a broad technological framework at industry level that is both flexible and adaptable, and can therefore be used to expand the options available within any given project, helping the latter perform as training grounds.

Using building projects as training opportunities without losing productivity, however, means that the technologies employed must have latitude for errors and non-optimal application ? i.e. they must be inherently "robust" as opposed to precise and therefore more "sensitive". In practical terms, this objective translates in the definition of technical options that can tolerate changes in the economic variables of projects on the one hand, and manage the intricacy of buildings' cultural and technical attributes on the other. A framework, that is, which can adapt to the level of complexity required and the level of expenditure possible in a project without penalizing the expected performance of the building, neither culturally nor technologically.

There are examples of the type of intellectual and technical robustness argued for above in the work of several Modern Architecture masters, who defined design and technological languages able to travel and develop consistently across markets to facilitate diverse spatial and cultural needs. Le Corbusier, for instance, designed the Maisons Jaoul in Paris in 1955 – possibly one of the most expensive small residential projects in France at that time – and then developed social housing structures in Chandigarh, India, a project built with much sweat-equity, without compromising his architectural ethos or the relative result. Eladio Dieste's church in Atlantida, made of reinforced concrete and post-tensioned brick tiles is the most renowned building in Uruguay, but his municipal bus terminal in Salto and the sheds for Massaro Agro-industries in Canelones use analogous solutions and are equally poetic and glorious. The India International Centre in New Delhi, designed by Joseph Allen Stein, has a monumental effect achieved by the unity of form and material. Yet, Stein's industrial structures for a bicycle manufacturing plant in Kerala have similar quality and character, but in a different sense of materiality as allowed by the limitations of its financial and cultural program.

7. In lieu of conclusions: the elements of a robust paradigm

Yet the construction of a pervasive robust framework cannot rely on the work of isolated masters taking advantage of discrete opportunities; rather, it has to be developed more "generically" from the bottom up, by looking at the industrial base of region and defining a design and technological vocabulary that feeds off the analysis of place-specific conditions and limitations. Within this perspective, the architecture of a robust framework must incorporate, normatively, a series of performance parameters. Operating "robustly" requires:

- *The ability to save money and time.* Scarce, expensive and labour-intensive materials and processes should be avoided, thus making the components and subsystems cost-effective compared to other systems available in the market. Clarity of design and the performance of technological systems should not depend on excessive craftsmanship so that flexible and economic use of labour across building markets can be achieved. A flexible programming of building process should be implemented to facilitate different demands of production, while easy-to-erect connection techniques and modular design for easy handling should be preferable engineering options to allow faster erection and use of cross-market labour.
- *The ability to allow greater flexibility in production, assembly and use.* Components and subsystems should be scalable, and subject to be coupled/decoupled as required to accommodate specific design and technological performances. Having the capacity for demountability, disassembly and reuse will allow systems to be used for different production requirements. Systems and subsystems should be also designed in such a way that discrete unit processes can be replaced with upgraded and enhanced technology as it becomes available through transfer from higher sectors.
- *The ability to provide high tolerance for human errors of design, manufacture, assembly or use.* To allow easy transfer across markets, resolution of a problem should be achieved via logic of construction and clarity of erection, without the need for care and precision in the making. When joining sub-systems together, different junctions should be allowed to accommodate diverse labour conditions. Strategies must be in place to prevent the failure of one module or element of a system from triggering a chain of failures.
- *The ability to allow greater adaptability to social circumstances.* Different permutations of products and processes need to be established, so as to give rise to different but equally valid solutions in terms of functional and social make-up of technical objects. Balancing of resources in the construction industry should be allowed, particularly by allowing users to take advantage of other users' investment in production, labour, land and machinery, thus optimizing factors' productivity. The capacity for disassembly and reconfiguration in components and subsystems should be supported, so that the same technology can respond to the changing needs of its users as well as to changing users across building markets.
- *The ability to build workforce capacity.* By implementing a mix of labour-intensive and capital-intensive processes for building production, less skilled labour can be

used through limited training and modular breakdown of activities. Labour productivity should be increased by enforcing better health and safety standards, and by diminishing the extent of job casualization, fragmentation and traditional skill demarcations in the industry. The gap between operative and professional/technical skills (or informal/formal) should be reduced by translating explicit knowledge into tacit knowledge, and vice versa.

- *The ability to establish organic links.* Finally, organic cross-industry links, naturally connecting or acknowledging all participating actors, must be in place to facilitate easier transfer of knowledge across the construction sector.

References

De Silva, W.I. (2000), *Population Change and Environmental Degradation in Sri Lanka. Demography of Sri Lanka: Issues and Challenges*, Department of Demography, University of Colombo, Colombo.

Groak, S. (1990), "The decline of robust technologies in the building industry", *Building Research and Practice*, No. 3.

ICTAD (2003), *Bulletin of Construction Statistics*, Institute of Construction Training and Development, Colombo.

IPS (2005), *Sri Lanka: State of the Economy*, Institute of Policy Studies, Colombo.

Lewis, W.A. (1990), "Economic development with unlimited supplies of labour", in Agrawala, A.N. and Singh, S.P. (Eds), *The Economics of Underdevelopment. A Series of Articles and Papers*, Oxford University Press, Delhi.

(The) MARGA Institute (1986), *Institute Housing Development in Sri Lanka*, Tisara Press, Colombo.

Pathirana, H. (2002), *Refugees and Homelessness: Analytical Focus on the Settlement Villages. Built-Environment, Sri Lanka*, Board of Architectural Publications. SLIA, Colombo.

Rajasiri, K.P.W. and Dayananda, M. (2004), "Sri Lanka Country Report 2002/2003", paper presented at the 9th Asiaconstruct Conference, Sydney.

TAFREN (2005), *TAFREN Post-Tsunami Recovery and Reconstruction Strategy. District Wise Post-Tsunami Rehabilitation and Reconstruction Projects*, TAFREN, Colombo.

Todaro, M.P. (1976), *Internal Migration in Developing Countries: A Review of Theory, Evidence, Methodology and Research Priorities*, International Labour Office, Geneva.

UDA (1998), *Colombo Metropolitan Regional Structure Plan*, Vol. 1, Urban Development Authority, Colombo.

Ukwatta, S. and Boyagoda, K. (2000), "Migration and urbanization in Sri Lanka", *Sri Lanka Journal of Population Studies*, Vol. 3, pp. 67-83.

Winch, G.M. (2003), "Models of manufacturing and the construction process: the genesis of re-engineering construction", *Building Research & Information*, Vol. 31 No. 2.

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The role of knowledge management in post-disaster housing reconstruction

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Abstract

Purpose – A disaster is a serious disruption for the operation of a society, causing extensive life and property losses. Since construction activities are highly knowledge-intensive, knowledge management (KM) practices will encourage continuous improvement, distribute best practices, quick response to beneficiaries, share valuable tacit knowledge, reduce rework, improve competitiveness and innovations, and reduce complexities in post-disaster housing reconstruction. Therefore, this research aims to study and explore the degree to which KM is involved in post-disaster housing reconstruction and the effect that KM has on post-disaster housing reconstruction in the Sri Lankan context.

Design/methodology/approach – The study was conducted by systematically reviewing the literature in Knowledge and KM to highlight the basic principles. Data collection mode for the study was close-end questionnaires and semi-structured interviews. Data were collected from donor and consultancy organisations which are involved in post-disaster housing reconstruction in Sri Lanka.

Findings – The results show that most of the donors and consultancy organisations carry out permanent disaster housing reconstruction for tsunami devastation. Further, the study reveals that organisations use competences and repositories as the main sources of knowledge internal and external to the organisation. Project reviews, task teams, face-to-face interactions, and electronic mail systems were greatly used to support KM. Even though the performance of the work was improved through KM, lack of compiling and synthesizing the accumulated data, information and knowledge, storing and organizing would be the main challenge faced by these organisations.

Practical implications – It is evident that a more concerted and formal approach will improve disaster housing reconstruction. Since knowledge gatekeepers have extensive tacit and explicit knowledge, the organisations have to use it as a significant source. Even though the majority of the donors and consulting organisations used competencies and repositories as main sources of K, the identification and exploitation of a variety of appropriate sources are of central importance. Further, organisations have to focus more on a variety of IT tools in order to store Knowledge for future use. Since there were challenges for KM, the organisations have to identify proper solutions in order to move towards and achieve the benefits of KM. Finally, the organisations have to provide an appropriate rewards system to encourage their employees in participating in KM.

Originality value – The disaster housing reconstruction will not end on a certain point and it will be a continuous process. Formal KM systems will help to improve the present state and further provide proper Knowledge in the future. There should be a standardised practice in order to improve the performance and give good value for beneficiaries. The study makes it quite evident that proper KM will improve the status of post-disaster housing reconstruction.

Keywords Knowledge management, Natural disasters, Sri Lanka, Construction works, Housing

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1. Background

1.1 An overview of disaster

A disaster is a serious disruption of the functioning of a society, causing widespread human, material, or environmental losses, which exceed the ability of affected society to copy using only its own resources (Disaster Management Centre of Sri Lanka (DMC), 2007). Disasters can be classified as sudden or slow (according to onset speed), or natural or man-made (according to cause). Disasters are often named by the hazards that cause them (Abrahams, 2001). A disaster occurs when the hazards impact badly upon a community, which is susceptible to that hazard. There are several hazards like floods, tsunami, tropical storms, landslides, drought, high wind, rock falling, etc. affect Sri Lanka from time to time.

Natural disasters attack the poor at three levels: they interrupt income, reduce personal assets, and destroy essential public infrastructure (World Bank, 2000a cited Jha, 2005). The World Bank estimates that losses due to natural disasters are 20 times greater (as a percentage of GDP) in developing countries than in the industrialized nations (Ofori, 2002). According to National Construction Association of Sri Lanka (National Construction Association of Sri Lanka, 2005), a joint study by donors in January 2005, damaged over a US$ 1 billion worth of infrastructure (about 4.5 percent of GDP), but the replacement costs were estimated to be between US$ 1.5 billion to US$ 1.6 billion (7.5 percent of GDP). Further, Ofori (2002) states that disasters have a greater impact on the built environment of developing countries than industrialized ones.

1.2 Post-disaster housing reconstruction

Reconstruction means the action of constructing new buildings to replace buildings, which have suffered damage, or repair of damaged buildings (UN, 2006 cited Malalgoda, 2006). Reconstruction stage develops after the rehabilitation stage and aims to provide proper permanent housing for the victims in a short period of time (Limoncu and Çelebioğlu, 2006). The stakeholders of post disaster projects are the government, donors, lending agencies, beneficiaries, contactor, and social, environment and religious groups.

Whilst relying on routine processes proved adequate in many ways for these small-scale disasters, a higher level of coordination and management would be needed for programmes of reconstruction following a larger disaster (Rotimi *et al.*, 2006). Further, Gunasekera (2005) added that all the phases and activates of a project done under normal conditions have to be done when managing projects after a disaster and all phases and activities need to balance with the time factor. Most of the time, this is done at a cost, because there is a minimum quality level and scope requirement that each project has to achieve (Gunasekera, 2005).

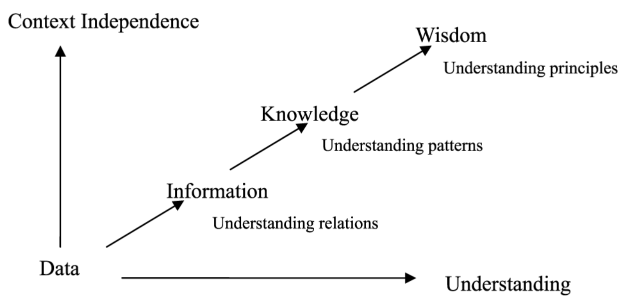
As per Barenstein and Pittet (2007), one of the most visible consequences of many disasters is the widespread devastation of houses. Quarantelli (1995 cited Johnson *et al.*, 2006) proposed four stages of housing in the recovery process such as immediate relief (within hours), immediate shelter (within day or two), temporary housing (preferably within weeks), and permanent housing reconstruction (probably within few years).

Post-disaster housing reconstruction is considered by many experts as one of the least successful sectors in terms of implementation (Barenstein and Pittet, 2007). Further, a lack of effective information and knowledge dissemination can be identified as one of the major reasons behind the unsatisfactory performance levels of current disaster management practices (Haigh *et al.*, 2006). According to Banerjee (2005) (cited Haigh *et al.*, 2006), a lack of prior knowledge and proper point of reference have made most of the recovery plans guessing games, eventually failing without adding appropriate values to the recovery attempts. Therefore, applicable external knowledge support based on actual recovery processes can play a crucial role in promoting post disaster recovery (International Recovery Platform (IRP), 2005). However, in case of the Sri Lankan construction industry, there has not yet been any appropriate research done in this area. Thus, little is known about how knowledge is managed in Sri Lankan post disaster reconstruction works.

2. Knowledge hierarchy

2.1 Data, information, knowledge

A common theme in the KM literature is that data is combined to create information, and information is combined to create knowledge (Hicks *et al.*, 2006). Information is data that has been interpreted, verbalized, translated, or transformed to reveal the underlying meaning and context (King, 2005). For example, when a disaster occurs, different types of information might come from different sources, such as the disaster field, remote sensors, public information centres, and the World Wide Web (Zhang *et al.*, 2002). Knowledge can be defined as a dynamic human process of justifying personal belief toward the "truth" (i.e. a justified true belief) (Nonaka and Takeuchi, 1995 cited Carrillo *et al.*, 2000). According to Siemieniuch and Sinclair (1999) (cited Carrillo *et al.*, 2000, various classification of knowledge include: formal (explicit) and tacit (expertise) knowledge; foreground and background knowledge; classifications with respect to the role of knowledge for business relevance (e.g. knowledge of business environments), or with respect to the functional roles within an organisation (e.g. knowledge for control activities). One of the most practical distinctions is that between tacit and explicit knowledge (Nonaka and Takeuchi, 1995 cited Robinson *et al.*, 2004). As per King (2005), tacit knowledge is the personal knowledge resident within the mind, behaviour and perceptions of individual members of the organization. On the other hand, explicit Knowledge is the formal, recorded, or systematic K that can easily be accessed, transmitted, or stored in computer files or hard copy (King, 2005). Knowledge sources, in this context, mean the "reservoirs of knowledge", which a knowledge-worker has to fall back on in fulfilling his/her responsibilities (Egbu *et al.*, 2003). As per Egbu *et al.* (2003) there are two main categories of knowledge sources, i.e. sources internal to the organisation (other individuals, team(s), routines, competences, and repositories) and sources external to the organisation (other individuals, communities of Practice, other networks, repositories, and knowledge gate-keepers) (see Figure 1).



Source: Gene Bellinger (cited in Leng (2005))

Figure 1.
The relationship for data, information, knowledge and wisdom

2.2 Knowledge Management (KM)

Knowledge Management: the systematic strategy to collect; store; and retrieve knowledge, and then help distribute the information and knowledge to those who need it in a timely manner (King, 2005). However, the KM has not only limited to human centered asset but also extended to intellectual assert. While some definitions specify the management of intellectual assets, it also spells out the benefits of KM. However, the parameters to be managed, has been fairly addressed by some academics like Huber (1991) (cited Kululanga and McCaffer, 2001), King (2005), and Robinson *et al.* (2005).

Organizations who are successful in leveraging knowledge, normally witness increased efficiencies in operations, higher rates of successful innovations, increased levels of customer service, and an ability to have foresight on trends and patterns emerging in the marketplace Desouza and Awazu, 2006). The lack of common knowledge has been known to impede the flow of knowledge, resulting in failures to stimulate innovation and creativity in the organization (Simonin, 1999; Szulanski 1997 cited Desouza and Awazu, 2006).

2.3 Knowledge Management (KM) sub-processes

The KM sub-process has been identified as locating and accessing, capturing and storing, representing, sharing, and creating (Egbu *et al.*, 2003). Knowledge acquisition is the process that involves imbibing information including making meaning of situations and other stimuli from the internal and external business environment Kululanga and McCaffer, 2001). Nonaka and Takeuchi defined knowledge production as a continuous, social process, which is a never-ending spiral of tacit and explicit knowledge through knowledge conversion, socialization, externalisation, combination and internalization (SECI) (Sverlinger, 2000 cited Egbu *et al.*, 2003). This is quite true when it comes to post disaster housing reconstruction, where the participants have to act according to the situation, which will have the above triggers and leads to knowledge production. According to Kululanga and McCaffer (2001), knowledge sharing encompasses thinking, speaking and perceiving and is not merely "transferring" knowledge and such a process is called "creative sharing". National Disaster Management Division (National Disaster Management Division, 2005) suggests that in order to enhance the information sharing and management of the knowledge generated in these institutions, it is highly essential to closely knit the organizations and moreover people. Storage of knowledge involves the keeping of intellectual assets in a form that promotes its preservation, retrieval and- utilization (Walsh and Ungson, 1991; Miyashiro, 1996 cited Kululanga and McCaffer, 2001). Knowledge transfer can be defined as a sub-process of KM that occurs when two or more individuals exchange information, in order to move towards each other (or apart) in the meaning they ascribe to certain events (Argote and Ingram, 2000).

2.4 Knowledge management tools

Anumba *et al.* (2005) distinguishes between KM tools, the terms "KM techniques" and "KM technologies" are used to represent "non- IT tools" and "IT tools" respectively (Table I).

2.5 Knowledge management in post-disaster housing reconstruction

KM initiative has been thoughtfully envisaged as a tool to store, retrieve, disseminate and manage information related to disaster management (National Disaster Management Division (2005). Furthermore, Johnson *et al.* (2004) states that organisations, such as governments in continuously disaster prone countries needs the ability to act as learning organisations and channels of information as well; however they do not seem to take advantage of this opportunity. The value of KM is that it provides senior management with a rationale to support the creation and maintenance of repositories of project histories (Maqsood *et al.*, 2006). In order to improve housing reconstruction projects we need to look back at past experiences, which the processes that created them. The demand for efficient KM to help the agencies make post disaster housing widely recognized.

3. Research methodology

Since the most of the objectives of this study was to identify and explore several parameters related to KM, "what" type of question was more suitable for the study and therefore, the structured questionnaire survey was carried out. A total of 75 randomly selected sample of 45 donors and 30 consultancy firms were used for questionnaire survey. Semi-structured interviews were done to identify the KM sub processes involved in post disaster housing reconstruction. In total, 12 semi-structured interviews, six from donors and six from consultancy organisations, were done to achieve the above objective. While the relative importance index (RII) was being used as an analysis technique for questionnaire survey, the semi-structured interviews were analysed using data matrix.

4. Research findings

The total number of targeted respondents for the research was 75 organisations consisting of 45 donor organisations and 30 consultancy organisations. The total response rate was around 74.67 per cent. The largest respondents were from donor organisation constituting 53.57 per cent of the total respondents, whereas the other 46.43 per cent of the respondents were from the consultancy organisations.

Post-disaster housing reconstructions were done in Sri Lanka for several disasters such as draught, rock falls, tropical storms, fires, landslides, high wind, floods and tsunami. However, according to survey, it was found that in Sri Lanka, most of the post disaster housings were done for the tsunami (Figure 2) through donors and construction consultancy organisations. According to Figure 3, majority of the

Table I.
A comparison between KM techniques and technologies

KM techniques	KM technologies
Require strategies for learning	Require IT infrastructure
More involvement of people	Require IT skills
Affordable to most organisations	Expensive to acquire/maintain
Easy to implement and maintain	Sophisticated implementation/maintenance
More focus on tacit knowledge	More focus on explicit knowledge

Source: Anumba *et al.* (2005)

respondents (100 per cent) stated that they were involved in permanent housing reconstruction. However, these figures were only relevant to the donor organisations and construction consultancy organisations, who were involved in post disaster housing reconstruction.

In this study, the sources of knowledge were categorised as internal to the organisation and external to the organisation. The list below indicates the list of sources of knowledge internal to the organisation in descending order of "usefulness" as perceived by the respondents.

Knowledge sources – internal to the organisation in descending order of use:

- competences;
- lessons learned;
- repositories;
- team(s);
- other individuals; and
- routines.

Further, Figure 4 illustrates the repositories used internal to the organisation. Majority of the respondents responded that they have used project-monitoring documents (87.50 per cent) more often than other repositories. Reports (82.14 per cent) were the second mostly used repositories.

Further, the list below suggests that the most significant external source of knowledge related to post disaster housing reconstruction in Sri Lanka was repositories. Moreover, the knowledge gatekeepers were the least significant external knowledge source.

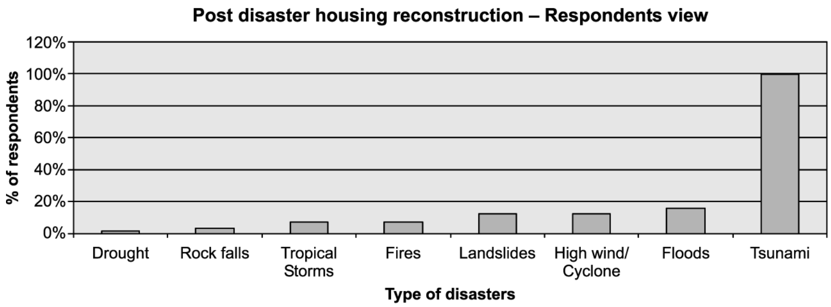


Figure 2.
Post-disaster-housing reconstruction

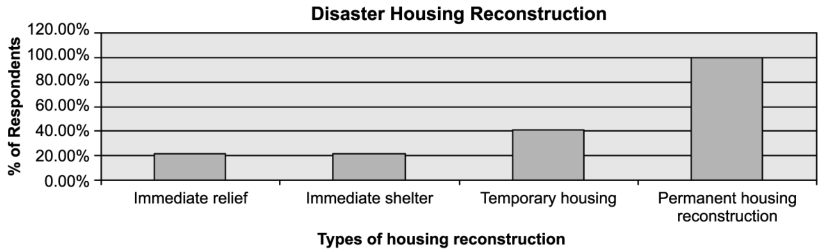


Figure 3.
Types of post-disaster-housing reconstruction

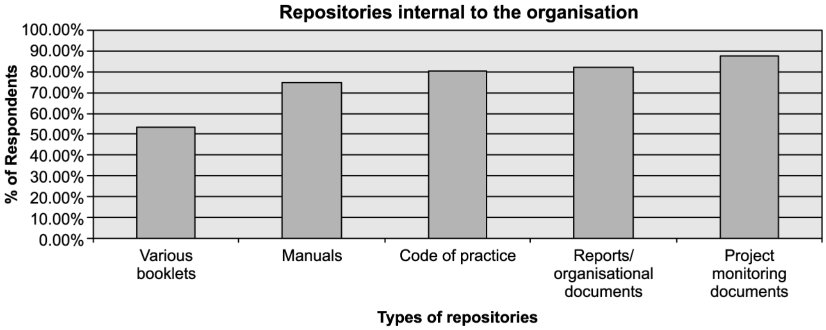


Figure 4.
Repositories – internal to the organisation

Knowledge sources – external to the organisation in descending order of use:

- repositories;
- communities of practice;
- other individuals;
- other networks; and
- knowledge gate-keepers.

The list below stipulates that the e-mail system was the high-useful KM technology used in post-disaster housing reconstruction by donors and consultants. Next significant tool was the costing and cost management system.

KM technologies: IT-based tools in descending order of usage:

(1) E-mail system.
(2) Costing and cost management system.
(3) Document management system.
(4) The central project file.
(5) Intranet.
(6) Knowledge bases.
(7) On-line project management.
(8) Data and text mining.
(9) Skills Yellow Page.
(10) Groupware.
(11) Technical call centre.
(12) Web-based application.
(13) Taxonomy/ontology.
(14) Online procurement system.
(15) Extranet.
(16) Online KM system.

According to the list below, the face-to-face interactions, task teams, and project reviews were the most significant non-IT based tools in post disaster housing reconstruction.

KM techniques: non-IT-based tools in descending order of usage:

(1) Project reviews.
(2) Task teams.
(3) Face-to-face interactions.
(4) Formal meetings.
(5) Brainstorming.
(6) Site liaison initiative.
(7) Quality circle.
(8) Recruitment.
(9) Seminars.
(10) Training.
(11) Communities of practice.
(12) Focused group sessions.
(13) Knowledge gatekeepers.
(14) Apprenticeship.
(15) Share fair.

While lack of compiling and synthesizing the accumulated data, information and knowledge, storing and organizing was the most significant challenge, conflicting priorities between KM and other business functions was the least significant challenge to KM in post disaster housing reconstruction (see list below).

Challenges to KM: challenges to KM in descending order:

(1) Lack of compiling and synthesizing the accumulated data, information and knowledge, storing and organizing.
(2) Lack of systematic collection of standardized data.
(3) Lack of documentation of knowledge and application of lessons learned and best practices for decision-making.
(4) No validation mechanism.
(5) Lack of measure to value the performance of knowledge assets.
(6) Unstructured KM approach.
(7) Overload of information in the form of reporting.
(8) Changing people's behaviour.
(9) What knowledge should be managed.
(10) Organisational culture.
(11) The difficulties associated with communicating the benefits of KM.
(12) Poor IT infrastructure.
(13) Bureaucracy associated with KM.

(14) People's fears.
(15) Conflicting priorities between KM and other business functions.
(16) Change management.
(17) Employee resistance.
(18) Lack of top management support.

Improved performance was the key benefit that the respondents got through KM and the other benefits like effective monitoring of initiatives, efficiently and effectively use available resources were some of the highly rated benefits among respondents (see list below).

Benefits of KM: benefits of KM in descending order:

(1) 1. Improved performance.
(2) 2. Effective monitoring of initiatives.
(3) 3. Efficiently and effectively use available resources.
(4) 4. Improved decision-making.
(5) 5. Improved reconstruction project delivery.
(6) 6. Improve effective acquisition, sharing and usage of information within organisations.
(7) 7. Reliable, useful, up-to-date and timely knowledge can be created and shared.
(8) 8. Can avoid repeating past mistakes.
(9) 9. Better valuation of Resources and services.
(10) 10. Respond very quickly to client's needs and external factors.
(11) Innovation.
(12) Organisation can retain tacit knowledge.
(13) Dissemination of best practice.
(14) Increased intellectual capital.
(15) Risk minimization.
(16) Lower cost in managing the projects.
(17) Promoting fair practices among the disaster management community.
(18) Creates competitive advantage.
(19) Increase profit, market share, market size and reduce cost.

Most of the KM sub-processes were practiced by the donors and consultancy organisations, but in an informal way. The respondents believed that the knowledge capturing is important to function effectively, work quicker, plan better, reduce cost, give good out put to beneficiaries, get more resources (attract new donors), carry out future disaster reconstruction, give good solution, learn from, and have a win-win situation. Further, the importance of knowledge creation or production was to improve performance, motivate staff, increase organisational asset, etc. While knowledge sharing was vital in order to grow knowledge; get best decisions; avoid duplication; save time and energy; share correct and timely knowledge; improve relationships, the knowledge storing was essential to get accurate information future; reduce cost; justify and accountable to donors and communities; and to show transparency. Moreover, the significance of knowledge transferring was to learn more, increase effectiveness and efficiency of the work force, reduce cost, change the quality of construction, capacity building for local technical people, get timely advice, and disseminate knowledge.

5. Conclusions

This research has investigated the concept of KM in the post disaster housing reconstruction in Sri Lanka. Mostly, the construction industry is relied on expertise of key members of staff. KM can be used as a tool to store, retrieve, disseminate, and manage information related to post disaster-housing reconstruction. It can be concluded that the most of the donors and consultancy firms, who do housing reconstruction, have got involved in tsunami housing reconstruction work compared to other disasters. Further, the respondents were mostly determined on permanent housing reconstruction rather than other types of disaster housings. While competence was the most significant internal knowledge source to the organisation, repositories were the most significant external knowledge source to the organisation. Analysis of the sample revealed that project-monitoring document was the highly used repository internal to the organisation.

While the e-mail system was used predominantly as IT based tool for KM, the project reviews; task teams; and face-to-face interactions were the most significant non-IT based tool for KM. This was further supported by the semi-structured interviews. The findings suggest that lack of compiling and synthesizing the accumulated data, information and knowledge, storing and organizing was the major challenge in managing the knowledge faced by the donors and consultants who do post disaster housing. This may be due to the sense of urgency shown by the parties. The improved performance was viewed as the key benefit of KM in post disaster housing reconstruction.

The KM sub-processes are important in order to avoid duplication of knowledge creation, store knowledge on local technical people, carry out future disaster reconstruction, change the quality of construction, disseminate knowledge, grow knowledge, get best decisions, get more resources (e.g. attract new donors), give good output to beneficiaries, improve performance, improve relationships, increase organisation asset, plan better, reduce cost by avoiding repetitive tasks, save time and energy etc.

Even though the study presents most of the elements of KM, most of the organisations have not implemented KM formally into post disaster housing reconstruction. Although, it can be concluded that the awareness of KM is there in the industry to implement KM in post disaster housing reconstruction to improve the performance. During the course of research, the researcher came across some interesting research opportunities. They are, study the same research question with additional unit of analysis, i.e. with donor, owner, consulting, and contracting organisations, study the each KM sub processes individually to deeper scope with regard to disaster reconstruction, study the role of KM in disaster management, and studying the procurement arrangement in post disaster housing reconstruction.

References

Abrahams, J. (2001), "Disaster management in Australia. The national emergency management system", *Emergency Medicine*, Vol. 13, pp. 165-73.

Anumba, C.J., Egbu, C. and Carrillo, P. (2005), *Knowledge Management in Construction*, Blackwell Publishing Ltd, Oxford.

Argote, L. and Ingram, P. (2000), "Knowledge transfer: a basis for competitive advantage in firms", *Organisational Behaviour and Human Decision Processes*, Vol. 82 No. 1, pp. 150-67.

Barenstein, J.D. and Pittet, D. (2007), "Post-disaster housing reconstruction. Current trends and sustainable alternatives for tsunami-affected communities in coastal Tamil Nadu", available at: http://idm.epfl.ch/covalentes/pdf/PointSud27.pdf (accessed 25 May 2007).

Carrillo, P.M., Anumba, C.J. and Kamara, J.M. (2000), "Knowledge management strategy for construction: key IT and contextual issues", available at: http://itc.scix.net/paper w78-2000-155.content (accessed 10 March 2007).

Desouza, K.C. and Awazu, Y. (2006), "Knowledge management at SMEs: five peculiarities", *Journal of Knowledge Management*, Vol. 10 No. 1, pp. 32-43.

Disaster Management Centre of Sri Lanka (DMC) (2007), *About Disasters*, available at: www.dmc.gov.lk/About_%20Disasters.html (accessed 14 March 2007).

Egbu, C., Quintas, P., Anumba, C., Kurul, E., Hutchinson, V. and Ruikar, K. (2003), *Knowledge Production Resources and Capabilities in the Construction Industry – Work Package 1 – Final Report*, available at: www.knowledgemanagement.uk.net (accessed 8 February2007).

Gunasekera, P.M. (2005), *Professional Management Handbook Series Managing Projects*, Academy of Management Science, Colombo.

Haigh, R., Amaratunga, D. and Kerimanginaye, K. (2006), "An exploration of the construction industry's role in disaster preparedness, response and recovery", in Sivyer, E. (Ed.), *COBRA 2006: Proceedings of The Annual Research Conference of the Royal Institution of Chartered Surveyors, University College London, 7-8 September 2006*, Vol. 2006, RICS, London.

Hicks, R.C., Dattero, R. and Galup, S.D. (2006), "The five-tier knowledge management hierarchy", *Journal of Knowledge Management.*, Vol. 10 No. 1, pp. 19-31.

International Recovery Platform (IRP) (2005), *Development of a Cross-Disaster Knowledge Management Kit to Support Better Recovery Learning from Good Practices and Lessons*, available at: www.adrc.or.jp/irp/pdf/200511ADRCDis.pdf (accessed 13 May2007).

Jha, S.K. (2005), *Multi-donor Trust Fund for Mainstreaming Disaster-Reduction for Sustainable Poverty Reduction*, available at: http://siteresources.worldbank.org/INTDISMGMT/Resources/ 3394561158594430052/TrackIIMulti-DonorTrustFundAnnexD.pdf?resourceurlname = TrackIIMulti-DonorTrustFundAnnexD.pdf (accessed 6 March 2007).

Johnson, C., Lizarralde, G. and Davidson, C. (2004), "Learning oriented evaluation of reconstruction projects", available at: www.coventry.ac.uk/c ontent/1/c6/01/02/90/ LEARNING%20ORIENTED%20EVALUATION%20OF%20RECONSTRUCTION%20 PROJECTS.pdf (accessed 25 May 2007).

Johnson, C., Lizarralde, G. and Davidson, C.H. (2006), "A systems view of temporary housing projects in post-disaster reconstruction", *Construction Management and Economics*, Vol. 24, pp. 367-78.

King, D.J. (2005), "Humanitarian knowledge management", in Carle, B. and Van De Walle, B. (Eds), *2nd International ISCRAM Conference, April 2005, Belgium*, Vol. 2005, US Department of State Humanitarian Information Unit, Washington, DC, pp. 1-6.

Kululanga, G.K. and McCaffer, R. (2001), "Measuring knowledge management for construction organisations", *Engineering, Construction and Architectural Management*, Vol. 8 Nos 5/6, pp. 346-54.

Leng, K.C. (2005), "Principles of knowledge transfer in cost estimating conceptual model", MSc thesis, University Teknologi, Johor.

Limoncu, S. and Çelebioğlu, B. (2006), "Post-disaster sustainable housing system in Turkey", available at: www.grif.umontreal.ca/pages/LIMONCU_Sevgul.pdf (accessed 25 May 2007).

Malalgoda, C.I. (2006), "Role of construction sector in disaster management and an analysis of the post disaster reconstruction work", unpublished dissertation, University of Moratuwa, Moratuwa.

Maqsood, T., Finegan, A. and Walker, D. (2006), "Applying project histories and project learning through knowledge management in an Australian construction company", *The Learning Organization*, Vol. 13 No. 1, pp. 80-95.

National Construction Association of Sri Lanka (2005), "Tsunami reconstruction costs jump 60 percent", *Constructor*, Vol. 12 No. 3, p. 30.

National Disaster Management Division (2005), *Knowledge Management in Disaster Risk Reduction: The Indian Approach*, available at: http://unpan1.un.org/intradoc/groups/public/documents/APCITY/UNPAN022469.pdf (accessed on 4 March 2007).

Ofori, G. (2002), *Construction Industry Development for Disaster Prevention and Response*, available at: /www.grif.umontreal.ca/pages/i-rec%20papers/ofori.pdf (accessed 24 February 2007).

Robinson, H.S., Carrillo, P.M., Anumba, C.J. and Al-Ghassani, A.M. (2004), "Developing a business case for knowledge management: the IMPaKT approach", *Construction Management and Economics*, Vol. 22, pp. 733-43.

Robinson, H.S., Carrillo, P.M., Anumba, C.J. and Al-Ghassani, A.M. (2005), "Knowledge management practices in large construction organisations", *Engineering, Construction and Architectural Management*, Vol. 12 No. 5, pp. 431-45.

Rotimi, J.O.B., Masurier, J.L. and Wilkinson, S. (2006), "The regulatory framework for effective post-disaster reconstruction in New Zealand", in I-Rec (Eds), *3rd International Conference on Post-Disaster Reconstruction: Meeting Stakeholder Interests, Florence, Italy, May 2006*.

Zhang, D., Zhou, L. and Nunamaker, J.F. Jr (2002), *A Knowledge Management Framework for the Support of Decision Making in Humanitarian Assistance/Disaster Relief*, Knowledge and Information Systems, available at: www.eng.usf.edu/~ayalcin/hdr/KNOWLEDGE%20MANAGEMENT.pdf (accessed 4 March 2007).

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