A Stakeholder Proactive Approach to Floodplain Risk Management for the NSW Built Environment

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Abstract
The risk of any natural disaster is a function of the likelihood such an event will occur and the extent of the harm such an occurrence will cause. A significant factor in the extent of potential harm is the resilience of the built environment. Effective floodplain risk management must therefore consider how the likelihood of a flood can be reduced (mitigation) and the management of a disaster improved (preparation, response and recovery) specific to the built environment. Mitigation and preparation activities represent a proactive approach. Response and recovery represent a reactive approach. A resilient built environment is one where floods are proactively managed by stakeholders.
There is a definite lack of empirical evidence specific to proactive floodplain risk management related to the built environment. More particularly, the question remains why some stakeholders appear to focus efforts on mitigation and others on preparedness and rarely on both. This paper reports on a recent study of Local Councils in New South Wales that examined the factors influencing stakeholder adoption of a proactive approach in floodplain risk management. The study involved a questionnaire survey of Local Councils developed from a comprehensive review of the literature and what decision-making models are available to frame floodplain risk management of the built environment. Particular attention is paid to the role of the mitigation and preparedness attributes.
The study developed a unique rating system to measure the mitigation and preparedness of those Local Councils. Results indicate that Local Councils have given more emphasis to preparedness than mitigation activities. The overall study identifies a series of flood risk reduction factors that collectively contribute to the resilience of built environment in flood prone areas and effectively provide rewarding insights for policy makers in the resource allocation process.

Introduction

The global weather climate is becoming increasingly volatile and will continue to change in ways that affect the planning and operations of the built environment. The manifestations of climate change include higher temperatures, altered rainfall patterns and more frequent or intense extreme events (AGO, 2006). Various forms of natural disaster are associated with climate change, including bushfires, storms and floods. However, flood is widely regarded as the most destructive, and expensive, of the natural disasters (Alexander, 1997). Flood is also now the most frequently occurring cause of natural disaster in the world (Sohn, 2006). Australia is one of the most susceptible countries to flood damage, with around $13 billion of direct economic impact from floods over the past three decades (CRED, 2012). Almost $250 billion worth of buildings and transport infrastructure is potentially exposed to flooding by 2050 (Emergency Management Australia, 1999), making flooding the most costly potential cause of natural disaster in Australia (Blong, 2004).

Built environment and associated infrastructure such as roads, bridges, airports and tunnels can be at particular risk of direct damage from flooding events. Meyer (2008) pointed out that transport infrastructure is vulnerable to extremes in temperature, precipitation/river floods, and storm surges, which can lead to damage to road, rail, airports, and ports (Meyer, 2008). Although built environment is considered vulnerable to flooding, the level of exposure and impact will vary by region, location/ elevation, condition of infrastructure, etc. (IPCC, 2012; Meyer, 2008).

Relevant research to date has tended to focus on quantifying the socio-economic impact that floods have on the built environment. Little has been done to investigate the role that key factors such as proactive stakeholder mitigation and preparedness activities have on the scale of that socio-economic impact. Indeed, there is little agreement even on how proactive stakeholder mitigation and preparedness activities might be classified and measured in this context. Several studies have investigated mitigation and preparedness in the context of seismic risks (Lindell & Prater, 2003), but no empirical studies have considered the impact of mitigation and preparedness tasks separately. This paper reports on a recent study that specifically aims to develop effective indicators for built environment mitigation and preparedness activities in a floodplain risk management context.

The key stakeholders in this study are Local Government Areas (LGAs) and Local Councils across NSW because they represent the bodies responsible for providing infrastructure, preparing and responding to disasters, developing and enforcing planning regulations and connecting national government programs with local communities (Huq et al., 2007; UNISDR, 2011). Effective localised mitigation and preparedness activities can minimise both the causes and consequences of natural disasters (Bulkeley, 2006). This study draws candidate mitigation and preparedness activities from previous studies (e.g., Altay and Green, 2006) as potential indicator factors for the economic impact of floods on built infrastructure. The framework for a flood risk index is developed from these indicator factors using a Multi-Attribute Decision Making (MADM) technique specifically developed for this purpose.

Conceptual framework

The primary objective of floodplain risk management is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property and to reduce private and public losses resulting from floods (OEH, 2005).

There are two approaches to floodplain risk management in this regard: proactive and reactive approaches. Proactive approaches refer to activities that are planned and conducted before the flood event. Reactive approaches are undertaken during and immediately following a flood event. The focus of this study is on proactive approaches which include mitigation and preparedness activities. Mitigation activities aim to eliminate or reduce the probability and/or consequences of flood events to impact built infrastructure facilities. This includes any measures to contain or reduce the severity of human and material damage by constructing resilient infrastructure (Alexander, 2000). Preparedness activities include developing emergency procedures and stakeholder institutional capability in advance of a flood event in order to ensure effective response to the impact of disasters. An effective response to floods will help to reduce deaths, injuries, property damage and overall cost. Preparedness accepts the existence of residual, unmitigated risk and attempts to support society in eliminating certain adverse effects that could be experienced once a flood occurs (IPCC, 2012).

Most studies claim that stakeholders generally rely on preparedness activities (Bosher et al., 2009; Brilly & Polic, 2005; Loosemore & Hughes, 1998). Preparedness activities are part of a broader Flood Management (FM) approach. There is a substantial difference between FM and Flood Risk Reduction (FRR). FM includes a broad range of activities that extend from proactive (preparedness) to reactive (response and recovery) activities. Thus, FM refers to the social processes used for designing, implementing and evaluating strategies, policies and measures that promote and improve the preparedness, response and recovery activities at different organizational and societal levels (IPCC, 2012). FRR, on the other hand, involves a more systemic development of mandates, strategies and practices that proactively reduce the impact of potential vulnerabilities, including livelihoods and assets, while ensuring an appropriate and sustainable management of the environment (UNISDR, 2004). FRR covers flood risk identification and risk transfer (IPCC, 2012). Flood risk identification involves individual perception, an evaluation of risk and social interpretation (Carreño et al., 2006). Risk transfer is related to the financial protection of public infrastructure (Mercer, 2010). Thus, FRR denotes a policy goal or objective, including the strategic and instrumental measures used to anticipate future flood risk whilst reducing existing exposure and vulnerability and improving resilience (Birkmann and von Teichman, 2010).

Investment in FRR is strongly advocated by governments and the insurance sector as a key means to reduce the adverse economic impact of floods (Kreimer et al., 2003). However, it would appear that FM is often the principal focus for policy makers, partly because activities such as mitigation are less often regarded with the same urgency (Bosher et al., 2007) and partly because there are limited resources and FM has been a traditional focus. An important consideration is clearly how to prioritise the investment of a limited capacity between FM and FRR. Figure 1 represents the conceptual framework for such a consideration. The framework proposes a set of indices be identified that best represent the most effective mitigation and preparedness activities. These indices then combine to provide an overall index or measure of the effectiveness of that particular stakeholders proactive management of flood risk.

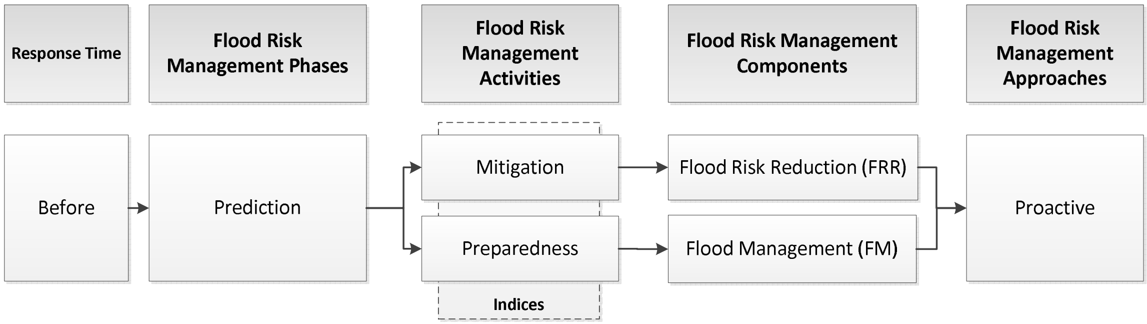

Figure 1: Conceptual framework of stakeholder flood mitigation and preparedness indices

Research method and results

Research design and data collection

A structured questionnaire was developed to collect data on each candidate indicator factor identified from a review of the literature. The questions were designed to solicit the experiences of each Local Council in managing their flood events. The list of factors identified is presented in Table 1.

Table 1: Indicator factors for developing mitigation and preparedness indices

Activity	Indicator Factor
Mitigation	Training and education on FRM
Mitigation	Analysing risks to measure the potential areas for floods
Mitigation	Zoning and land use controls to prevent building of roads in flood prone areas
Mitigation	Insuring roads and bridges to reduce the financial impacts of floods
Mitigation	Developing a master plan for FRM
Mitigation	Developing FRM information system among stakeholders
Mitigation	Developing engineering design standards for resilient roads and bridges
Mitigation	Providing timely and effective information related to FRM
Mitigation	Constructing flood retarding basins, barriers, culverts, levees and drainage
Preparedness	Recruiting personnel for flood emergency services
Preparedness	Developing flood emergency management systems
Preparedness	Developing strategies for public education
Preparedness	Budgeting for flood emergency equipment
Preparedness	Maintaining flood emergency supplies
Preparedness	Locating places for emergency operation centres
Preparedness	Developing prediction and warning communications
Preparedness	Conducting FRM exercises to train personnel and test capabilities
Preparedness	Using technology to identify and assess floods, and damaged roads and bridges
Preparedness	Developing coordination and collaboration procedures with other stakeholders

The questionnaire was administered using a web-based survey instrument. With the assistance of the Floodplain Management Association (FMA), all Local Council members of the FMA were invited to participate. Responses were sought from floodplain engineers, planning and infrastructure engineers, emergency management officers and others with direct experience in floodplain management. The survey had a response rate of 48% (36 out of 74 members).

Data analysis techniques

In order to index the various factors a multi-attribute decision making technique is required. TOPSIS (Technique for Ordered Preference by Similarity to the Ideal Solution) is an effective method for analysing and ranking alternatives that uses the shortest distance from the Positive-Ideal Solution (PIS) and the farthest from Negative-Ideal Solution (NIS). TOPSIS concurrently takes into account both PIS and NIS distances to calculate a Relative Closeness (RC) ratio (Chen, 2000). The RC notion is derived from prospect theory which is used to identify the ideal point from which a compromised solution would have the shortest distance (Mojtahedi and Oo, 2014). In this paper, TOPSIS and the notion of RC is used to develop index values for each mitigation and preparedness activity.

Characteristics of the Local Councils

Table 2 presents the broad characteristics of participating Local Councils in staffing and budget terms. For the majority (58.3%), only 1 or 2 staff are employed in floodplain management roles. This equates with the relatively low average annual capital works budget ($16 million for 2012-2013). Where the average annual budget is as high as $51 million the number of staff working in floodplain management increases to 9 or 10.

Table 2: Broad characteristics of the Local Councils

Staff employed in floodplain management	Number of councils (%)	Average capital works budget 2012-13 (A$ million)
1 - 2	21 (58.3%)	16
3 - 4	7 (19.4%)	25
5 - 6	5 (13.9%)	31
7 - 8	1 (2.8%)	42
9 - 10	2 (5.6%)	51

Table 3 shows how each Local Council prioritises the allocation of their annual works budget to different elements of flood risk management. It can be seen that private residential buildings and transport infrastructure are generally regarded as having the highest priority. However, there is a range of difference across all Local Councils and priorities vary considerably.

Table 3: Council priorities in floodplain risk management

Facility	Number of councils (%)	Rank
Private residential buildings	8 (18.55%)	1
Public roads and bridges	7 (18.31%)	2
Public buildings	7 (18.07%)	3
Utilities (water, telecomms, electricity, etc.)	6 (16.88%)	4
Private commercial/industrial buildings	6 (16.65%)	5
Rural industries	4 (11.53%)	6

Mitigation and preparedness indices

Table 4 presents the respective final scores (RC) obtained from the TOPSIS procedure using equal weight factors for the two alternatives. The table shows that the preparedness activities (RC = 0.795) have a greater focus than mitigation activities (RC = 0.434). Given the format of the questionnaire, this might reflect either a perceived focus or an actual focus, but the implications of either account are the same.

Table 4: Local Council mitigation and preparedness indices

Proactive activities	PIS	NIS	RC (index)
Mitigation	0.095	0.073	0.434
Preparedness	0.045	0.175	0.795

Conclusions

This paper reports on a recent study that specifically aims to develop effective indicators for built environment mitigation (flood risk reduction) and preparedness (flood management) activities in a broader floodplain risk management context. The specific consideration of proactive approaches is intended to drive a more effective balance of regular stakeholder investment between FM and FRR activities. The most substantive outcome of this research is clear confirmation that Local Councils focus more on flood management (preparedness) activities than flood risk reduction (mitigation) activities.

This imbalance of consideration is important. It signifies that, in general and particular to the time of the survey, a transfer of funding from FM to FRR would result in a greater reduction to the overall risk associated with flood events. This holds in general, but each individual stakeholder will have their own level of imbalance depending on their particular current investment strategies and general situation. The benefit of the index is that values can be determined for each individual stakeholder. Based on that individual index value, each stakeholder can then determine their own level of imbalance and where new or revised investment is best placed in value for money terms.

A further benefit of the index approach is that the activities of different stakeholders can be directly compared in floodplain risk management terms. Individual Local Councils can benchmark their floodplain risk management activities against other, comparable Local Councils. Funding agencies can utilise the index values in prioritising the allocation of resources to stakeholders. Insurance agencies can utilise the index values to better plan portfolio diversification and/or inform how they calculate insurance premiums. Monitoring individual stakeholder indices over time will also assist in planning and policy development across the sector (Davidson, 1997). Developed indices are powerful tools for policy and operational decision-makers to prioritise the allocation of resources and make decision-making more transparent.

The results clearly indicate that stakeholders are focusing more on preparedness than on mitigation activities, but it is worth considering further why that might be the case. The stakeholder theory of Freeman (1984) identifies three distinctive attributes that drive stakeholder behaviour: power, legitimacy and urgency. Power is a measure of how likely it is that the stakeholder is going to be in a position to carry out its own will, despite resistance. The power of a stakeholder is able to mobilise social and political forces and to withdraw resources from an organisation (Olander, 2007; Post et al., 2002). Legitimacy is a generalised perception that the actions of a stakeholder are desirable and/or appropriate. The more legitimate an organisation then the more capable it is to abide some ongoing risk or benefit. In disaster risk reduction, legitimacy is a generalised assumption that the behaviour of a stakeholder is proper within socially constructed systems of norms, mandates and procedures. Urgency is the extent to which any given stakeholder claim might call for immediate attention (Mitchell et al., 1997; Olander, 2007). Without power Local Councils may be unable to secure the funding they require to invest in mitigation activities and elect instead to wait for the social and political imperatives that accompany an actual flood event. Without legitimacy Local Councils will find it difficult to justify investment in risk reduction, where success is measured in terms of costs that are not incurred in the event of an actual flood event. Without urgency Local Councils may be unable to mobilise the proactive activities required to mitigate risks when there is no immediate threat of disaster. A deeper consideration of stakeholder theory and study of how the power, legitimacy and urgency of a Local Council might impact the scale of a flood disaster is worth further investigation.

The research presented in this paper establishes a novel approach to flood risk management. The TOPSIS technique provides a more realistic form of modelling for multi-attribute decision making because it allows for trade-offs between criteria. The resulting indices are relatively straight-forward to compute, are replicable and readily modified to reflect changes in the values of any factors. With the methodology established, future studies can examine the indices for reactive approaches including response and recovery with relative ease. Developing a model where the interplay between mitigation, preparedness, response and recovery activities can be articulated and measured will have a profound influence on floodplain risk management for all key stakeholders.

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