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The adaptive capacity of hospital facilities to cope with the risk of disasters caused by extreme weather events: a case study approach

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Abstract:

A three-year study is currently being conducted to determine the adaptive capacity of hospitals in Australia and New Zealand to cope with climate change-related extreme weather events. The primary objective of this research is to develop strategies that can be employed to improve the resilience of hospital facilities to these events. A case study approach was adopted to collect data through focus groups comprising participants who had experienced extreme weather events. Using risk and opportunity management methods, focus group workshop sessions were used as a structured approach to identify, assess and control the risks and opportunities associated with an extreme weather event scenario. The research findings indicate that there is considerable scope for clinical and non-clinical staff to work cooperatively in developing preventative as well as response and recovery strategies. The findings reinforce the view that the relationship between building users and building facilities needs to operate in an integrated fashion if any adaptive strategy is to be effective. This raises interesting governance issues which will be explored in future research.

Keywords:

adaptive capacity, case study, hospitals, opportunity, risk

1 Introduction

In recent years there has been an accumulation of evidence pointing to links between climate change and extreme weather events (Hennessy et al., 2007; Steffen, Love, & Whetton, 2006; Stern, 2009). For Australia and New Zealand, this is likely to manifest itself as more frequent and severe heatwaves, floods and storms (Australian Greenhouse Office, 2006; Hennessy et al., 2007; Preston & Jones, 2005). Extreme weather events are caused when an individual climate variable such as temperature or rainfall “exceeds a particular threshold and deviates significantly from mean climate conditions or when there is a critical combination of different variables” (Linnenluecke & Griffiths, 2010, p. 2). This can occur either when climatic conditions fluctuate much more than normal, thus resulting in a severe weather event, or when the event falls outside the normal climatic season, such as a flood occurring during a normally dry season. Due to the unpredictability and impact of these events, they pose significant risk to society at large, and place strain on critical infrastructure. The health sector is especially vulnerable to natural disasters (PAHO/WHO, 2004) and the capability of hospitals to carry out their

vital roles during and immediately after an extreme weather event is paramount to the success of the wider recovery process. While new hospitals are relatively resilient to external forces, existing building stock would benefit from the application of adaptation strategies to improve their resilience (Australian Greenhouse Office, 2007). The aim of this research is to identify what actions can be employed by hospital management, both clinical and facilities, to enable the continuity of health care during an extreme weather event.

Whilst the impact of climate change on healthcare delivery is currently the focus of considerable research (Bonnett et al., 2007; Lalonde, 2007; McCaughrin & Mattammal, 2003), physical healthcare infrastructure has been relatively neglected. The importance of addressing this deficiency was acknowledged by the Australian Science Engineering and Innovation Council (PMSEIC Independent Working Group, 2007) and by the Council of Australian Governments (2007) when they recommended that Australian governments should give priority to developing climate change adaptation strategies for Australia's health infrastructure. Given the age of Australian and New Zealand healthcare infrastructure, they recognised that extreme weather events are likely to create increasingly challenging physical and patient-related demands which were not envisaged in original hospital designs. Hence it is important to undertake research which focuses on the interplay between health service providers and designers, constructors and managers of hospital facilities.

The research method adopted was a multiple case study approach employing in-depth focus group workshops. The case study approach yielded successful outcomes with the focus group sessions identifying a detailed range of controls that could be employed to mitigate risks and also opportunities for the development of adaptive strategies. There was general agreement amongst workshop participants that the exploration of risk and opportunity profiles which marked the culmination of this stage of the project was of both conceptual and practical use in the management of hospitals particularly during and after an extreme weather event.

2 Research agenda

The research project commenced in June 2009 and comprises three stages viz.

- Stage 1 - vulnerability analysis
- Stage 2 - adaptive capacity analysis
- Stage 3 - development of adaptive strategies

A case study approach was used for Stages 1 and 2 with the same case study hospitals being used for both stages. Stages 1 and 2 of the project have now been completed and Stage 3 has recently commenced. The results from Stage 1 are discussed in previous publications (Carthey, Loosemore, Chandra, & Chand, 2010; Loosemore, Carthey, Chandra, & Chand, 2011); the topic of this paper is the Stage 2 results.

3 Research Methodology

The case study approach deployed for Stages 1 and 2 is widely accepted as a useful tool for studying organisational responses to crisis and for developing theory inductively by recognizing patterns of relationships across cases (Loosemore & Hughes, 2001). This is important because understanding the operation of hospitals requires more than a simple appreciation of building related issues given that a hospital is a complex organisation

with many diverse stakeholders and functions. Responses to extreme weather events are similarly complex and involve an interplay of many economic, social, organisational, political and cultural considerations which can only be explored fully using a case study approach (Yin, 2009). A broader approach, such as a survey or questionnaire may have failed to provide the depth of insight needed to understand the social and organisational complexity of the adaptive system in responding to an extreme weather event.

3.1 Description of Case Studies

Three major referral hospitals were chosen in close consultation with partner health services in Australia and New Zealand. The case studies were selected based on their size and age, population dependency, historical climatic records and future climatic predictions. The three case studies comprised Coffs Harbour Base Hospital; Whangarei Hospital; and Ceduna District Health Services. Each of these facilities had previously been subjected flash floods, floods caused by storm surges and heatwaves respectively.

3.2 Description of Case Studies

3.3 Coffs Harbour Base Hospital

Situated on the mid North Coast of NSW, Coffs Harbour Base Hospital is the largest hospital in the North Coast Area. It serves a population of 100,000, an estimated 68,000 of which resides in Coffs Harbour city. Coffs Harbour is a humid, sub-tropical area with an average annual rainfall of 1,700mm (Coffs Harbour City Council, 2009). Flooding and storms are relatively common, although its intensity has increased dramatically in recent years, with the region experiencing six major flooding events in 2009 alone. Whilst Coffs Harbour Base Hospital is relatively new, being operational only since 2001, the hospital suffers from its location adjacent to a creek and on a flood plain, and the area around the hospital is one of the first in town to be inundated in a flooding event.

3.4 Whangarei Hospital

Whangarei Hospital serves a district of 78,000 and is located in the North Island of New Zealand in the Northland area which has a population of approximately 155,000 people. The hospital building is situated on a hill, and accessed by only one road which can be cut off during floods and storms. A major renovation was undertaken in 2001, but many of the buildings date from the 1950s-1960s or even earlier. The NZ Ministry for the Environment (2009) warns that due to climate change, Northland's temperature is expected to rise by 3°C over the next century and the frequency of floods could increase fourfold by 2090. Specifically, summer and autumn tropical storms may bring an increase in the intensity of extreme rainfall causing severe flooding to the hospital and surrounding areas (Ministry for the Environment, 2008).

3.5 Ceduna District Health Services

Ceduna is located in the remote northwest corner of the Eyre Peninsula, South Australia and is approximately 10 hours by road from Adelaide. Out of its small population of 3,731, 25.5% of the population in 2006 identified themselves as indigenous i.e. of Aboriginal or Torres Strait Islander origin (Australian Bureau of Statistics, 2010). Located within an arid zone, the town is exposed to hot, dry summers with limited rainfall, during which time the daytime temperatures can reach up to 47°C for a week or longer. In early 2009, when Adelaide reported up to 6 days over 40°C - some of the

hottest days recorded in the region for more than 70 years - Ceduna recorded a temperature of 46.2°C (ABC News, 2009).

Ceduna District Health Services offers a mix of 25 acute care beds and 10 beds for high level aged care, with a further 29 beds for low level aged care located on another site (Country Health SA, 2009). A major upgrade of the health service facilities are currently being undertaken (South Australia Parliament House of Assembly Public Works Committee, 2009).

4 Data collection

Data collection was by means of a series of focus group sessions using a risk management tool called 'Risk and Opportunities Management System' (ROMS, 2011) to capture stakeholder experience. Focus groups are designed to promote interaction and self-disclosure among a carefully structured group of respondents who can share their perspectives about a specific topic in a non-judgemental environment (Morgan, 1997). ROMS is a process which uses multimedia technology to provide a structured approach to identifying, assessing and controlling the risks and opportunities associated with an nominated problem – in this case “How to respond effectively to an extreme weather event scenario”. By acknowledging employees' expertise and insights as an organisation's key asset in managing risks, it provides a multimedia platform for the organisation's key stakeholders to come together to engage in an interactive and constructive process (Loosemore, 2010). The scenarios for these ROMS workshops were different in each case study and reflected the local extreme weather event possibilities. Scenarios are an accepted method in risk management in helping stakeholders think about risks and opportunities (Henstra & McBean, 2005). In our case studies the scenarios were generated from scientific advice and statistical evidence from UNSW Climate Change Research Centre (a partner in this research). In both Stages 1 and 2 the ROMS workshops were conducted in each case study hospital with key stakeholders including clinicians, emergency department staff, facility managers, nurses, technical staff, health care specialists and health service representatives. Stage 1 involved a one-day workshop to identify and assess the risks and opportunities for each case study hospital and Stage 2 (the subject of this paper) involved another one-day workshop to consider the controls which could reduce the risks to an acceptable level and maximise the opportunities associated with the climate change scenario. The results of Stage 1 (Carthey et al., 2010) showed that the overriding organisational objective was continuity of service delivery with the primary supporting objectives of (a) preserving the building structure's integrity along with its building services; (b) having effective communication both externally and internally; (c) maintaining access to and from the site; and (d) ensuring availability and safety of relevant staff on hand to respond to the crises. From the profile of the risks and opportunities identified from the first round of focus-groups, it was also clear that many of the risks and opportunities were in a dynamic relationship where the occurrence of a single event could trigger a number of associated events. For example in one of the case studies the lack of an early warning flood monitoring system resulted in the inundation of a car parking area with the consequential loss of 90 cars belonging to staff, and key clinical and maintenance staff not having enough time to arrive on site before the roads became inaccessible.

5 Findings and discussion

In Stage 1 a total of 90 risks and 36 opportunities had been identified across the three case studies. In the Stage 2 ROMS workshops a total of 158 'additional controls' were identified. Additional controls are items that the stakeholder group felt could be accomplished 'in-house' to supplement or complement their existing controls in order to mitigate the risks or maximise opportunities. An end 'residual level' is computed, showing the resulting severity(/benefit) of the risk(/opportunity) if those additional controls identified were to be implemented. This is calculated based on the stakeholders' judgement of the probability of the risks(/opportunities) happening and the impact to their ability of achieving the objectives if it were to happen (i.e. residual probability x residual consequence = residual level). Table 1 shows an extract from the second workshop at Coffs Harbour Base Hospital by way of illustrating the nature of some of the additional controls identified.

Table 1. . Some of the additional controls identified for the objective “to ensure staff and patient safety” at Coffs Harbour Base Hospital

	Risks and Opportunities	Additional Controls	Residual Probability	Residual Consequence	Residual Level
Objective	To ensure staff and patient safety (including vulnerable patients within the community) (Weighting 40%)		Rare Unlikely Possible Likely Almost certain	Insignificant Minor Moderate Major Extraordinary	Low Medium High Very High Exceptional
Risks	(13) Roads being cut (Almost Certain, Major, Very High)	Lobby Road and Traffic Authority/Council to upgrade roads from hospital to bypass – as part of Pacific Highway upgrade and Coffs Harbour bypass to ensure all weather access	Likely	Major	Very High
		Further develop support provided to local hospitals	Almost Certain	Moderate	High
		Developing a process of when we receive early warning that those on call physically come into the facility so we have them on site (intensivist, anaesthetist, general surgeon etc)	Almost Certain	Minor	Medium
	(21) Adequacy of community age care facilities BCM plans and capacity to implement those plans (Possible, Major, High)	Help age care providers to secure funding to develop risk management/emergency/business continuity management plans	Possible	Major	High
		Lobby commonwealth to make risk management plans/business continuity management part of age care facility accreditation process	Rare	Major	Medium
		Lobby local Government planners to make location of age care facilities in development application approval consider risk of where they are building	Rare	Major	Medium
	(25) Inability to respond to speed of event (Possible, Major, High)	Improve internal communications relating to early warning – give staff time to move cars etc	Possible	Major	High
		Provision of real time data about levels of creeks (currently a critical lag of 15 minutes) - linked to triggers which commence activation of plans	Unlikely	Major	Medium
		Automated early warning system is needed to ensure that alarms ring if rate of creek flooding rises above a certain rate – currently manual	Unlikely	Major	Medium
Opportunities	(21) Develop and implement flood mitigation strategy for the site (e.g. Coffs Harbour bypass may present opportunity, engage with urban planning controls) (Possible, Major, High)	Work together with council and SES to develop a mitigation strategy – document procedures	Unlikely	Major	Medium
	(38) Build a multi-storey car park (Unlikely, Moderate, Low)	Private medical centre developer wants to build one – negotiate with them as a JV to build one	Likely	Moderate	High

Table 1 provides a sample of the large range of possible controls identified to reduce the risk exposure of hospitals to climate change related extreme weather events. In each case study, the foreseen residual risks and opportunities profile were compared to the

original risk profile from the Stage 1 workshops (for combined results from all three case studies, see Figure 1). When compared to the original risk profile, the residual risk profile shows how the risks and opportunities would shift as a result of implementing the additional controls, assuming the organisation chooses to and is able to act on the additional controls and that the controls have their intended effect. Figure 1 show how across the three case studies, the existing climate change risks can be significantly lowered, and the opportunities improved with the *caveat* that the lowering of risks and the improvement of opportunities represents the most optimistic projection of outcomes.

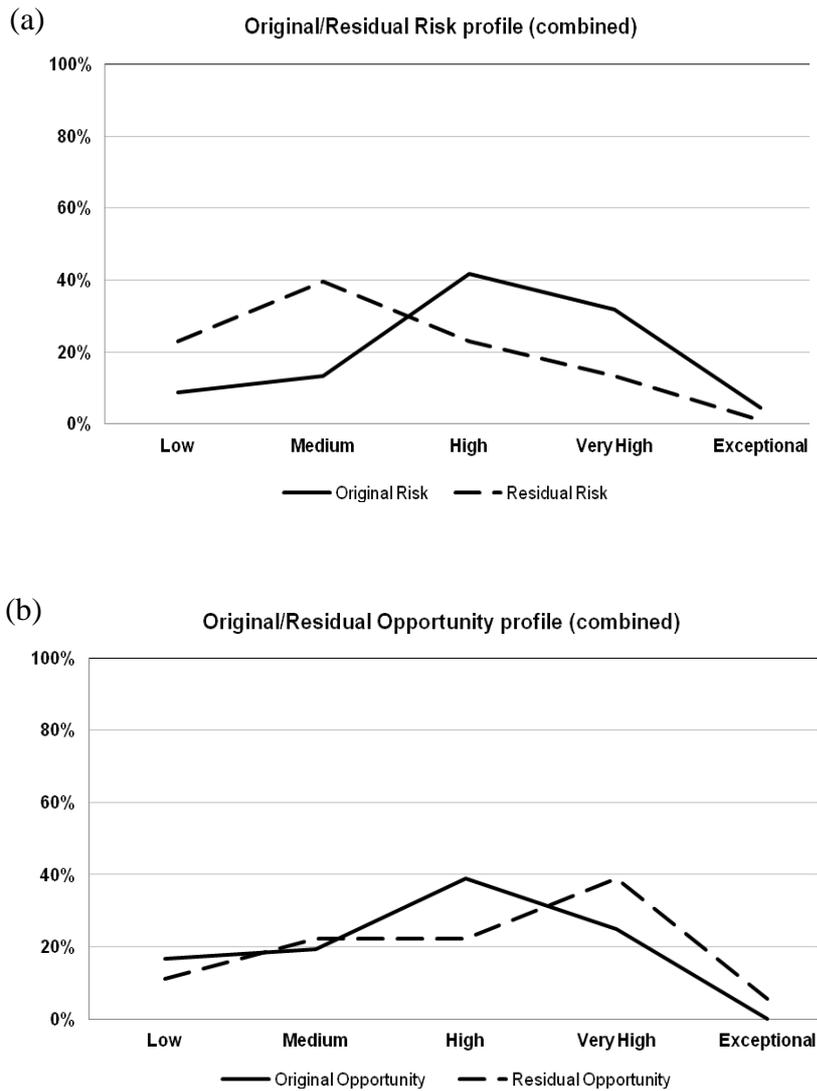


Figure 1. Graphs of the combined results from the three case studies profiling the distribution of (a) original risk versus residual risk and (b) original opportunity versus residual opportunity.

Three main observations can be made regarding the additional controls:

1. The controls relate to a wide range of health service delivery issues. Some are building related; others are organisational in nature and some relate to situations where the organisation and the building are closely inter-connected.
2. Some controls have a particularly strong impact and have a ‘knock-on’ effect on other controls. For example an automated early flood warning device.

3. Although by definition additional controls should be able to be accomplished 'in-house' the implementation of a control may not always be within the sphere of influence of the health service organisation in question – for example lobbying the Roads and Traffic Authority and the local Council to upgrade access roads is a case in point.

Observation 3 raises some interesting issues with respect to the ability to implement a control which is not directly within the sphere of influence of the stakeholders. In order to explore this issue further, a coding exercise was undertaken to categorise the nature of the controls identified. The objective of the coding exercise was to systematise possible strategies in order to compare like-with-like and to identify any patterns that could be used towards formulating an adaptive strategy. Patterns were identified by examining co-occurrences such as correlation between “themes, respondents or events” (Guest & McLellan, 2003, p. 188). Each item coded was checked against the others to establish analytical categories, in a process referred to as ‘constant comparison’ (Pope, Ziebland & Mays, 2000).

This analysis was, in essence, a fine grained exploration of spheres of influence. Controls were coded into endogenous and exogenous categories and then further broken categorised into ‘within sphere of influence’, ‘partially within sphere of influence’ and ‘outside sphere of influence’. These categories reflect the nature of healthcare systems which are characterised by a complex hierarchical structure of decision takers with varying spheres of influence (Becker, 2007). The term ‘endogenous’ refers to the sphere of influence of decision takers in the case study hospitals. The term ‘exogenous’ refers to the sphere of influence of external agencies, such as other government departments or private organisations. The approach which was adopted is similar to that advocated by Wu et al (2006, pp. 352-353) who grouped risk factors, in their case inbound supply risk factors, into similar categories. It is interesting to note that natural disasters are classified by Wu et al as “external uncontrollable” (i.e. ‘exogenous and outside sphere of influence’), whereas the ROMS process has helped our case study organisations to gain an element of control to deal with these external risks. Examples of endogenous and exogenous controls are provided in Table 2. Although these are presented as two distinct categories, in practice the boundary between the two is often a fuzzy continuum. It was clear from our second workshop that the likelihood of a control being proposed and, in turn, implemented is directly correlated to the degree of influence or authority which a stakeholder is able to exert. For example, in the case of Ceduna hospital, the stakeholders were assertive in taking control over seemingly exogenous issues. When faced with the challenge of needing to provide accommodation on site for an extended period of stay for staff during a heatwave event, ideas of appealing to a higher authority for funding quickly turned inwards, with participants noting “I think we can do some of that ourselves... we could publically raise funds [from the local community] for beds and the like”.

Table 2 gives examples of each endogenous control and exogenous control with 3 levels of spheres of influence with the proviso that the boundary between these spheres of influence has been presented as clear cut for illustrative purposes.

Table 2. Endogenous and exogenous controls

	Categories	Definition	Example (extracted from workshop transcript)
Endogenous (En)	Within sphere of influence (a)	Actions that can easily be implemented using existing resources and associations within the hospital organisation	Set up a pseudo pharmacy service for visitors
	Partially within sphere of influence (b)	Actions that will require collaboration or assistance from other health departments	Develop support system amongst local hospitals
	Outside sphere of influence (c)	Strategic decisions relating to the hospital that its organisation does not have the authority to make	Build a new hospital
Exogenous (Ex)	Within sphere of influence(a)	Actions involving or dealing with outside bodies but which the hospital organisation can easily manage and control	Educate public about extreme weather event risks
	Partially within sphere of influence (b)	Actions involving or dealing with outside bodies but which the hospital organisation can manage and control somewhat	Negotiate with nearby mining company to share their resources
	Outside sphere of influence (c)	Actions involving or dealing with outside bodies and which the hospital organisation has little scope or likelihood of management and control	Lobby commonwealth government to change the building requirements for aged care facilities

As part of the process of identifying suitable adaptive strategies, Stage 2 of this research project is primarily concerned with the interplay between organisational activity (the users) and the built environment (the physical infrastructure). In order to ascertain the ratio of controls relating to 'organisational activity' and 'physical infrastructure' the data was further analysed by sieving the results of the sphere of influence exercise illustrated in Table 2 through these two identifiers. The results of this exercise are illustrated in Table 3. In all 158 additional controls were analysed as part of this exercise.

Table 3. Coding of additional controls into categories of endogenous and exogenous, with sub categories of 'within sphere of influence', 'partially within sphere of influence' and 'outside sphere of influence'

	Total	Organisational [#]	Built Environment ^{##}
Endogenous (En)	109	57	52
En – within sphere of influence	88	50	38
En – partially within sphere of influence	15	7	8
En – outside sphere of influence	6	0	6
Exogenous (Ex)	49	30	19
Ex – within sphere of influence	21	17	4
Ex – partially sphere of influence	15	7	8
Ex – outside sphere of influence	13	6	7
TOTAL	158	87	71

Protocols; internal procedures; disaster plans

Building envelope; building services; equipment; layout and provision of space

Given that the data is derived from three case studies no statistical inferences can be drawn from the results of the analyses. They do however provide an interesting insight into the stakeholders' perceptions of risk and opportunity management. The scenario presented to stakeholders at the commencement of the ROMS workshops for Stage 2 was "What controls in addition to existing controls can the organisation implement internally to minimise risks and maximise opportunities?". This approach is very much in line with systems thinking where the main causes of change in an organization (i.e. a system) are considered to be the interactions within the organization itself, not influences from outside the organization. Problems of the organization are not attributed

to outside circumstances – the competitors, the press, the markets, the economy or the government. “Systems thinking implies that there is no outside; that you and the cause of your problems are part of a single system” (Senge, 1990, p. 67). This view does not mean ignoring effects of external factors; it does however mean that the way the system responds to external factors depends on the dynamic structure of the system itself (Mbiti, 2008). Previously we have made the point that natural disasters are classified by Wu et al (Wu et al., 2006) as “external uncontrollable”, whereas the ROMS process provides organisations with an element of control to deal with these external risks. The ability of our case study participants to think inside the system boundaries is confirmed in the results obtained from the coding of the additional controls. Table 3 illustrates that the dominant area for suggested improvement, both in terms of organisational activity and the built environment is ‘endogenous – within sphere of influence’ with very few suggestions being deemed to be outside the sphere of influence. In the exogenous zone it is worth noting that ‘exogenous-within sphere of influence’ (for example a public education program) has the largest number of controls and typifies an organisation taking a pro-active role in influencing external circumstances. This analysis is still at an exploratory stage of the ongoing research project and may lead to the development of an assessment tool to measure the adaptive capacity of hospital facilities both in terms of the management of the physical infrastructure and the management of the organisational activities.

The ratio between endogenous organisational controls and endogenous physical infrastructure controls is evenly balanced indicating that the stakeholders do perceive the physical environment as being important to the stakeholders. This was to some extent an unexpected result given that most of the workshop participants were clinicians or administrators whose primary responsibility has more to do with organisational issues than issues relating to the built environment.

6 Conclusion and Further Research

Extreme weather events are, by definition, an extraordinary event which falls outside of the norm. The ability to mitigate the risks posed by such an event and to identify opportunities for improvement is a reflection of the adaptive capacity of hospital facilities (facilities being defined in the broad sense of the physical infrastructure and the users of the facility). Whilst it could be argued that extreme weather events are uncontrollable occurrences, this does not necessarily mean that the impact of the event cannot be lessened or indeed absorbed by a combination of a robust physical infrastructure and a properly prepared organisation. Although the study is limited to three case studies the application of the ROMS system produced a large and rich data set which allowed insight into user perceptions of controls which could be implemented to improve the adaptive capacity of hospital facilities.

To date research into physical healthcare infrastructure has been relatively neglected. Our research has added to knowledge in this field. Amongst other things our analysis of the data from the case studies demonstrates that it is possible to categorise controls into user activities i.e. organisational and physical infrastructure with the proviso that the built environment includes not just the building envelope and building services but also the provision of space. The findings demonstrate that hospital organisations are capable of identifying risks associated with extreme weather events and of conceptualising a wide ranging set of controls which can be implemented to improve the adaptive capacity of hospitals. The findings also demonstrate that stakeholders perceive most of

the proposed additional controls as being endogenous and within their sphere of influence which is indicative of a positive and proactive mind set.

The use of a case study approach in Stages 1 and 2 of the project has provided a clear insight into user perceptions. Stage 3 of the project, which is about to commence, will seek to validate the findings of Stages 1 and 2 by undertaking extensive consultation with key decision takers.

7 Acknowledgement

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