2011

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Publication Details

Smith, S., Winchester, D., Hasan, H. M. & Finnegan, P. (2011). IS for government climate change adaptation activities: an exploratory case study. Proceedings of the Australasian Conference on Information Systems: ACIS 2011 (pp. 1-12). Sydney, Australia: Association for Information Systems.

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Keywords
era2015

Disciplines
Business | Social and Behavioral Sciences

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'Infomating' for Government Climate Change Adaptation Activities: An Exploratory Case Study

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Abstract

This paper reports a case study of climate change adaptation activities of the New South Wales Government's Climate Change Working Group where ten agencies have responsibility for thirty-five long-term activities. A concurrent Data-Centre Consolidation project has highlighted the mammoth amount of data held by different agencies that must be integrated into information to adequately support these adaptation activities. Our analysis of data collected from interviews and documents reveals the potential of a retrospective ontology capability, and a unique citizen record in enabling this integration. Adaptation activities require resolution of differences in the perspectives of government agencies and citizens and changes to current restrictive sustainability practices in order to meaningfully engage with a wide range of non-governmental stakeholders in a way that ensures visibility of action and confers the authority to act in the context of climate change adaptation activities.

Keywords Green IS, Climate Change, Adaptation, Environmental Sustainability, Case Study.

INTRODUCTION

Much of the scientific and popular literature on climate change has focused on mitigating climate change, where mitigation focuses on "technological change and substitution that reduce resource inputs and emissions per unit of output" (IPCC 2007, p. 84). There is a smaller, but growing literature, addressing the interest in ensuring the sustainability of living standards, infrastructure and economic conditions through adaptation to climate change in concert with mitigation (Francisco 2008, Bedsworth and Hanak 2010). Adaptation, in this context, refers to "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects" (IPCC 2007, p. 76). The context for adaptation is the belief that it may already be too late to prevent some effects of climate change, and that government, organisations and citizens must engage in actions that ensure sustainability in light of such changes (Bedsworth and Hanak 2010, Tessa and Kurukulasuriya 2010). In the context of climate change, "the design and implementation of information systems that contribute to sustainability of business processes" (Watson et al. 2008, p. 2), is referred to as 'Green IS'. While central to both mitigation and adaptation activities, Green IS research has, to date, focused almost exclusively on mitigation and its consequences for sustainability; neglecting the equally important challenges of adaptation. Extant Green IS literature has also neglected the needs and activities of government agencies, despite the centrality of information, systems and data issues in enabling such agencies to make critical planning and action decisions in light of climate change. Thus, prior research falls short of addressing the needs of government as a vital stakeholder in the sustainability debate.

The objective of our study is to explore climate change adaptation activities within the government sector, with a view to enhancing understanding of both the nature and role of information, systems and IT in enabling solutions to the sustainability problems created by climate change. The next section evaluates extant Green IS literature; noting the emphasis on mitigation for sustainability and beginning the exploration of the requirements for information systems for adaptation activities. Using an in-depth study of the New South Wales (NSW) Government in Australia, we reveal five high-level objectives for climate change adaptations that are driving 35

projects of the Climate Change Working Group (CCWG). Our analysis reveals how these projects necessitate the collaborative actions of 10 separate governmental agencies and non-governmental bodies, and rely on the availability of large quantities of information, dynamically integrated across the databases of these agencies/bodies. This provides a challenge, opportunity and responsibility for IS expertise and knowledge to make a vital environmental contribution. We conclude by conceptualising the nature of information and systems required to mediate climate change adaptation activities over an extended time span during which unpredictable technological advances will occur.

THEORETICAL GROUNDING

Information systems research on environmental issues began with a focus on what has been termed 'Green IT' issues; energy efficiency of digital services and ICT equipment utilisation, adoption of ICT configurations, such as virtualisation, with lower green house gas (GHG) emissions, and environmentally responsible ICT life-cycle management (Elliot 2011, Kuo and Dick 2009, Molla et al. 2009). This literature has been dominated by studies of commercial enterprises (Molla et al. 2009), particularly IT manufacturing (e.g., Butler and McGovern 2009); echoing the predominant view that IT is a major contributor to climate change (Fuchs 2008, Gartner 2007). In contrast, recent Green IS research concerns the use of IT in information systems for ecological and environmental sustainability (Chen et al. 2008, Daly and Butler 2009, Melville 2010), energy and cost efficiency (Sayeed and Gill 2008, Molla et al. 2009), as well as environmental monitoring (Caldille and Parmigiami 2004, Velte et al. 2008), and compliance management (Butler and McGovern 2009). The impact of such research is, thus, focused on improving methods of monitoring, controlling and supporting organisational activities that are believed to contribute to GHG emissions with a view to mitigating climate change. However, viewing sustainability purely from a mitigation perspective implies a conservative aim of sustaining things as they are now. A widely held view is that sustainability should focus on meeting "the needs of the present without compromising the ability of future generations to meet *their own needs*" (Brundtland 1987, p. 1, emphasis added). We contend that future generations will need to adapt to the consequences of climate change.

Governments are now, more than ever, conscious of their responsibility to provide environmental sustainability for citizens, with both mitigation and adaptation initiatives receiving increased attention (Settle et al. 2007). Climate change mitigation activities tend to focus on carbon emissions, energy efficiency, recycling or technology innovation (Aldy et al. 2010). In contrast governmental climate change adaptation is concerned with chronic problems (e.g., sea level rise, temperature increases, population management and food production) as well as critical threats (e.g., flooding, storm, fire, heat waves) that arise from climate change. Adaptation activities manifest in a number of ways including long term planning (Bedsworth and Hanak 2010, Lisø 2006), technology transfer (Tessa and Kurukulasuriya 2010), emergency management (Francisco 2008), population movement (Mimura 1999), and refugee management (Docherty and Giannini 2009). In addition to national and global issues, government climate change adaptation frequently involves different initiatives for specific regions; including rezoning land, building shelters, and establishing a permanent disaster levy/tax (Laukkonen et al. 2009).

The knowledge and expertise of the field of IS is particularly relevant for adaptation as it includes the combination of business and IS strategies and activities needed to produce sustainable 'green' solutions for governments, businesses and citizens; such solutions being both people and technology orientated (see the seminal works by Boudreau et. al. 2008, Chen et al 2008, Melville 2010, Watson et al. 2010). In a government context, we envisage IS enabling the planning, design, and execution of adaptation initiatives by mediating the activities of individuals and teams charged with such work. Government adaptation initiatives generally involve holistic cross-agency planning, decision-making and action for programs in specific locations. IT has the potential to contribute to such initiatives through systems that produce high quality, integrated information and permit dynamic information sharing. However, "despite the claimed benefits of sharing data and information in organisations, and the undoubted and ever increasing capabilities of information technologies to enable it, such sharing evidently remains remarkably problematic" (Hart 2002, p. 23).

In light of the complex nature of climate change adaptation, we claim that the existing information systems and management processes that manage the transactions of commercial and governmental organisations cannot automatically be considered suitable for the support of adaptation activities. *First*, transactions within and between agencies generally take place in the context of known, or knowable, scenarios. This allows agencies to share data, integrate processes and develop routines to provide actionable outcomes using enterprise systems (Blair 2004). The nature of adaptation activities (e.g., long range planning, preservation and crisis management) is such that the scale, nature, and timing of action cannot be prescribed (Bala et al. 2009) in a manner that would allow for the development of similar systems.

Second, while existing enterprise systems have transactional and record-keeping benefits, their decision-support capabilities are limited (Holsapple and Sena 2005). The information systems that do support decision makers focus on much shorter term planning horizons (Goul et al. 1986) and more structured planning scenarios

(McLain and Aldag 2009), than the up to 50-year projections and ill-structured planning scenarios that characterise adaptation activates. Nevertheless, recent developments with the use of merged data sets and evidence-based management in strategic planning have promise (Morrel-Samuels et al. 2009).

Third, although data warehousing technology allows for the large scale analytics (Kelly 1996) required by adaptation activities such as disaster recovery (Bala et al. 2009), the low level of data granularity and relatively slow processing speeds that characterise such analytics necessitate the separation of operational and decision-making data (Kelly 1996) in a way that makes the real-time operationalisation of actionable outcomes from the analysis (i.e., 'closing the loop', Kelly 1996) difficult (Bala et al. 2009).

Fourth, adaptation systems will need to efficiently and effectively deal with public information. Governments are under increasing pressure from citizens to provide them with more involvement in decision making and a greater input into the design of public services (AGA 2010, Feller et al. 2011). In this context, public agencies are being encouraged to engage citizens using Web 2.0 applications and processes (Gruen 2009). Such tools have proven extremely beneficial in the aftermath of recent critical weather events (CCI 2011). However, their use in the context of operational government systems is fraught with difficulty (Hossain and Kuti 2010).

Finally, IT management invariably involves centralised control with an enforced uniform standard for reasons of cost, efficiency and data integrity. Even then, such technical considerations represent only part of a more complex story in IS success, with less tangible managerial and incentive issues playing a crucial role (Van Alstyne et al. 1995), particularly when such issues arise between agencies and organisations (Robbins and Stylianou 1999). IT management approaches will undoubtedly be required to successfully enable the multi-agency, multi-purpose and flexible systems environment required for adaptation activities.

To conclude, in line with other sustainability initiatives, we argue that governmental climate change adaptation activities will require more complex information systems than those described in the Green IS mitigation literature people, processes, software, and information technologies (Watson et al. 2010). The dramatic increase in the number and heterogeneity of included components, relations, and their dynamic and unexpected interactions signify new types of IT artefacts generically labelled Information Infrastructures (Hanseth & Lyytinen 2010). Distinctly different from the systems currently employed within commercial and governmental settings such information infrastructures are concerned with the information requirements of a fuller range of human activities; addressing the needs of the current generation and the unknown needs of future generations.

RESEARCH DESIGN

This research is exploratory due to the emerging nature of the topic and the scarcity of extant literature. Given the exploratory nature of this research, as well the need to obtain rich data in a complex contemporary context, a case study approach was considered appropriate (Marshall and Rossman 1989, Stake 1995). Case studies are the most commonly used qualitative research method in IS, and are especially useful for studying organisational aspects of IS (Benbasat et al. 1987). "A case study examines a phenomenon in its natural setting, employing multiple data collection methods to gather information from a few entities. The boundaries of the phenomenon are not clearly evident at the outset of the research and no experimental control or manipulation is used" (Benbasat et al. 1987, p. 371). As context and action are interwoven, it is important to consider the past and present when looking to the future (Pettigrew 1992). Appropriately, cases are particularly useful when there is a need to examine the phenomenon in context and to draw upon inter-connected levels of analysis that may extend over time (Pettigrew 1990), as here. Our method is consistent with the case study approach of Orlikowski and Baroudi (1991) and Stake (1995), in that we study the phenomenon in its natural setting, employing multiple data collection methods to gather rich information, without employing experimental control or manipulation.

Our case study is the Government of New South Wales, Australia. Australia, like the rest of the world, has experienced an average increase in temperature warming of about 1.6°F (0.9°C) over the last century. The Government of New South Wales believe that "it is now more than 90% certain that observed increases in global temperature are caused by greenhouse gas emissions. The projected effects of this warming include changing rainfall patterns, rising sea levels and increased evaporation" (DECCW, 2009 p. 46). It thus acknowledges, "climate change is one of the most serious challenges that society faces, [with] …the potential to affect all aspects of human life and the environment" (DECCW, 2010, p. 1).

Our study focuses on (i) the Climate Change Working Group (CCWG), and, (ii) the 10 agencies responsible for climate change adaptation. The CCWG, was formed to advise the NSW Government on the impact of climate change on regions across the State where citizens and communities may need to adapt to its consequences. It acknowledges the imperative to make determinations as to what is likely to happen over the next 50 years and to put in place programs to minimise the impact of climate change on citizens. Our analysis of the adaptation activities of the CCWG included consideration of a data centre consolidation (DCC) project. The DCC project is predominantly motivated by cost savings but it also has outcomes for climate change mitigation as it aims to reduce energy consumption through more efficient management of the data server equipment across the 13

'super-agencies' of NSW government based on portfolios. The DCC is the culmination of strategic consolidation activities by government agencies that began in 1989, and which have a significant impact on both the current and future information systems infrastructures in NSW. From the IS perspective the DCC project has heightened awareness of the potential benefits to the adaptation activities of the CCWG that could be gained by further consolidating the data now stored at the DCC site. This could in turn lead to greater effectiveness in information sharing among the different super-agencies.

Primary data gathering took place during 2010 and 2011 and consisted of 42 elite interviews (Marshall and Rossman 1989) with senior management within NSW Government and four hours of participation in Climate Change Working Group meetings. Interviewees included 22 members of the State Emergency Management Committee, and the Climate Change Working Group CCWG representatives from Emergency Management NSW, Fire and Rescue NSW, NSW Rural Fire Service, State Emergency Service, DECCW (Department of Environment Climate Change and Water), Department of Planning, Lands Authority, Department of Health (Ambulance), Bureau of Meteorology University - Bushfire CRC (Collaborative Research Centre). In addition, interviews took place with the Government Chief Information Officer; NSW Police Commissioner, Assistant Commissioner, Fire and Rescue NSW, first Secretariat Climate Change Working Group (three interviews), Chairman, Department of Environment, Climate Change and Water, Manager, Department of Environment, Climate Change and Water, second Secretariat, Department of Environment, Climate Change and Water, External Consultant, Office of the NSW Premier, Senior Strategist, Government Chief Information Office (two interviews), Senior Media Officer, Department of Services, Technology and Administration.

Interviews were generally up to one-hour duration with follow-up telephone conversations and emails used to clarify and refine issues that emerged during analysis. A two-phase coding process was employed as described by Miles and Huberman (1994). During the first-level coding phase, each segment of the data was summarised and labelled. This was followed by a pattern coding process in which the segments of data were organised, analysed and synthesised within the themes/concepts emerging from our theorisation of adaptation. While the emphasis of the first-level coding phase was on description, the pattern coding process focused on explanation. Interviews were complemented by comprehensive reviews of documents. In total 810 separate documents were analysed for the study. These documents included; government policy documents, information strategies and charters, hazard profiles, progress reports on the adaptation projects, strategy documents for government agencies, presentations, and minutes of meetings. The documents were analysed using Leximancer (Version 2.2); a software application for text mining that uses artificial intelligence to develop and identify high level concepts and the relationships between them from an analysis of text (Smith and Humphreys 2006). Leximancer develops a co-occurrence matrix from analysing concept frequency and the co-occurrence of data, and then applies a statistical algorithm to derive a two-dimensional concept map. The labels and themes are developed solely from the text analysed; thus avoiding researcher bias (Hewett et al. 2009).

ANALYSIS

The Department of Environment, Climate Change and Water is one of 13 government portfolios (super-agencies) in New South Wales; advocating the importance of climate change for the state. Evident from our investigation on the work of the Department are several principles relating to climate change adaptation: (i) acceptance that climate change will impact the community, who will require the capacity to adapt, (ii) a need for a whole of government approach to climate change adaptation, as evidenced by the establishment of the Climate Change Working Group (CCWG), (iii) the existence of risks associated with climate change that imply uncertainties with respect to adaptation activities, (iv) the need for government plans and processes to adapt in the context of climate change, and (v) citizen feedback. Based on these principles, government activities on climate change adaptation centre on five high-level objectives: (i) identifying new risks for emergency management agencies, (ii) enhancing community resilience (e.g., storms, floods or fire), (iii) adapting planning processes to emerging risks, (iv) identifying risks to critical assets, and (v) adapting emergency management arrangements.

These objectives are evident in 35 discrete adaptation activities (see Table 1) that require the input and co-ordination of 10 NSW government agencies and non-governmental bodies. Each of the CCWG initiatives listed in Table 1 as adaptation activities were proposed, and are managed, by members of different NSW government agencies or other non-government groups. Among the initiatives listed as adaptation activities in Table 1 are: (i) activities requiring information from multiple databases such as modelling, planning, identifying critical infrastructure at risk, and health impact of heatwaves, (ii) activities generating information that may be vital for future unknown uses and users, e.g., research, consolidating survey responses, various local studies, (iii) activities requiring information about citizens and their properties, e.g., the Village Protection Plan, advice for bushland residents, land uses, building standards, (iv) activities that create informational tools: Self assessment tools for both government employees and citizens, measures, mapping of hazards, patterns of fires, or floods, and (v) activities involving citizen participation, including community education campaigns, training for self-assessment of hazards, and volunteer incentives, flexibility, and training. There are also several activities dealing

with people issues for example resilience and life style issues, like where to live and what to accommodation to build. Chronic adaptation activities are also mentioned or implied, such as the impact of sea-level rise (inundation), food security and production (land use), drought (heatwaves), and biodiversity.

Data consolidation and information sharing between multiple super-agencies and other entities is essential for almost all adaptation activities. The data analysis confirmed that this was an instance of an information infrastructure of enormous complexity, with huge interconnected and often incompatible data sets, Figure 1 illustrates a first pass at mapping the interdependencies between the 35 activities listed in Table 1 and the multiple agencies with primary responsibility for each activity, as well as the reliance on other agencies for critical inputs to undertake the activity. For example, the primary responsibility for assessing critical infrastructure resilience to critical weather events is jointly held by the State Emergency Services (SES), Rural Fire Services (RFS), the Department of Health and various Emergency Response agencies. However, the success of the activity depends on crucial data about changing information relating to prevailing weather and climate conditions, from the Bureau of Meteorology, together with information from the Department of Environment, Climate Change and Water (DECCW) and the Land Authority. However, the findings of Bushfire Research and local knowledge of the various RFS Units can also be regarded as critical as it enables the process of planning, preparation and response for extreme climate events. However, consolidation of these inputs into timely and meaningful information is a major challenge.

Table 1. CCWG Adaptation Activities

Objective 1: Identifying new risks for emergency management agencies	
1.1	Development of natural hazard and risk profiles for each region of NSW.
1.2	Improve the understanding of climate phenomena in low-lying coastal areas.
1.3	Identification of the likely impact of climate change on fire, storms, floods and coastal hazards and identify future hazards.
1.4	Ocean Inundation modelling
1.5	Long term bush fire planning and prevention
1.6	Determine health impacts of GHG emissions from control fires
1.7	A demographic analysis of residents moving to rural areas
1.8	Assessment of the resilience of buildings and infrastructure
1.9	Long term bush fire planning and hazard scenarios
1.10	Emergency management risk assessment and planning-
1.11	Enhancing volunteerism in the context of projected climate change demand on resources
1.12	Understanding bush fire behaviour in changing climatic conditions
1.13	Understanding global changes for bushfire risk in the future
1.14	Long term bush fire planning and risk management
1.15	Fire behaviour modelling of major events
Objective 2: Enhancing community resilience	
2.1	Determining community assessment vulnerability
2.2	Analysis of community surveys about levels of risk, knowledge and preparedness for floods
2.3	Incorporating climate change knowledge into existing Emergency Services community education programs.
2.4	Developing programs to assist landholders to defend their property and reduce hazards. Review of current community message systems
2.5	Identifying measures to reduce impacts of heat and better adapt to weather extremes
2.6	Developing a tool for self assessing of emergency dangers
2.7	Improving community resilience
2.8	Conduct community education campaigns targeting at new residents with little or no fire experience
2.9	Developing of incentives for volunteers; promotion of skill training.
2.10	Develop tools for Land owners to assess their vulnerability to Bushfires
2.11	Engaging community participation for bushfire planning
2.12	Assisting landowners to manage land for biodiversity and property protection
Objective 3: Adapt planning processes to emerging risks	
3.1	Preparing Coastal Climate Change Land Use Planning Guidelines
3.2	Incorporating new research into Bush Fire Planning
Objective 4. Identify risks to critical assets	
4.1	Identifying of critical emergency services infrastructure that are under threat from natural hazards.
4.2	Critical infrastructure to flood risk
Objective 5: Adapt emergency management arrangements	
5.1	Planning emergency agency coordination in high demand climate change events.
5.2	Review of strategic approach to emergency preparedness and management.

5.3	Develop projections for climate change scenarios.
5.4	Review volunteer training, skills and knowledge programs

Our analysis of the available historical documents revealed that data issues have been a source of tension since, at least, the 1980s. Federated information exchange agreements were introduced in 2009 by the Government to enable agencies to share data. However, the GCIO explained that such agreements are insufficient to enable the inter-agency data exchange necessary for long term planning and crisis management activities required for climate change adaptation. While senior managers of all agencies expressed reluctance to share data because of perceived ownership issues, the more significant problems arise due to the degree to which data/structures and models are determined by the operational requirements of each agencies rather than the requirement of ex-post inter-agency adaptation activities. In addition, there are legal barriers to data collected for one purpose being used in a different context; for example health records giving details of less able citizens being used for asset management.

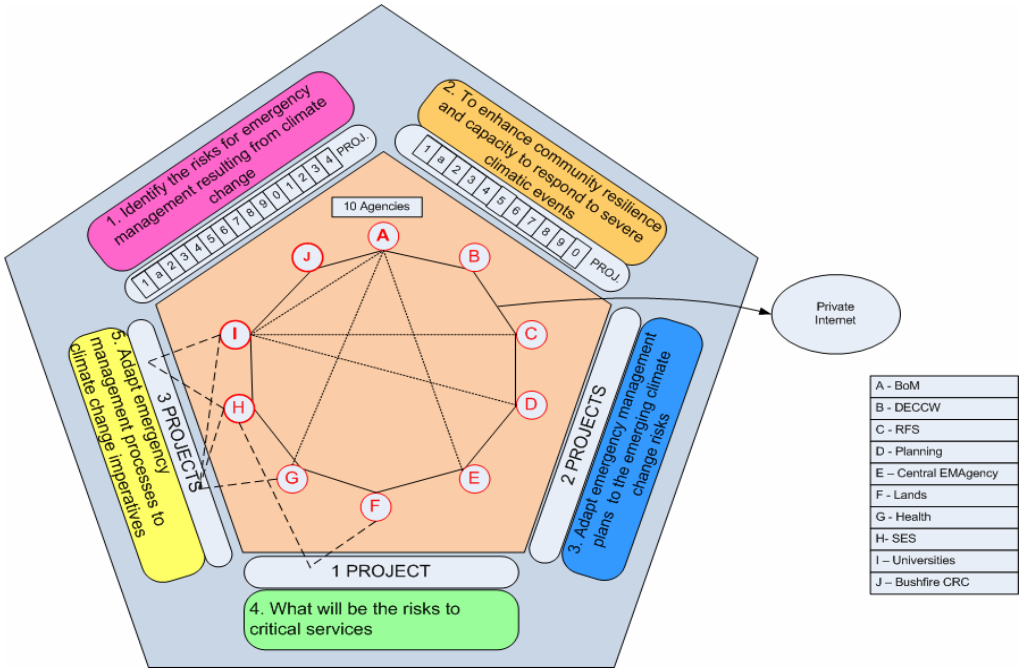

Figure 1: Interdependency in Governmental Climate Change Adaptation

While it is evident that adaptation activities rely on information systems and technology as key enablers, the use of systems and technology in adaptation activities also reveals the limitations of current systems and technology. The current system infrastructure relies on large monolithic organisational systems that process huge datasets (e.g., currently up to 200 pentabytes) from multiple agencies. The datasets are constrained by the data structures and data models in the operational systems that generated them. In addition, climate change analysis can be a time consuming process lasting up to several days. Climate change modelling by the CCWG in conjunction with the State Emergency Management Committee is critical in emerging events (e.g., rapidly approaching fires or storms). However, such modelling often lacks the lead-time to reliably predict weather or fire patterns as current systems are rather inflexible with respect to remodelling the data or running a report out of schedule. Decision making is therefore overly constrained by existing analysis and operating models. This highlights a similar problem to the legal issues with respect to data use issue highlighted above. Together regulatory and data structure issues severely impede the use of valuable existing data for adaption activities.

Our analysis reveals that the provision of timely integrated information in appropriate forms is a key enabler of adaptation activities and that data consolidation would be one mechanism to improve effective exchanges between agencies with responsibility for managing the 35 adaptation activities. Consolidated data is required to (i) overcome the problems associated with data (files or records) duplication by individual agencies, (ii) improve timeliness of information provision and analysis, (iii) improve information quality, (iv) lower the cost of adaptation activities, and (v) avoid re-collecting the data. Together these improve confidence in adaptation planning and the quality of decision making with respect to climate change adaptation, a key objective of the CCWG. Consolidated data also creates a common starting point for the next generation of models and tools that must use the data.

Viewing the work of the CCWG and 10 agencies at a high level, the focus is very broad across government, business and community encompassing all five adaptation objectives. However, our analysis suggests that the central entity in the exchange of data necessary to enable cross-agency coordination is the individual citizen. This is because, as individuals, citizens are both the benefactors of the adaptation activity and the lowest level of granularity for data exchange amongst the agencies/bodies charged with such activities. While the creation of an authoritative and current unique citizen record would be desirable as a means of facilitating data consolidation, it has not yet been achieved within any Australian Government. Indeed a national referendum to create a single citizen unique identifier (such as the USA social security number) was rejected in 1987.

Our analysis revealed that significant differences in attitudes to issues surrounding adaptation activities existed between (i) government employees and citizens, and (ii) IT and non-IT personnel. Differences in perspectives between government employees and citizens were evident in aspects of community resilience and acceptability of risks resulting from climate change. The substantive nature of such differences related to issues of property value, costs of living and lifestyle choices. The CCWG Land representative explained that decision models relating to planning and rezoning of land use typically considered impacts at the community level ; neglecting the individual concerns for drops in property value, or access to land. In addition, substantial differences emerged with respect to individual privacy as evidenced by submissions by citizen advocacy groups on the need by various agencies to collect and store individual level data in order to be able to adequately plan for, and respond to, climate change. A particular privacy issue surrounds the potential use of health records to plan for evacuation procedures and to determine the location of less able, and senior, citizens in a crisis.

Different perspectives were evident between IT and non-IT personnel regarding the operation of systems to support adaptation activities. IT management generally sought to ensure that systems were reliable, operational, and easily maintained. In contrast such issues are of little concern to frontline government personnel and citizens, who are much more aware of the complexity of the activity that the technology should be supporting. The Police Commissioner revealed that the complexity and uncertainty of emergency alerts necessitates in-built redundancies using multiple channels of communication and multiple instances of message storage to reach citizens at least once. This contrasts with the policy of IT management to have a standard operating environment that supports dedicated communication channels and single data storage points.

Currently local community groups' involvement in local planning for adaptation activities is limited by lack of access to relevant government data. IT management policies have resulted in the centralised, controlled and security environment necessary for the delivery of current services. However, this approach reduces the flexibility required for non-government access (e.g., citizen and community bodies) to government information. For instance, the adoption of particular government policies and platforms restrict, and sometimes prohibit, access to government information using social technologies. Citizens extensively used such technologies during the critical weather crises in 2010-2011. However, the senior media liaison officer stated that current departmental policies limit the usefulness of such technologies for government to citizen communications. She explains that all external communications must have prior approval from the agency head. This can take up to two weeks prohibiting the use of Twitter and other social tools for Government to citizen emergency messages in crisis events.

CONCLUSION AND RECOMMENDATIONS

This study has articulated the need for information systems researchers and practitioners to consider governmental climate change adaptation initiatives in the overall context of environmental sustainability. Advice from key NSW State government officials we interviewed indicated that such initiatives were being considered by most other national and international governmental bodies with which they had ongoing discussions. Such wide-spread initiatives are of scientific and practical interest for a number of reasons. First, governments are convinced by the growing evidence that critical weather events resulting from climate change will have a significant impact on current and future generations. While mitigation strategies, such as the reduction of greenhouse gases, may ultimately reduce the occurrence of such events, governments that focus on adaptation as well as mitigation provides the most complete approach to addressing sustainability issues. Second, governments are significant stakeholders in sustainability initiatives due to the significant environmental impact of their own behaviours, as well as their ability to influence the behaviours, and consequential environmental impact, of businesses and citizens. Third, information systems infrastructure and decision models are challenged by the uncertainty and long planning horizons associated with adaptation activities, as well as the extensive range of stakeholders.

Technological and organisational forms rarely emerged as envisaged by those charged with anticipating and planning for them and it would be naïve to assume that today we could predict technological changes within 10 years, never mind the 50 year planning horizon for government climate change adaptation projects. However, the data that this technology is likely to use will certainly include the data that is currently being gathered. Indeed, the climate data gathered 150 years ago, is today, being used in ways never envisaged by those that

gathered the data. However, decisions made about data today may affect its future utility. Top down development approaches and centralised organisational structures are widely used to ensure that data, systems and organisational activities served operational, transactional and decision making needs. The inability to determine the nature of such needs for adaptation means that information systems for adaptation need to deal with emergent situations. Emergent approaches to data organisation such as tagging are bottom up in nature, but the subjective nature of their derivation means that there is a need to reconcile the tags to form a coherent perspective of data for climate change adaptation activities.

Our conjecture is that information systems to support adaptation will require a retrospective ontology capability to enable such systems reconcile the categorisation of data (from a data structure perspective e.g., tagging) in order to leverage such data for adaptation activities. Such ontology would need to be able to dynamically restructure the data to provide the required level of granularity and appropriate semantics to be meaningful for any emergent scenario. We suggest that an authoritative citizen record will provide two advantages in being able to dynamically restructure. First it provides the context for semantics down to the level of an individual as, from a sustainability perspective, adaptation activities focus on the future needs of collections of individuals. Second it will provide a reference point from which data can be aggregated.

While government agencies believe that the data sharing between agencies for adaptation activities will take place within the confines of a 'private intranet, we believe that current evidence suggests that responding to climate change will need to engage, in a meaningful way, a wider number of stakeholders than most government initiatives currently do. Adaptation activities increasingly suggest that, for both analytical sophistication and real-time responsiveness, it will be necessary to leverage the expertise and activities of individuals. Aggregating the activities of individuals (e.g., using GPS to track individual movements in a crisis situation) can provide useful real-time information to help enact evacuations. In addition, the mitigation and adaptation efforts (e.g., recycling, reuse) and life activities (e.g., food consumption, foreshore usage) of individuals can be aggregated to enable sophisticated modelling to help future planning. In this context, information systems will need to both enable the non-intrusive collection of the data, as well as the use of that data. Emerging technologies (smart-phones, RFID, etc.) may provide the non-intrusive collection of data. However, non-technical issues (e.g., privacy concerns) may prove an obstacle to the use of the data.

The emergent nature of climate change necessitates being able to call on expertise that may be unanticipated, rather being able to identify and recruit all necessary experts. Specifically, adaptation activities suggest a much-increased role for non-government employees and citizens in activities previously performed by government agencies (e.g., contingency planning, and crisis management). In this context, governments will need to (i) provide citizens with the ability to interact with information (ii) ensure visibility of action, and (iii) confer the authority to act. Information systems will be required to ensure that citizens can self-identify for particular problems (e.g., designing evacuation procedures), allow the design of multiple potential solutions, provide filtering facilities to ensure that a viable solution is selected, and confer the authority to act. This represents a major change from the perspective of the degree to which non-government employees (e.g., citizens and external experts) have meaningful access to government systems. Overall, our conjecture as to the nature of information systems for adaptation assumes an intrinsic interplay between design and action, as the tools/technologies that enable the information systems envisaged are likely to emerge from the adaptation activities that they serve to mediate.

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