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The Asian Tsunami: An urgent case for improved government information systems and management

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Abstract

This discussion paper provides a timely consideration of how regional governments in Asia and other national governments around the world collect, manage, and share information in what is becoming an increasingly global community. The paper addresses the socio-technical perspective of government information systems and management, and draws on several public reports, media articles, and expert opinions published in the aftermath of the Asian tsunami of 26 December 2004. On the basis of the published material, the paper observes how critical early warning information was handled by government authorities in the hours before the tsunami wave strike, discusses the availability of technological solutions that can provide earthquake and tsunami warning information, and poses that government bureaucracies and human relations form the weakest link in the information chain. The type of early warning information system that might be created to avoid another loss of life, suggested improvements to inter-government information sharing and communications, and the emerging requirement for earthquake and tsunami information dissemination and education are also discussed. The paper concludes with a research agenda for government warning information systems and management.

Keywords

Tsunami, earthquake, government, information, systems, management.

INTRODUCTION

On 26 December 2004, at approximately 00:58:53 UTC (Universal Coordinated Time), a massive earthquake measuring 9.0 on the Richter scale struck off the western coast of northern Sumatra in Indonesia. The epicentre of the earthquake was 18.6 miles under the Indian Ocean at the geographic coordinate 3.32 degrees North and 95.85 degrees East. This seismic event represented the fourth largest earthquake since 1900 and fired giant 50 foot high tsunamis waves (a Japanese term for 'harbour wave', used by fishermen who, having not experienced any unusually large waves at sea, returned home to find a devastated harbour shoreline) into the shorelines of Indonesia, Sri Lanka, India and Thailand. Some effects were felt as far away as Somalia and Kenya on the east coast of Africa (Wikipedia 2005).

In gaining some perspective on this seismic event, the earthquake that triggered the tsunami released 2 $x10^{18}$ joules of energy and shifted some island landmasses by up to 36 metres. Several aftershocks measuring between 5 and 7.3 on the Richter scale only served to remind and reinforce the enormity of this catastrophic event. Over 159,000 people perished in the wake of the tsunamis, with over 43,000 still unaccounted for, and over 1.5 million people displaced from their homes (Wikipedia 2005). The scale of this disaster has seen a number of government and humanitarian aid organisations launch into action to assist the injured and displaced. However, once the dust settles on these tragic events, some government analysts will ask the question: Could we have done more to prevent the loss of life?

There is little, if anything, that the regional governments could have done to prevent the loss of property and homes. The nature of the seismic event and its devastating after effects were clearly not within the contemplation of citizens, commercial operators and tourists whom these countries depend on as part of their economy. However, in the aftermath of the tragedy several parties (including the international press) have speculated that critical information system and management failures may have cost lives. Lives that might otherwise have been saved had it not been for socio-technical breakdowns (ie, social and technical system failures) in the government information chain. This paper will examine some of the more critical failures that were publicly reported and appear to have diminished the available early warning times for those most effected.

The balance of the paper is set out as follows:

- A short review of information system and management failure literature.

- The theoretical basis selected for the study.
- A brief outline of the information collection process for this paper, including the limitations of the research approach.
- A review of some the more glaring examples of government information system and management failures.
- A discussion on the available warning information systems and technologies.
- An outline of some of the valuable lessons learned and reactions to the tsunami.
- A possible future research agenda in the area of government warning information systems and management.

GOVERNMENT INFORMATION SYSTEMS AND MANAGEMENT FAILURE

The failure of government information systems and management procedures and processes has a history that can be traced back to the 1960s and 1970s when Bostrom and Heinen (1977a and 1977b) conducted research into management information systems problems, failures and causes using a socio-technical frame. The research found that information systems developers and designers held a range of preconceptions on how organisational users typically behave, and that systems users should be closely monitored and managed. Bostrom and Heinen (1977a and 1977b) also found that these preconceptions were often wrong and resulted in difficulties when developing and implementing new organisational systems. The research showed that political infighting and conflicts in party interests also impacted new systems implementation, and that users must take responsibility for systems implementation success.

In another relevant study, Schmitt and Kozar (1978) developed a case study that outlined management's role in the failure of an information system development project within a state government-planning agency. The research highlighted critical management failures in the areas of insufficient systems knowledge, unwarranted trust, poor contracting processes, and an inescapable project failure cycle. Lyytinen and Hirschheim (1987) also published a substantial compendium of information system and management failure research. The case research used witness accounts of system failures published in government reports, computer and information system journals, and newspaper press articles as the archival sources of evidence.

In a promising contemporary review of information systems failures, Rocheleau (1997) studied a number of US government agencies and developed a summary table of problems and limitations that afflict government information systems and management practices. In particular, the review identified system integration limitations, obstacles to data sharing, poor management, and low data quality as important problems. Rocheleau (1997) quoted the following examples:

- The US Environmental Protection Agency experienced system integration difficulties as the organisation attempted to integrate the separate systems within each of its field offices. The data integration problems inhibited the agency's understanding of national pollution types and sources, and its capacity to deal with pollution problems (US General Accounting Office 1992).
- Small emergency agencies such as police and fire departments have difficulties sharing and exchanging information sets. Organisations may be reluctant to share information fearing a loss of political power or control, misuse of the data or information, or criticism in the media or public domain (US General Accounting Office 1994). As a consequence, many individuals jealously guard and control their most important information.
- High quality information systems and technologies are not a substitute for poor management. Using a high quality information system cannot rectify poor system and/or organisational goals, deficient business and management processes, and weak leadership and decision-making (Schmitt and Kozar 1978). Other management factors that can impact system failure profiles include insufficient staff or staff skills and ineffective organisational structures (US General Accounting Office 1995a).
- Missing or inadequate data impacts the capacity to make accurate and fast management decisions. Incomplete data sets do not support informed judgments on important public issues such as community health or civil aviation safety (US General Accounting Office 1994, 1995b).

Other studies have also highlighted the criticality of data timeliness, completeness, and relevance for decision-making and solving business problems (Fisher and Kingma 2001). Some of the issues identified in the prior research, such as information timeliness, completeness and relevance, will be discussed in the balance of the paper.

THEORETICAL BASIS FOR THE STUDY

The Bostrom and Heinen studies (1977a and 1977b) provided a useful socio-technical systems lens for the conduct of the study. Bostrom and Heinen (1977a and 1977b) characterised the organisation as a larger 'work system' that could be bifurcated into a technical system and a social system. The work system was conceptualised as a complex interdependent and complementary set of information systems, with the work outputs resulting from the various systemic interactions. From the technical perspective, the study examined the technical processes, tasks, and technologies required to produce and deliver the government warning information sets (ie, telecommunications, satellite communication platforms, radio services, geographic information systems). The social systems analysis investigated and observed the social relationships among people, including the attributes of people such as educational background, attitudes, skills, values and personal qualities.

INFORMATION COLLECTION PROCESS AND LIMITATIONS

The information collected for this paper used the archival research approach adopted by Lyytinen and Hirschheim (1987). The information was extracted from published public reports, articles from world media sources, and expert opinions and public commentaries collected over a two month period from 27 December 2004 to 27 February 2005. Particular emphasis was placed on high profile information system and management failures reported through several independent sources or entities. The paper also draws heavily on technical information systems papers and data sets produced by geological and environmental government agencies and academic institutions, and the public opinions and commentaries from world experts and researchers in the fields of earthquakes, volcanoes and tsunamis. This data collection process was undertaken to canvass and develop balanced views of the information systems and management failures and the potential solutions for providing early warning information for impending natural disasters.

This research approach has similar limitations to the work of Lyytinen and Hirschheim (1987). The archival data collected relies on negative accounts of the information systems and management failures and generally does not provide any positive or counterbalancing views. A number of the expert opinions reported in the international press, and used in the research are of a limited and non-analytical nature. Also, in this paper information systems and management failure has been defined as the breakdown of systems and management procedures that ultimately led to the loss of life. In other studies, information systems failure has been characterised by the limitations in corporate understanding (US General Accounting Office 1992), inhibited corporate system integration (US General Accounting Office 1994), or a loss of management control (US General Accounting Office 1995a). These differences in the definition of failure do not readily support comparisons with the prior information systems and management research studies.

GOVERNMENT INFORMATION SYSTEMS AND MANAGEMENT FAILURES

The following examples, drawn from public reports, media articles and expert opinions, discuss some of the more visible and unusual government information system and management failures that occurred prior to the tsunami wave strike. While the early warning information would have done little to alleviate the physical and property devastation from the tsunami, the information may have allowed people to escape to higher ground or take other emergency actions.

India's tangled and complacent bureaucracy

In possibly the worse case of government information system and management failure, the Indian government wasted valuable time in issuing the first tsunami alert (Channel News Asia International 2004; Chadda 2005). In a chronology of events that reflects the poor state of information management within that country, the Indian Air Force was advised of the earthquake at 7.30am (0200 GMT). Before the communications link failed, a frantic message that: *the island was sinking and there is water all over* was received. However, it was some 45 minutes later at 8.15am that the Chief of the Air Force requested an administrative assistant to alert the defence ministry.

Independently, at 8.54am the Indian Meteorological Department sent a warning fax message to the former science minister, not the current minister who was installed in May 2004 due to national elections and a change in the ruling government. Unaware of this mistake, the department sent another fax to the Home Ministry's disaster control room at 9.41am. Nearly an hour later at 10.30 am (0500 GMT), the disaster control room advised the cabinet secretariat. India's crisis management group met at 1.00pm (0730 GMT) that afternoon (five and a half hours after the initial alert).

To make matters worse, the head of the science and technology department stated publicly that the first advice his department received on the earthquake-tsunami was what they saw on the television! Indian seismologists had monitored the seismic event, but in their complacency had ignored the data as it was outside India's geographic borders. Critical and relevant early warning information was ignored and thousands were now dead or missing.

Messages to Indonesia go unanswered

In Indonesia, the situation appeared little better than the experiences of India. Some twenty minutes after the earthquake hit, the Pacific Tsunami Warning Centre, operated by the US National Oceanographic and Atmospheric Administration (NOAA), in Honolulu issued e-mail messages to Indonesian officials warning them of the likelihood of a tsunami and impending disaster. US officials were unable to confirm what had happened to those warning messages (Kayal and Wald 2004). Additionally, because the US monitoring centres concentrate on the Pacific Ocean, NOAA staff had no counterpart addresses or contacts in the effected countries bordering the Indian Ocean. The well-intentioned collaboration and information sharing between national geological survey organisations had not been sufficiently progressed to assist effected countries. Despite the best efforts of the US scientists, inter-government information transfer and sharing had failed.

Staffing absences, slow information processing, and limited coverage

The International Monitoring System (IMS) of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) recorded the earthquake on 78 of its seismic monitoring stations within minutes of the event. Seventy-one stations were using the seismic, six the hydro-acoustic, and one the infrasound technologies for the earthquake monitoring task (CTBTO 2005). Following standard operating practices during the Christmas and New Year holiday period, the first automatic event list containing the Sumatra earthquake data was released by the International Data Centre (IDC) in Vienna to effected treaty signatories (ie, Australia, Indonesia, Thailand, Kenya, Malawi, South Africa, Oman) about two hours after the event, that is at about 03:00 UTC on 26 December 2004 (The Times Newspaper 2005). The second and third automatic event lists followed at 6 hours and 12 hours after the event. In this case, not only was the transmission of the warning information slow due to personnel absences, but some of the worst effected countries were not informed (ie, were not signatories to the treaty or did not have data centres established). Again information transfers and sharing had failed.

Inter-government Protocols – with lives in the balance

In another unusual chain of events, Geoscience Australia's earthquake monitoring centre reacted quickly to the incoming data and issued warning messages to Australia's regional embassies within thirty-three minutes of the initial earthquake. However, no warning information or earthquake data was passed to foreign governments in accordance with proper inter-government and diplomatic protocols being observed. Information transfer between the impacted countries had failed. With thousands of lives in the balance, the current government to government protocols, built upon outdated foreign country engagement guidelines and outmoded cold war philosophies, may require substantial simplification and improved flexibility (The Times Newspaper 2005).

WARNING INFORMATION SYSTEMS, TECHNOLOGIES AND EDUCATION

Reflecting on the reported examples of critical information system and management failures, it becomes evident that seismic and earthquake warning information was handled poorly at the intra and inter governmental levels. Several information transfer choke points or bottlenecks have worked to reduce the warning information velocity, and appear to have lead to the preventable loss of life. However, the technology and educational processes required to save lives exists today. The following sections discuss some of the available warning information systems and education processes, and pose that human relations, in particular government bureaucracies, are the weakest link in the information chain. It could be argued that the systemic weakness resides with government bureaucracies and the human side of this tragic event.

Tsunami detection information systems and technologies

The US NOAA commenced using a deep-water sensor array to measure water pressure and changes in water depth as a tsunami wave passes overhead in 2003 (NOAA 2003). The Deep Ocean Assessment and Reporting of Tsunamis (DART) sensors deployed to the Pacific Ocean basin are more accurate than the seismograph and tidal gauge sensor systems, and generally lead to fewer tsunami false alarms. Importantly, DART sensors transfer the critical tsunami warning information (ie, water pressure and depth changes) to surface buoys, which in turn relay the information to the monitoring centres via geostationary satellite communication systems (see **Figure 1**). Clearly, noting that no tsunami monitoring system is deployed in the Indian Ocean, the modern technologies, such as DART sensors, that are capable of detecting tsunami waves and distributing this vital government warning information presently exist and are protecting the Pacific Ocean basin.

The importance of the DART sensor arrays and associated information technologies cannot be underestimated given the costs of issuing incorrect warning information. In one notable case of a tsunami false alarm, the evacuation of a section of Hawaii in 1986 cost the United States government approximately $30 million (Vergano 2004). Additionally, from the social perspective, false alarms have proven to be counter-productive, including breeding psychological complacency to warning signs, and lulling the community into a false sense of security.

Satellite imagery and communication systems

Satellite based imaging systems deployed by the Centre for Remote Imaging, Sensing and Processing at the National University of Singapore (CRISP-NUS) were able to identify unusual wave patterns off the coast of Thailand on 26 December 2004 (see **Figure 2**) (CRISP-NUS 2005). Using the satellite data, NUS scientists noticed a series of unusually fast moving water patterns just off the Thai coastline. In the following hours and days, the reasons for those unusual wave patterns became clear. A further series of high-resolution satellite images (including processed geographical information systems data) shows the physical devastation of Katchall Island in India's Nicobar group (see **Figure 3**) (CRISP-NUS 2005).

Despite the availability of these advanced technological tools, warning information was not successfully managed and transmitted to the relevant government authorities. One could speculate that even if information had reached the appropriate people, the question of available and reliable communications to the effected population remains unanswered. David Ovadia, Head of British Geological Survey International outlined the problem: *It's one thing knowing a tsunami is coming and another to warn the population in time. The real problem is what to do after the red light, which is an infrastructure problem* (Knight 2005). The government officials would have required the appropriate warning information infrastructure to alert the local population of the impending disaster. This type of communications and broadcast information system infrastructure does not exist in the effected countries, and shows a distinct weakness in government information systems and management processes.

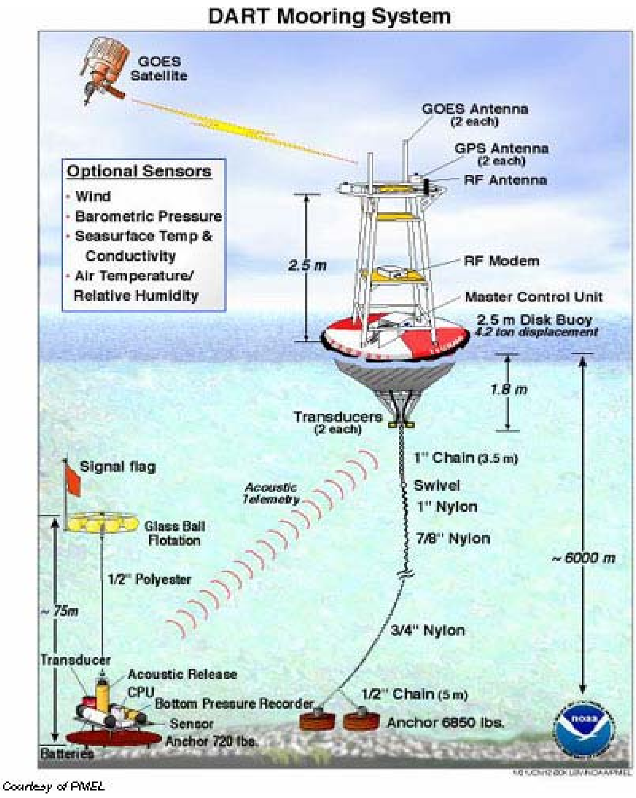

Figure 1: Schematic of the DART oceanographic information system (NOAA 2003)

Education – disseminating earthquake and tsunami information

The requirement for educating people and disseminating information on the dangers of earthquakes and tsunamis was further reinforced in the light of the government information management failures. A good example is the actions of hundreds of Sri Lankan children who were swept away while combing the receding shoreline for fish (ie, the water line recedes appreciably just prior to a tsunami strike following an earthquake). Earthquake and tsunami education might have alerted the children and their parents to the impending danger posed by the incoming walls of water (Wikipedia 2005). In an example of relevant education and information saving lives, one British family fled northern Phuket in Thailand after their 10-year-old daughter remembered a geography lesson that explained how the beach line recedes prior to a tsunami wave strike. In this case, people's understanding of geological events and the physical warning information helped to save lives that would otherwise have been lost (Wikipedia 2005).

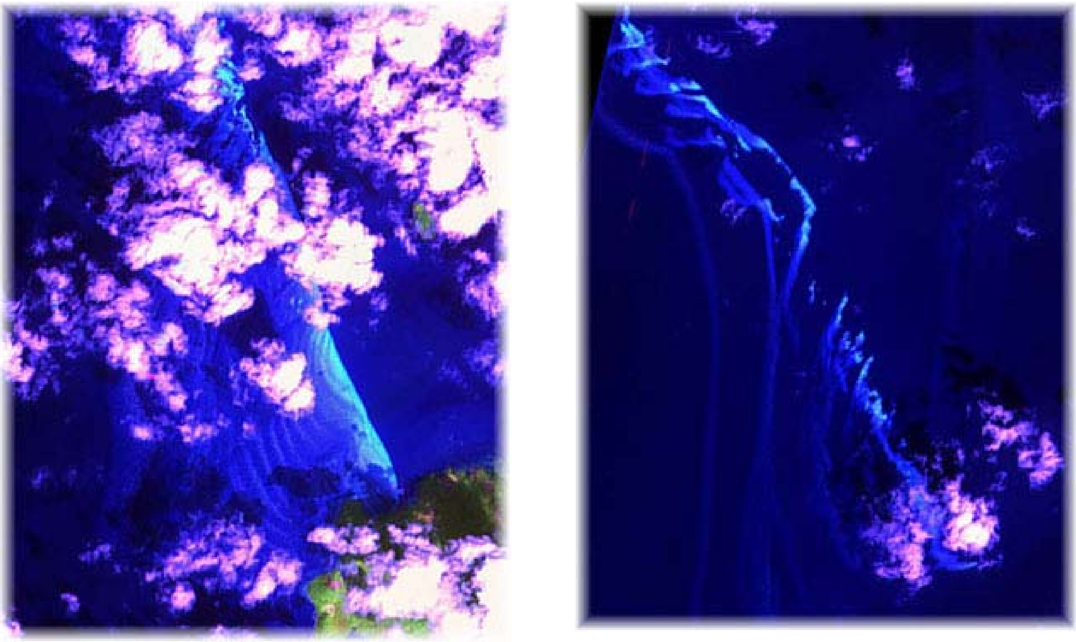

Figure 2: Unusual Wave Patterns on the coast of Thailand on 26 December 2004 (CRISP-NUS with SPOT-4 Satellite images, Centre National D'Etudes Spatiales 2004)

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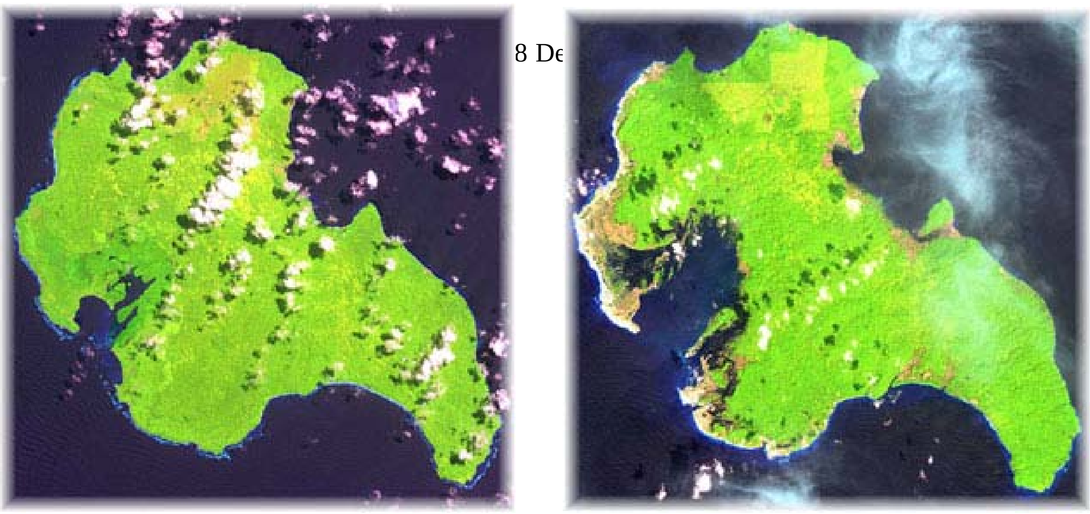

Summary

The information and communication technology systems that can detect and warn people of an impending tsunami currently exist and are deployed in other ocean basins around the globe. It can be argued that humans, including the intrinsic understanding of earthquakes and tsunami events, form the weakest link in the tsunami warning information system. Whether it is the tangled government bureaucracies of countries like India or Indonesia, or the lack of sanctioned government information system infrastructure for disaster warnings and widespread communications, information sharing and dissemination will continue to be a problem in the immediate term. Any future government information systems that will be developed for the issuing of tsunami warnings should carefully consider the human and technological aspects of the problem. Teng-Fong Wong, a geophysicist from the State University of New York in Stony Brook, put the two parts of the problem into perspective: *It's a people problem not a technology problem. Governments just have to co-operate* (Vergano 2004).

VALUABLE LESSONS AND REACTIONS TO THE TSUNAMI

The following sections provide a summary of the valuable lessons learned and some of the international community's reactions to the Boxing Day tsunami and the issues surrounding this catastrophic event.

Technical systems implementation

The regional governments in the tsunami impact zone have now taken steps to establish a proper early warning information system similar to that deployed in the Pacific Ocean. Phil McFadden, the Chief Scientist at Geoscience Australia, has been commissioned by the Australian government to design an early warning system for the Indian Ocean. Early designs suggest the system could consist of 30 seismographs to detect earthquakes, 10 tidal gauges, and six DART buoys at a total estimated cost of A$20 million (Knight 2005). Additionally, the United States government has announced plans for an improved tsunami detection and warning system. The expanded system will form part of the Global Earth Observation System of Systems (GEOSS) and will see 32 new DART buoys deployed at a total cost of $37.5 million during 2005-2006 (NOAA 2005). If implemented properly, this approach should address the technical side of the government information system problem.

Information sharing issues

The human side of the tsunami warning problem is something that may prove far more challenging to solve. For example, government to government information sharing protocols must be established in order to maintain warning information velocity. One of the biggest lessons learned from this natural disaster is that international government agencies have not worked hard enough to establish clear high velocity communication links. This inter-government communication work must be expedited in the immediate term. Charles McCreery, Director of the Pacific Tsunami Warning Centre, gave his account of the information transfer difficulties and the urgent need for future work: *We wanted to try and do something, but without a plan in place then, it was not an effective way to issue a warning, or to have it acted upon. One of the things that was running through my mind is just that our international group has in many past meetings had discussions about what can be done for other ocean basins (to issue warnings of impending tsunamis). And I guess I was wishing in retrospect that more progress had been made in that area* (Kayal and Wald 2004).

Disaster management and evacuation planning information

Tightly coupled to the need for improved government information sharing is the requirement for disaster management and evacuation plans. The challenge in protecting people from earthquake and tsunami disasters is *"getting the word out"* and *"getting people to abandon their homes and cities at a moment's notice"* (Coren 2005). Jeff LaDouce of the US NOAA emphasised that, given the speed of a tsunami, warnings are of little use without firm population evacuation plans: *Even if you give the tourists resorts in Thailand a half-hour's notice, it's no easy matter to evacuate swaths of coastland. You have to plan and train people. And then do it all over again* (Vergano 2004). Harold Mofjeld, a senior scientist within the NOAA tsunami research program, also highlighted the importance of timely tsunami warnings when the waves travel at over 750 kilometres per hour over deep water: *The basic criteria is to get a warning out within 10 and 20 minutes* (Coren 2005).

In a statement to government leaders, the Director of the US Geological Survey, Dr Charles Groat advised the US Senate Committee on Science, Commerce and Transportation that providing adequate warnings to people in areas like Hawaii was very difficult, let alone in less developed countries like those effected by the tsunami: *The* *run-for-your-life business has to be communicated very quickly and very effectively and that's a challenge even in our country* (Cable Network News 2005). As a priority, national governments need to take an active role in establishing disaster plans for coastal and tourist resort areas. Emergency and warning infrastructure, such as robust and disaster-proof communications centres, evacuation sirens, sign-posted vehicle escape routes, and visible high ground shelters should form part of these future protective arrangements.

Earthquake and tsunami education

Public and community education on the dangers of seismic events also needs to be pursued with some urgency. For too long, complacency has seen Asiatic earthquake tremors go unnoticed with local people, foreign visitors, and tourists generally uninformed of the potential dangers and unconcerned for their personal safety. The world renowned US seismic expert and Robert P. Sharp Professor of Geology at the California Institute of Technology, Dr Kerry Sieh toured the Sumatra area some three weeks before the eruption distributing educational posters and warning information to locals that outlined the potential devastation that earthquakes and tsunamis can cause. Dr Sieh also lectured several government officials on the dangers posed by earthquakes all to no avail (Kayal and Wald 2004). In this case, public education, information on earthquakes and tsunamis, and heeding expert opinion might have played a positive role in saving some of the lives that were lost.

Information – the universal resource

In a stark reminder that Mother Nature does not discriminate on the basis of geographic or international boundaries, disaster-warning information should be looked upon as an international asset with no pure sovereign value. As this tragedy has shown, Indian scientists learned an important lesson that seismic events can have far reaching effects well outside the event's national boundaries (Channel News Asia International 2004; Chadda 2005). This form of seismic data and information is typically collected and shared by government agencies on a co-operative international basis, and accordingly should be classified as information belonging to the broader global community. This is an important issue for all governments around the world not just those directly impacted by the Asian tsunami.

GOVERNMENT WARNING INFORMATION SYSTEMS AND MANAGEMENT - FUTURE RESEARCH

This paper provides a basis for future research directions in the area of government warning information systems and management. A potential research agenda that might be developed and progressed in the future is outlined in the following points:

- Case research techniques might be used to study the various governmental actions and reactions to the earthquake and tsunami. A comparison between pre-tsunami and post-tsunami warning information systems and management procedures and processes (including infrastructure developments) could be conducted in one or more of the effected countries.
- Comparative research studies might be conducted in countries and/or areas that have instituted earthquake and tsunami warning information systems (eg, Hawaii) and those that have not (eg, Indonesia). The research program might identify exemplar approaches to warning information systems development and implementation, business continuity planning, and produce best practice guidance for countries that are seeking to develop and implement similar systems. A further spin-off area of research would be the applicability of these types of warning information systems and technologies to other natural disasters, such as uncontrolled fires, flash floods, hurricanes, or cyclones.
- Research on the scope and types of earthquake and tsunami warning information dissemination and education programs might be conducted in the effected countries. This could include attitudinal surveys towards physical seismic warnings (such as low level tremors) in pre and post education program delivery environments, or a consolidated review and analysis of warning information dissemination and education program delivery modes, channels and materials.
- A policy research program might also be initiated to examine the future changes in government information sharing arrangements between countries that have advanced warning information systems and management procedures (such as the United States) and less advanced countries (such as Indonesia or Thailand) that are susceptible to earthquakes and tsunamis. The research might investigate changes in government information sharing policy and procedures at the broader whole-of-government (eg, United States and Indonesian governments) or specific inter-agency (eg, The National Coordination Agency for Surveys and Mapping of Indonesia and United States Geological Survey or NOAA) levels.

CLOSING COMMENTS

The problems and issues highlighted in this paper shows that information systems and management practices are critical for saving lives in times of natural disasters. In the wake of Asian tsunami tragedy, governments should carefully review their critical information systems and information management practices. The systematic failures outlined in this paper also demonstrate the importance of information and data sets to the global community, not just the sovereign nations who recorded the data or created the information. This paper presents that governments around the world must take positive actions to address global warning information system and management shortcomings. Those who perished on 26 December 2004 should not have died in vain. Dr Sieh made this point most poignantly in his article for Time Magazine: *One test of whether humanity acts differently in the next millennium is this: Can we marshal the visionary persistence needed to take charge of our future? Or will we carry on as we did throughout most of the past—simply reacting to tragedies as they happen? If the answer is the second, then there will continue to be more tragedies like that of last week* (Sieh 2005).

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