An information infrastructure for disaster management in Pacific island countries

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Introduction

There is nothing more certain in the disaster management business than the fact that once a disaster starts to unfold, it is too late to start looking for the information needed to manage it.

This paper[1] reports on a study into the information needs of disaster managers in Pacific Island Countries (PICs) and the nature of the information infrastructure needed to ensure delivery of that information. It addresses two key aspects. First, it provides a guide to follow by those engaged in disaster management and research in building their own project, national or regional disaster information collections. It is specifically targeted at the National Disaster Management Officers (NDMO), regional agencies such as the South Pacific Applied Geoscience Commission (SOPAC) and aid donors. Second, it makes some observations on a range of technical and organisational issues, such as data formats, transfer standards and custodianship arrangements, that need to be considered in establishing and operating any modern information infrastructure.

Key input to the study was gained through two workshops. The first was in Suva, Fiji, in October 1998 in conjunction with the 7th IDNDR Pacific Regional Disaster Management Meeting and the second was held in Cairns in November 1998 in conjunction with a conference organised by the Centre for Disaster Studies at James Cook University.

Data, information & knowledge

Collections of data are raw material. They are of little value on their own, but begin to gain value when they are drawn together to create a body of information. Decisions can begin to be made once this has been done. Information, in turn, gains greater value and potency when it is integrated with other information (and experience) to generate knowledge. Sound decisions are based on knowledge. Wisdom, for disaster managers, emerges from learning the lessons of success and failure gained through managing actual disasters, and requires a store of knowledge. It is clear that a large store of knowledge of disasters already exists in villages and communities throughout the Pacific. For modern disaster managers, it will need to be built through the formal analysis and assessment of actual events and the post-disaster debriefing process.

One of the first systematic reviews of the need for information and the application of information technology in the disaster management field was undertaken by a subcommittee of the US Congress after the Mount Saint Helens volcano disaster of 1980 (US Congress 1983). That group described the development of 'profiles of need' and the identification of the 'essential elements of information' as integral parts of the information management process that lies at the heart of any information infrastructure.

Information management

Information management is a simple cyclical process with has four stages: direction, collection, processing (or collation) and dissemination (*Figure 1*).

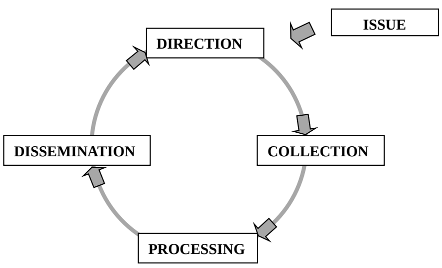

Figure 1: The information management cycle

Direction

The first steps in establishing any information management regime are to:

- monitor the external environment to identify problems as they evolve and to be responsive to issues that are identified from outside the 'system'
- define the problems to be addressed
- identify the information requirements that flow from them
- identify who is to benefit from the information

It is through this process that the elements of information and profiles of need discussed in the US Congress report (1983) are established and the broad nature of the information requirement becomes clear. Once the problem has been defined, the collection of information can be planned to satisfy the profiles of need and to assign responsibility for gathering and maintaining the information.

In a disaster management context, delegation of responsibility for information collection and maintenance might parallel the responsibilities outlined in the disaster plan. For example, the agency with responsibility for the provision and management of emergency shelter would, as part of that, gather and maintain information on shelter resources and their status. Such an approach avoids the need to set up an information collection and management system completely separate from the disaster management system.

A central point of control for directing the information management process is, none-the-less, needed within the disaster management process. This will need to interact with the wider local, provincial or national information management control arrangements to ensure that the disaster management information requirements and needs are adequately represented in the wider process.

Collection

Implementation of the collection plan should focus on the essential elements of information that have been identified, with collection priorities flowing from the profiles of need. Working to the standards established by the directors of the information management system, information collectors need to employ all the data capture resources available to them. These include making use of *existing* information, which may have been developed for other purposes, such as land management or social planning, but which is also relevant to disaster management.

Where data must be captured from scratch, remote-sensing technology, on satellites or aircraft, holds great potential in a disaster situation especially in remote areas, while global positioning systems (GPS) make accurate positioning very simple. The bulk of information collection, however, will need to rely on more basic and traditional methods such as getting out and asking questions or making measurements on the ground.

Getting the gathered information to those who need it is part of the collection process. Again, technology provides many advantages, though traditional methods continue to remain important in Pacific Island Countries.

It is important to involve the eventual users of the information in the design and development of the collection process, not only to ensure that their needs are fully taken into account, but also to maximise acceptance of the process by users. This is a central focus of the village-based Community Vulnerability Assessment (CVA) methodology being developed as part of the South Pacific Disaster Reduction Program (SPDRP), for example (see UNDHA 1998).

Processing

In this stage, answers to the various questions are developed by converting data into information. This calls for a system that facilitates the collation, analysis, evaluation and interpretation of the data. Here, tools such as GIS, databases and spreadsheets provide considerable help. It is important, however, to ensure that information processing for disaster management is not totally dependent on technology or the skills and experience of one person.

Some of the more complex forms of processing, such as terrain modelling or analysis of multi-dimensional inter-relationships, such as the effect of wind at different levels on the spread of ash during a volcanic eruption, are simply too slow, too difficult, or too daunting to be undertaken manually. They are also the types of processing that can (and should) be undertaken *before* the onset of disaster. It is also important to recognise that much of this processing does not need to be done by disaster managers. This is the role of specialists such as vulcanologists, meteorologists, social scientists and engineers, for example. Disaster managers do, however, need to receive the processed information in a form they can understand and use.

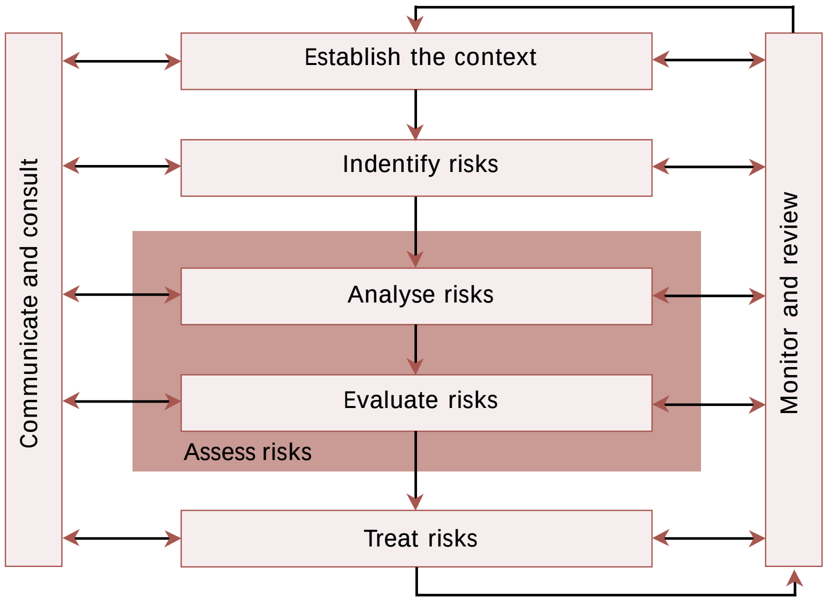

Figure 2: Risk management process *(from Standards Australia, 1999)*

Dissemination

The final process in the cycle is the timely distribution of information to those who need it to make decisions. The ability of modern systems to present processed information in a variety of forms greatly assists the dissemination of information and its understanding, thus reducing the chance of disaster managers and the general public falling into the old trap of 'information-free decision making'.

And then the process starts all over again as more disaster lessons are learned, problems are posed, and questions arise.

Disaster management and risk context

It is important that the development of an information infrastructure for disaster management be seen in the context of the community-wide information infrastructure, and that the disaster management process be seen in the broader context of community governance and risk management. Disaster management is not an end in itself, but one part in the much larger process of community governance. It involves a wide range of people and disciplines, not just those designated as 'disaster managers'.

The holistic nature of this broad view of disaster management can be illustrated by reference to the risk management process described in *AS/NZS 4360:1999* in the following terms (*Figure 2*):

> *Management of risk is an integral part of the management process. Risk management is a multifaceted process, appropriate aspects of which are often best carried out by a multi-disciplinary team. It is an iterative process of continual improvement.* (Standards Australia 1999)

In this context the prevention, preparedness, response and recovery (PPRR) components of disaster management require a multi-disciplinary approach. The medical staff involved in treating victims, the agricultural people who monitor crop production, the Red Cross organiser involved in public awareness programs at the village level, for example, are all 'disaster managers' in their own right. Collectively, they are involved in all stages of the PPRR process, even though they may not identify it as such until there is a need to respond to an actual disaster event.

The information required to support disaster management is, to a significant extent, the output from a wide range of other processes that are seemingly remote from disaster management. Professional disaster managers should, therefore, not attempt to carry out the whole process by themselves, but they should participate in the various stages so that the information flowing from each stage is understood and appropriate to their needs

Spatial information and *risk-gis*

Much of the information needed for effective decision-making by disaster managers is to do with location. This is spatial information. Typically, it includes the information that appears on maps, but it can also include information linked to locations by name or a variety of other referencing systems.

Over the past decade or so, GIS have been used increasingly as a tool to provide information to address specific aspects of disaster management problems, especially in hazard mapping and modelling of phenomena such as flood and storm

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Note

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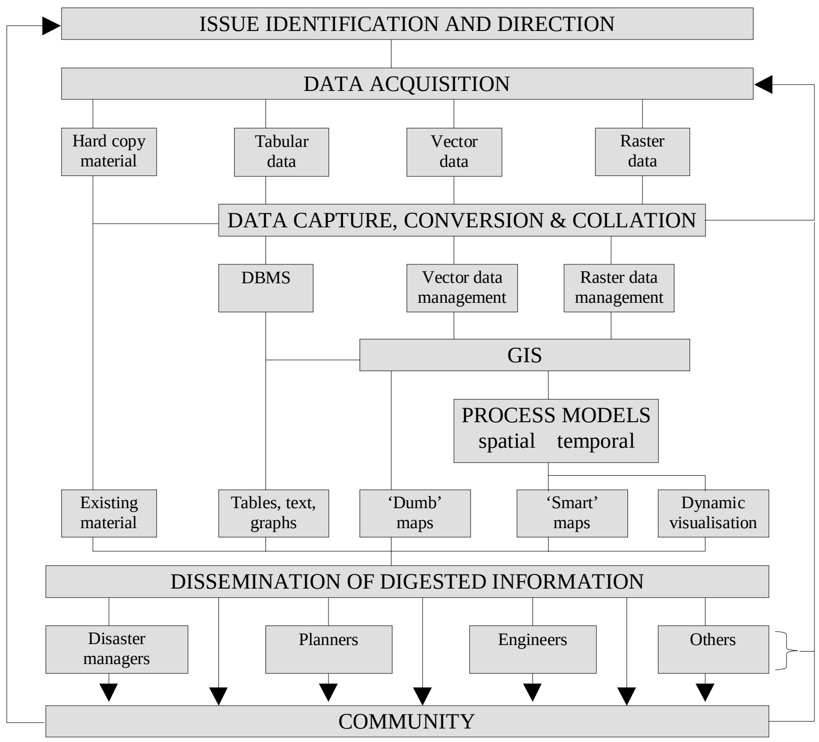

Figure 3: Risk-GIS structural elements

tide inundation. Burrough (1987) typically defines GIS, the tool, as '*a powerful set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes*'.

This definition has a clear focus on the technology, and the term 'GIS' is used in this paper to specifically refer to the technology component. There are clear advantages, however, in developing a fusion between the broad philosophy of risk and/or disaster management and the power of GIS as a decision support tool, hence *Risk-GIS* as it has been christened in the AGSO *Cities Project*. It has, as its philosophical roots, the comprehensive risk management approach outlined in the Australia and New Zealand risk management standard and the view embodied in Cowan's (1988) definition of GIS as '*a decision support system involving the integration of spatially referenced data in a problem solving environment*'. In this context, the 'problem solving environment' is risk or disaster management.

Disaster management demands a wide range of information products. To cater for this, *Risk-GIS* must be structured to cope with all external inputs, internal operations and output to a wide range of external consumers. *Figure 3* summarises the key structural elements of *Risk-GIS*.

This model goes somewhat beyond the conventional view of GIS as being made up primarily of hardware, software and data. It also incorporates the people, administrative arrangements and infrastructure issues, as well as recognising the significance of:

- the information management cycle
- the range of information products that satisfy the diverse needs of risk managers and the communities they serve and the diverse source material that must be drawn on to create those products
- the information infrastructure, which facilitates the flow of data and information throughout the model (shown as the linking lines)
- the fact that the process and structures are aimed at meeting the needs of the community as the ultimate beneficiaries, who in turn provide input to the system.

An information infrastructure

The process of information management and the structural requirements of *Risk-GIS* provide the foundations on which to build an information infrastructure, especially a spatial information infrastructure. It should be emphasised here that an information infrastructure is not a physical thing, it is more of an accepted way of doing things.

There are six elements in this model of an information infrastructure. They are:

- an information culture
- the right people
- a coordination process
- data and information products
- guidelines and standards
- an institutional framework

This model is applicable at any level of jurisdiction—from the smallest local village or project, to the local council or business level, the provincial and departmental level, the national level, and the international level. It is also applicable to any 'industry' focus. In this paper, however, it generally relates to the disaster management 'industry' in its widest context.

An information culture

The phenomenon of 'information-free decision making', referred to earlier, is not confined to disaster managers or the Pacific—it is very widespread.

There are at least four powerful forces working against developing and sustaining an information culture. The first such force is what I have called 'spinformation' (i.e. the output from 'spin doctors'), which distorts, misuses or censors knowledge for the purposes of exerting power and influence (Granger 1997).

The second is the general lack of spatial awareness shown by many decision makers, despite the fact that the overwhelming majority of decisions made in most fields contain a spatial element. How often are decisions handed down that do not make sense environmentally or in terms of community safety, simply because spatial relationships have been ignored? Housing developments on flood plains or areas prone to coastal inundation, or waste disposal facilities sited in aquifer recharge areas are just two of the more obvious.

The third force is the widespread fear of information and knowledge. There appears to be an unwritten law that the higher up the corporate or institutional ladder one climbs, the less knowledge one should seek because of the constraints it places on 'independent' decision making. The American futurist, Alvin Toffler, observed in an interview published in *Wired* (November 1993):

> *If you have the right knowledge, you can substitute it for all the other factors of production. You reduce the amount of labor, capital, energy, raw materials, and space you need in the warehouse. So knowledge is not only a factor of production, it is the factor of production. And none of the powers that be, in Washington and in the industrial centres of our country, seem yet to fully comprehend it. It scares them. It's threatening.*

The fourth, and possibly most widespread, force is a general lack of good information management practices. The 'file and forget' and the 'why bother to file' approaches are said to be very much alive and well in PICs—and elsewhere.

These barriers have got to be overcome before an information infrastructure can become a reality. Disaster managers need to remind themselves regularly of the observation made by that other great futurist, Aldous Huxley, in his essay *Proper Studies*, that 'facts do not cease to exist because they are ignored.'

The right people

GIS (the technology) is not a 'black box' solution that only requires the right buttons to be pushed to obtain 'the truth'. It requires people who not only understand the technology of GIS and its associated systems, such as GPS and remote sensing, but who also understand the real world problems they are trying to solve with GIS (the disaster, natural resource, planning, engineering and human services managers, for example). The 'right' people provide the input that energises the whole infrastructure. The 'right' people are those who are competent, committed, cooperative and communicative.

Competent people

Competent people are those who have and maintain the skills needed to do their job. This requires ongoing education and training, a fact well recognised in the disaster management field.

Given the real-world, holistic nature of disaster management, as discussed earlier, and its place in community governance processes, it is clear that professional disaster managers should, ideally, have a broad span of knowledge, but should they be expected to have, for example, a competency in, or understanding of the sciences associated with the various hazard phenomena (geology, meteorology, hydrology, volcanology, etc); structural or civil engineering; the demographic, social, economic and cultural aspects of the people that make up their communities; the psychology, sociology and politics of disaster; the logistic, communications and transport resources that support the community; and/or all of these and more?

The Australian *National Emergency Management Competency Standards* (EMA 1995), developed for professional and volunteer disaster managers, do not help to answer those questions definitively, but they do identify the need for emergency managers to be competent in the use of (unspecified) information. They contain two explicit competency units relating to information (Unit 10, Manage information, and Unit 11, Process information). Both are 'core' (i.e. compulsory) competencies and are described in terms of the 'processes of collecting, recording, verification, interpretation, structuring, collation and dissemination of emergency management information', i.e. they relate to the information cycle described previously.

The Australian competency standard also contains reference to the use of GIS, as one of the activities under Unit 2, Assess vulnerability, a process described in the standards as examining 'the interaction of hazards, communities, agencies and the environment'.

There is another spectrum of competencies involving GIS. These range from the highly technical levels of professional GIS analysts who have strong skills in programming and spatial modelling; to those who use GIS to analyse spatial issues as part of their core work; to those who simply use GIS to display a map.

The Suva workshop clearly demonstrated that there is a good pool of competent people ranging across this spectrum of GIS use. At the professional and applications end, most of these are graduates from the University of South Pacific (USP) in Suva, the PNG University of Technology (Unitech) in Lae or from universities in Australia or New Zealand. USP offers a range of courses in disciplines including earth science, geography, land management, sociology, population studies, environmental science and tourism. Some of these involve or can include training in the application of GIS.

While there may not be a large number of NDMOs or their staff who have yet gained access to or experience in the application of GIS and other spatial technologies, there are certainly competent people available in most PICs to provide that type of support to disaster managers.

Committed people

Skills alone do not guarantee a successful use of information or tools such as GIS (or indeed, disaster management). That requires a strong measure of commitment to the process involved. Again, it is clear that there is a good resource of people in the PICs who understand the issues and challenges they are meeting in the GIS and disaster management processes and want to make a difference. They are dedicated to solving the problems that confront their communities.

Communicative people

Competence and commitment are of little value if the people with those attributes are not willing to pass on their knowledge. In PICs, the widely dispersed population and, at times, tenuous links call for special efforts to be made to facilitate communication. This requires the operation of both formal processes, such as workshops and conferences; newsletters such as those facilitated by SOPAC; and informal networks such as the GIS user groups that exist in Suva and other centres.

Cooperative people

It is clear that no individual or organisation has all the answers, either in disaster management or in the use of GIS. To maximise the acknowledged benefits of both, it is essential that an environment of cooperation both within organisations and between organisations is strongly maintained. There is clearly a strong level of cooperation within and between the various NDMO organisations. That commitment is not, however, always experienced between organisations that develop, manage or look after spatial information and GIS resources.

This situation is not peculiar to the PICs. In the multi-hazard risk assessment undertaken by the AGSO *Cities Project* in Cairns, data was assembled from at least 35 different sources, most of whom, at the time, did not share information with any of the others (Granger 1998). Some were not even aware that the others actually existed!

A coordination process

PIC disaster managers clearly acknowledge that information is an essential ingredient to effective and sustainable decision making at personal, organisational and jurisdictional levels. A culture of information is well established in this community. The practice and experience of using it, however, has yet to develop to the same degree.

It is also clear that the information needed for decision making tends to be developed, used and managed in an insular fashion (also by individuals and organisations), without much reference to others, who may have an interest in or need for the same or very similar information. There are many instances of expensive information collection programs being undertaken by two or more different agencies, more or less simultaneously and in the same community, without the knowledge of, or reference to, agencies with similar needs.

There are solutions available to facilitate the linkage of the many 'islands' of information and thus break down this insularity. While many of these are built round technology, the principles of coordination and cooperation, on which they are based, are non-technical. The development of these links is the objective of what is usually referred to in the literature on spatial data infrastructures as the 'clearinghouse' network or mechanism.

The clearinghouse

The US literature on their National Spatial Data Infrastructure (NSDI) describes the clearinghouse concept as 'a system of software and institutions to facilitate the discovery, evaluation, and downloading of digital geospatial data' (FGDC 1997). This description identifies two distinct aspects, namely:

- from an *institutional* perspective, it is a referral service, or a 'library index' used to discover who has what information; and
- from a *technical* perspective, it is a set of information stores that use hardware, software and telecommunications networks to provide access to information.

Institutional issues: The key objective of the clearinghouse is to identify what information is available, where it came from and who has it. In reality, a clearinghouse can be as simple as a box full of reference cards or as complex as some of the directories that are already in place, such as the Internet-based Australian Spatial Data Directory or the CD-ROM-based Queensland Spatial Information Directory.

SOPAC's Internet-based 'virtual library' provides another, more general, example of a technology driven directory (found at *www.sopac.org.fj*).

Like any library index the clearinghouse directory does not contain actual information, it only contains information that will help the researcher to make a judgement as to whether it is what they are looking for, and if so, where to find it. This information is referred to as metadata (data about data).

Metadata describes the content, quality, condition and other characteristics of the material of interest, be it data in a database, a satellite image or a coverage of aerial photography, a report or a map. The key headings for a metadata directory for spatial information (i.e the SII 'library index') should include:

- Identification (title of the database, map, report, etc.; area, place, etc. covered; themes and subjects addressed; currency—when the material was produced or last updated; whether the material can be released to anyone or if there are access restrictions).
- Data quality (accuracy; completeness; logical consistency; lineage—where the data originated and what has been done to it since)
- Data organisation (is it spatial or non-spatial, structured or free text, digital or analogue, etc.; if it is spatial data, is it vector data with or without topology, is it raster data, and what type of spatial elements are involved—point, line, polygon)
- Spatial reference (projection; grid system; datum; coordinate system)
- Entity and attribute information (features—topography, buildings, social value, cultural feature, etc.; attributes; attribute values—quantitative, qualitative, names, scales, etc.; time perspective—historical, real-time, forecast, etc.)
- Distribution (distributor or custodian—who to contact; on line or postal access address; language or languages available; formats available—database, spreadsheet, map, book, etc.; media available—audio tape, video tape, floppy disk, CD-ROM, paper, film, etc.; price and payment details)
- Metadata reference (when was the metadata developed; who was responsible for the metadata)

This scheme can be applied to any form of information, be it the most sophisticated *Risk-GIS* information, or an oral history recorded in a remote village; a satellite image or a sketch in a field notebook, and so on—it is all information and it all needs to be properly indexed.

The Australia New Zealand Land Information Council (ANZLIC) has established a standard for spatial metadata, the details of which can be found on their Internet site at www.anzlic.org.au/metaelem.htm. This is a highly technical standard, designed mainly for traditional spatial data products such as cadastral and topographic databases. It is, none the less, in increasingly wide use in Australia and it might be a useful model for SOPAC and PIC authorities to look at if it is decided to go down a more formal information infrastructure path.

Technical issues: Once the information needed has been identified and access has been arranged, the next issue is to transfer it from its source to the user. Traditional 'hard copy' materials, such as books, reports, maps, films and photos, are typically transferred physically, i.e. sent by hand, post, courier, and so on. For digital material the transfer options are somewhat greater, though in many cases the actual transfer will still rely on physically carrying or posting the transfer medium from the originator to the user.

Data and information products

The identification and provision of the data sets and products required by the widest range of users is a central aspect of any information infrastructure. The data sets and products provide the foundation on which all decision support applications may be built. It is usual to establish minimum (or fundamental) requirements for both baseline data sets and those required for direct disaster management. Those requirements will evolve as experience in the application of spatial information increases in disaster management in PICs. It is a function of the coordination process to monitor and manage that evolution.

What information?

Disaster management is, by its very nature, an information-hungry activity. It must deal with real-world issues and cover the full range of activities involved in preventing, preparing for, responding to and recovering from disaster impacts. It is also important to reiterate that the PPRR of disaster management is but one of the treatment strategies of comprehensive community risk management. It should, therefore, be supported by the process of risk assessment as outlined previously. The information needed across this combined span of activity must be capable of describing or defining the widest possible range of real-world issues. This differs markedly from most other activities, such a land management or regional planning, which tend to have a significantly narrower subject focus.

The temporal span may also need to be comprehensive. Throughout its various stages, disaster management can require information that is, at least by human timeframes, timeless (such as climate, terrain or geology); it needs information on past events; it needs immediate information about the current situation; and, it needs information about the future, in the form of forecasts or predictions. Disaster managers may need access to great detail down to the level of individual buildings and people, or general information across wide areas, such as sea surface temperatures across the whole Pacific Basin.

This does not, however, mean that disaster managers need to know everything about everything. The trick is to identify what information and information products are required at which stages of the risk assessment and disaster management processes, so that they can be prioritised. It is important, therefore, to follow a systematic process that maximises the efficiency of information management and minimises duplication of information collection and, more importantly, gaps in information—hence the need for an information infrastructure.

Dividing the task

There are many ways of systematically dividing the task of information management. The scheme described here is based on the experience we have gained under the AGSO *Cities Project* (Granger and others 1999).

'Risk' is the outcome of the impact of hazards on a community. The organisation of information can, therefore be split between the two key factors:

- the hazards and environments in which they operate
- the elements at risk and their characteristics that make them more or less vulnerable to disaster impact.

This approach, however, does not take account of the level of community awareness and acceptance of risk that is an important component in risk communication and in the prioritisation of risk treatment options, and hence disaster management. This factor also needs to be included.

These components come together in the *Cities Project's* understanding of the risk management process, and consequently our approach to information management. This is illustrated in *Figure 4*.

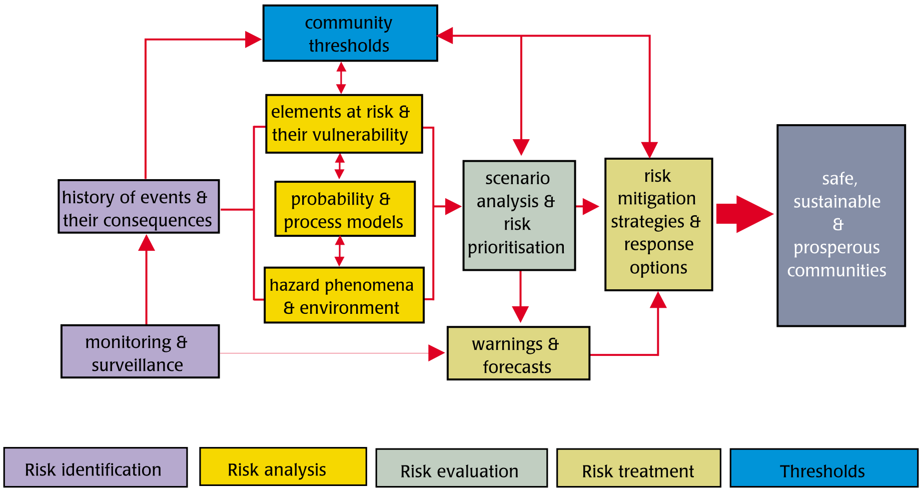

Figure 4: *Cities Project* understanding of the risk management process

Atmospheric	Earth	Biological	Human
tropical cyclones	landslides	human epidemics	industrial accidents
tornadoes	earthquakes	plant epidemics	transport accidents
storm surges	tsunamis	animal epidemics	crime
floods	volcanoes	plagues	political conflicts
frosts	lahar	bush fires	structure failures
droughts	erosion		structure fire
severe storms	ground failure		contamination

Table 1: Classification of hazards

Hazards

The hazard phenomena that are most relevant in PICs can be divided into four groups, on the basis of their origin, as shown in *Table 1*.

Obviously, not all of these hazards are experienced in all PICs. Frosts, for example, are probably only an issue in PNG, whilst tropical cyclones are a relatively rare problem in PNG. Overall, however, most countries can potentially be affected by most of these hazards.

The information required by disaster managers on hazard phenomena is typically confined to:

- the history of hazard impacts and their consequences
- warnings or forecasts of an impending hazard event
- forecasts of the likely level of impact of events of different probability (i.e. hazard scenarios).

To provide that information on at least the last two of these, however, hazard scientists require a wide range of data on the respective phenomena and the environments they function in.

Hazard history: Information on the community's experience of hazard impacts is, in my experience, perhaps the single most important resource that should be available to disaster managers. It represents reality and helps to overcome the inherent problem that human memory tends to be significantly shorter than the return period of most hazard phenomena.

There are many sources for this information. The availability of well-managed collections of such information, however, is highly variable and typically confined to the larger PIC and international agencies, such as AGSO at *www.agso.gov.au*, the Australian Bureau of Meteorology at *www.bom.gov.au*, the New Zealand Institute for Geological and Nuclear Sciences at *www.gns.cri.nz*, the US Geological Survey at *gldss7.cr.usgs.gov/neis/bulletin/bulletin.htm* and the US National Oceanographic and Atmospheric Administration at *www.ceos.noaa.gov*.

Documentary records of disaster events in PICs can, in some areas, extend back to the mid-to-late 19th Century or (in rare cases) even as far back as the 16th Century. These records are found in the journals of explorers, missionaries and other travellers, official government reports and through contemporary press reports. These reports are valuable because they frequently contain much information on the consequences of the disaster and how the affected community coped with the experience, though they are largely presented from the perspectives of outside observers.

Oral tradition, local myths and creation legends can also provide evidence of such events. These records often contain information on how the affected community experienced the event and how they responded. Typically, they are associated with major events in specific named locations and can be of value as a guide to modern scientific investigation.

More detailed scientific records, especially those in which instrument measurements are available, tend to date from the 1940s at best. The availability of satellite data on cyclones over much of the Pacific generally dates from the 1970s. The instrumental coverage of hazards such as earthquakes, volcanic eruptions, cyclones, severe storms and tsunamis is constantly improving, as is the number of researchers who take an interest in those phenomena in the Pacific.

The 'damage assessment workshops'

held in three PICs under the SPDRP in 1997 and 1998 have established an excellent framework on which to collect post-event impact information. The generic 'initial damage report' forms developed for Cook Islands, Samoa and Tonga, and the 'drought assessment' forms used in Fiji and Solomon Islands during 1998, are very comprehensive. In the case of Tonga, their form has been translated into Tongan and has been distributed to outer island District Officers. They were used for the first time following Cyclone *Cora* in February 1999 (Angelika Planitz, SOPAC, personal communication).

It is, however, one thing to have the proforma in place, another to have it used, and yet another thing for the data collected to be subsequently collated, analysed and preserved to ensure that the maximum value can be gained from the effort of collecting it. At this stage completed forms tend to be accumulated at the National Emergency Operation Centre in the respective country.

It is worth observing that these proforma place the PICs well ahead of most Australian jurisdictions, where there is a very poor record of detailed and coordinated post-event studies. The most comprehensive collection of post-event information for Australia is that collated by the Newcastle Region Library on the experience of the 1989 earthquake in that city. It is a very good model for such collections. The Web site *www.newcastle.infohunt.nsw.gov.au/library/eqdb/earthq.htm* provides details.

Warnings and forecasts: There are only two hazard warning and forecasting services that cover all PICs. They are the Tropical Cyclone Warning Centre (TCWC) based in Nadi and the Pacific Tsunami Warning Centre (PTWC) based in Hawaii. The Pacific ENSO Applications Centre (PEAC) in Hawaii also provides forecasts of El Nino events, though their primary clients are the US and former US Territories. These centres have well-established procedures and communications networks to provide warning and tracking of their respective phenomena. Many of the active volcanic centres close to populated centres are also monitored for activity, and warnings of impending eruption are provided. Perhaps the most comprehensive of these is that centred on the Rabaul Volcanological Observatory in PNG.

Apart from the system on Fiji's Rewa River, there appear to be no local flood-warning warning systems available in PIC. The dissemination of the warnings from the Rewa system to the communities under threat relies on established telecommunications systems, especially broadcast radio.

Hazard scenarios: Perhaps the most familiar way of providing hazard information to disaster managers and others is through the use of maps portraying the extent of the area likely to be affected by scenario events such as the '1:100 year' flood or storm tide, or the likely ash fall or blast areas for a given volcano. These are frequently referred to as 'risk maps', though they typically relate only to a modelled, or postulated, hazard scenario.

There are many hazard or site-specific studies that contain hazard scenario (or probability) information. These include an earthquake hazard assessment of Fiji (Jones 1997), seismic risk in the principal towns of PNG (Gaull 1979), various volcanic disaster plans in PNG, Solomon Islands and Vanuatu and the Suva earthquake risk management scenario pilot project (SERMP) developed under SPDRP (Rynn 1997).

Elements at risk & their vulnerability

Information on hazard phenomena alone does not provide an adequate base for disaster management. After all, if there are no people involved then there is really no disaster. The development of an understanding of the elements at risk in communities (also termed 'assets' or 'capacity' by some agencies), and their vulnerability (ranging from susceptibility to resilience) to a given hazard impact, involves input from a very wide range of disciplines, such as geography, demography, psychology, economics and engineering. It also involves many sources from both public, private and academic sectors.

There is undoubtedly a substantial amount of background or baseline information available, such as maps, population figures from national censuses and other population counts, and statistics from surveys of land use and so on. The biggest challenge is to find out that it exists, what form it is in and who has it—i.e. there is a need for a 'clearinghouse' directory. A systematic approach to listing the information needed is strongly recommended, so as to more easily identify where gaps exist.

The experience we have gained in AGSO under the *Cities Project* has led us to follow a system based on five broad groups of elements at risk, which we refer to as the 'five esses'—shelter, sustenance, security, society and setting.

Shelter: The buildings that provide shelter to the community at home, at work and at play, vary considerably in their vulnerability to different hazards. There is considerable diversity throughout the PICs as far as building structure and materials are concerned, ranging from engineered, high-rise buildings in urban centres, to temporary, 'bush material' shelters in many rural areas, and virtually everything else in between.

Disaster managers need to have details of emergency shelters and buildings that can serve as safe havens from events such as cyclones and storm tides. They also need information on the availability of material, such as tents, tarpaulins and rolls of plastic, to provide temporary post-impact shelter.

To assess the vulnerability of buildings, a range of information relating to their construction is required. These building characteristics contribute to the relative degree of vulnerability associated with exposure to a range of hazards. In Table 2, the number of stars reflects the significance of each attribute's contribution to building vulnerability.

A standard set of attribute information is now being collected in the urban centres covered by the SOPAC *Pacific Cities Project*. It is very similar to the approach followed under the AGSO *Cities Project*. This system is probably appropriate for any urban centre or for non-village settlements in rural areas such as mines, logging camps, missions, and so on, although. perhaps too detailed and complex for use in rural village communities. The SPDRP CVA method, which classifies village buildings along the lines shown in *Table 3*, provides an alternative approach.

Access to shelter is also significant; thus, information on mobility *within* the community is needed. Within urban areas, details of the capacity and vulnerability of the road network, for example, are important, e.g. flood points, bridges, steep-sided cuttings, traffic 'black spots' and so on.

Vehicles and their availability can also be important, especially for disaster managers who need to undertake an evacuation. For example, are there buses or trucks available to evacuate people who do not have their own transport, or ambulances available to move people from hospitals, and so on?

Sustenance: All communities depend on a safe and adequate supply of both water and food, and fuel (or energy) for cooking and warmth. These are the minimum requirements for a sustainable community.

The larger and more complex the community, the greater the range of infrastructures and services that have been established to sustain it. Modern urban communities are highly dependent on their utility infrastructures such as water and power supplies, sewerage, and telecommunications. These so-called lifelines, in turn, depend on each other and other logistic resources, such as fuel supply.

Power supply and telecommunications are overwhelmingly the most important of all lifeline assets in terms of what depends on them, followed closely by fuel supply, bridges, roads and water supply. Their significance to community sustainability, however, may be somewhat different; e.g. people cannot survive for long without a safe water supply, but they can survive (albeit with some inconvenience) without the telephone, fuel, light and even power for some time. Ports, airports and fuel supply are the most exposed in terms of their dependence on the widest range of other lifelines.

In most PIC villages, supplies of lighting kerosene and fuel can, to some extent, replace dependence on power, whilst water sources such as roof catchment, wells and streams substitute for a reticulated water supply. In village communities the sources of food can be very diverse, ranging from garden crops and fishing to animals (such as pigs and cattle) and 'bush tucker' gathered from the surrounding countryside. The availability of these may be seasonal and in some communities there may be traditional methods of food storage to cover times of hardship or to cover the seasons when produce is in short supply. A good knowledge of these food sources and their susceptibility to hazards, such as drought, frost or pests, is every bit as important as a knowledge of the availability of rice and tinned fish in an urban warehouse.

Security: The security of the community can be measured in terms of its health and wealth and by the forms of protection that are provided.

To establish a better understanding of health factors, information is needed on:
- hospitals, nursing homes, clinics, aid posts, doctors, nurses, dentists, x-ray services, etc.
- endemic diseases and efforts to control them, e.g. inoculation and screening campaigns
- demographic characteristics, such as the very young (under 5) and elderly (over 60 or 65)
- disabilities that reduce mobility or a capacity to cope with disaster and people who need to be accompanied by carers.

Characteristic	Flood[1]	Wind	Fire	Quake	Volc[2]
Building age	***	*****	*****	*****	****
Floor height or vertical regularity	*****	*	****	*****	***
Wall material	***	***	*****	****	**
Roof material		****	*****	****	****
Roof pitch		****	*		*****
Large unprotected windows	**	*****	*****	**	***
Unlined eaves		***	*****		
Number of stories	****	**	*	*****	*
Plan regularity	**	**	***	*****	***
Topography	*****	****	****	***	****

[1] Includes all forms of inundation hazard including storm surge and tsunami.
[2] Volcanic hazards including ash fall and blast.

Table 2: Relative contribution of building characteristics to vulnerability

Type of building	Use	Material
Timber house class A	Family	Sawn timber, nails, fibro walls, corrugated iron roof
Timber house class B	Family	Bush timber, nails and bush rope, corrugated iron
Timber house class C	Family	Bush timber, bush rope, matting walls, thatch roof
Concrete block house	Family	Concrete block walls, corrugated iron roof
Kitchen shed	Cooking	Round poles, thatch roof
Toilet	Toilet	Round poles, matting walls, corrugated iron roof
Community hall	Meetings	Concrete frame and block walls, corrugated iron roof
School classroom	School	Sawn timber, fibro walls, corrugated iron roof
Church	Meetings	Concrete frame and block walls, corrugated iron roof

Note: The CVA methodology envisages such a classification be developed specifically for each community.

Table 3: Example of a model building classification for village communities (based on UNDHA, 1998, Table 5.9, p. 39)

To better understand economic factors, information is needed on:
- the primary industries, such as commercial crops and grazing, mining, fisheries, etc.
- basic processing industries, such as sawmills, abattoirs, copra mills, basic ore treatment, fish processing plants, etc.
- other secondary industries, such as ship building, concrete batching plants and construction industries
- principal tertiary industries, including banks, insurance, clothing and footwear manufacture, crafts, tourist industry, repair services, etc.
- the degree of dependence on subsistence agriculture and fishing, i.e. the significance of the informal economy
- in the more formal economy, information on issues such as household income, unemployment and home ownership may be relevant

To better understand protection factors, information is needed on:
- ambulance stations, fire stations, police stations, defence force posts, etc.
- engineered works, such as flood detention basins, levees, sea walls, etc.
- traditional defences, such as mangrove belts to protect the coastline, etc.
- contact details for hazard specialists, such as meteorologists, geologists, engineers, etc.
- contact details for key emergency services staff, including disaster managers, police, fire service, military, etc.
- the resources available at the fire and police stations and military posts
- local, district and national disaster plans.

It is particularly important to identify those facilities and services, the loss of which would magnify the impact of the disaster on the affected community. These 'critical' facilities, such as hospitals and disaster management headquarters, may call for additional protection or planning because of their significance to the wider community.

Society: Here we find most of the more intangible, non-physical factors, such as language, ethnicity, religion, nationality, community and welfare groups, education, disaster awareness, custom and cultural activities, and so on. These are the aspects that define the social fabric of the community and the degree to which communities, families and individuals are likely to be susceptible or resilient to the impact of disaster.

Information required to better define and describe the social environment of the community can include consideration of:

- community and official languages and the levels of literacy in those languages
- ethnic and racial groups and their inter-relationships, tensions, etc.
- religions represented in the community and their inter-relationships, tensions, etc.
- cultural, social or religious constraints such as dietary restrictions, funeral requirements, cultural taboos, etc.
- representation by NGOs such as Red Cross, Saint Vincents, etc.
- contact details for key community and welfare staff such as ministers/priests/pastors, NGOs, business leaders, teachers, parliamentarians, local councillors, etc.
- contact details for traditional leaders such as chiefs and other custom leaders and community elders
- levels and availability of education and the contact details of teachers

Some of this information may be available from the periodic censuses conducted nationally. However, the more detailed information will rely very heavily on site-specific studies, such as those envisaged under the CVA methodology.

Setting: To place communities in a broader spatial and disaster management context it is beneficial to develop information on factors, including:

- the broad regional physical environment (climate, vegetation, geology, soils, land use, topography, elevation, etc.)
- population distribution and basic demographic information
- external access, including links by road, rail, air, sea and telecommunications infrastructures; the services that provide that access, such as postal services, airline and shipping service schedules, charter services, radio broadcast programming, etc.
- external sources of power and water supply, such as remote hydro-electric and water supply dams
- administrative arrangements, including local government, suburb, police district, electoral and other administrative boundaries
- legal arrangements such as cadastre and land tenure.

The broad administrative arrangements under which disaster management services are provided (while well known to insiders such as NDMOs) also need to be well documented, especially for outsiders.

Community awareness and risk acceptance

PIC communities are said to have a good level of awareness of the hazards that could have an impact on them. Certainly, where such events are fairly common (such as cyclones) or more obvious (such as an active volcano), a strong level of awareness is clearly the case. Where events are less frequent, such as tsunami and major earthquake, the level of awareness is less well developed. For communities to take active steps to reduce risks, they must obviously be aware that the risk exists and is real. This is central to determining issues such as risk tolerance or risk acceptance. To a large degree this is a key output of the risk assessment process.

In the approach to risk assessment set out in the Australia New Zealand risk management standard (Standards Australia 1999), it is the practice to compare the level of risk found during the assessment process with previously established risk criteria, so that it can be judged whether the risk is 'acceptable' or not. The acceptability factor is central to the process of risk prioritisation, and hence the development of appropriate treatment strategies, including disaster plans. This is the first step in the allocation of resources to risk mitigation, especially if considered in a multi-hazard context. Under the AGSO *Cities Project*, and with our SOPAC *Pacific Cities Project* colleagues, we are beginning to address the complex issue of comparing the risks posed by hazards with greatly different impact potential. In many coastal areas, for example, there is often a strong spatial correlation between the areas that are most at risk from major inundation hazards (river flooding, storm tide and tsunami) and those in which deep soft sediments are most likely to maximise earthquake impact. Conversely these are the areas that are at least risk from landslide impact and, to some degree, from severe wind impact. These issues are, to a degree, able to be addressed scientifically by computing probabilities and modelling *Risk-GIS* scenario impacts, and so on.

This scientific approach, however, does not really tell us what the community understands about the risks of disaster impact and how they believe those risks might be treated. It is here that the community consultation process embedded in the CVA approach really comes into its own. There are very few examples in the international literature to serve as a guide to what type of questions need to be answered in this process. One of the few I have encountered is the work undertaken in Cairns by Linda Berry of James Cook University. Her report (Berry 1996) includes a copy of the questionnaire used to survey some 600 Cairns households regarding their understanding of the risk of storm surge and their preparedness to cope. While that questionnaire would need to be modified for use in PICs, it provides an excellent starting point.

Observations: During the Suva workshop, PIC disaster managers were asked to complete a survey that asked them to rate a comprehensive range of topics according to their perceived need for information on those topics. The themes identified as being needed by more than 75% of respondents were:

- hazard history (details of previous earthquake, landslide, flood, cyclones, severe storms, drought etc.)
- population (census and estimates of numbers, age, sex, etc.)
- settlement type (city, town, village, hamlet, etc. names and locality)
- settlement structures (houses shops, schools, resorts, etc.)
- health services (hospitals, doctors, clinics, dentists, ambulance, etc.)
- welfare services (Red Cross, St Vincents, NGOs, etc.)
- agriculture (subsistence & other crops, livestock, storage, etc.)
- roads and streets (surface, capacity, bridges, etc.)
- telecommunications (phone, radio, TV, Web, mobile phone, etc)
- water supply (source, storage, treatment, reticulation, etc.)
- technical experts (GIS & computer staff, plant operators, builders, etc.)

This result is remarkably similar to the results of a similar survey I conducted within the police and emergency service agencies in Queensland in 1991.

Both surveys reflected a strong bias towards a response culture, rather than embracing a broader risk management culture. They also convey to me that there is an expectation that extra information will be provided by other agencies should, or when, the disaster managers need it. I suggest this is a very hazardous approach to disaster management, let alone risk management, unless those agencies that are expected to hold and manage that 'extra' information see themselves as part of the disaster management process and are aware of the requirements of disaster managers for their information.

As stated at the beginning of this paper, there is nothing more certain in the disaster management business than the fact that once a disaster starts to unfold, it is too late to start looking for the information needed to manage it. The risk management process tends to overcome this potential problem because much of the information needed to manage disasters has already been developed in the risk assessment process and is in a form best suited to the needs of disaster managers.

National guidelines and standards

To maximise the integration and exchange of spatial data it is necessary to establish a range of standards and guidelines as an integral part of the information infrastructure. Some of the more technical standards, such as the implementation of the national or regional spatial datum (such as WGS 84) may be mandated by legislation, whilst others may be established by default (e.g. through the widespread use of a specific GIS, such as MapInfo). The guidelines and standards developed will need to cover transfer standards (detailed technical standards to enable data to be moved from one GIS environment to another without loss of information); geographic guidelines and standards (coordinate systems and projections, location keys, such as property address; attribute content and classification standards (e.g. standard soil or vegetation classifications); algorithm guidelines and standards to cover computational operations of GIS such as slope analysis or DEM generation; and interpretation guidelines and standards to cover aspects of accuracy, uncertainty statements, descriptions of ground truthing and so on.

Institutional framework

The oversight of policy and administrative arrangements for building, maintaining, funding, accessing and applying national standards and guidelines and their application to the basic information products used across the nation requires an institutional framework. These matters typically lie outside the realm of disaster management; however, NDMOs will need to become involved so that their requirements and priorities are reflected in national and provincial spatial information programs.

It is patently obvious that, for an information infrastructure to flourish, the institutional framework in which it operates will need to be as free as possible from 'competing interest groups squabbling in the marketplace' (Mant 1997). Given that disaster managers carry relatively little 'power' when it comes to spatial information, they need to develop strategies to give themselves a greater degree of standing in what has been termed the 'information power environment'.

In these 'environments', information is *controlled* (owned, collected and maintained directly), *influenced* (the collection and maintenance of data can be influenced by long-term relationships, mutual interest, or money) or *appreciated* (users can only appreciate that the data exists and must anticipate the way in which it will evolve).

In a 'normal' organisational situation (Figure 5a) much of the information, such as that on budgets, accounts, inventory, assets, and so on, and the personnel resources that collect and maintain that data, belong to the organisation and hence, the information is 'controlled'. In the 'typical' GIS environment (Figure 5b), by contrast, there is significantly less control or influence, hence a greater reliance is placed on externally sourced (appreciated) information such as digital cadastral and topographic data. Knowledge of the existence and relevance of 'appreciated' information is, typically, also limited (Lyons 1992).

An institutional framework is required to facilitate the non-technology links (legal, fiscal, administrative, bureaucratic, etc) between various stakeholders in the information infrastructure, from the smallest user-focused project, such as a village CVA, to the highest national or international-level policy environment and laterally within the widest circumference of the disaster management and spatial information communities. The institutional framework is the indispensable infrastructure within the overall information infrastructure.

In a study of the spatial information infrastructure requirements of PNG, a group of experienced consultants recommended the development of an institutional framework along the lines shown in Figure 6. This recognises the need for both high-level political support, and for both information users as well as technical experts to have input. It would clearly be advantageous for one of the theme-based consultative committees to have a disaster management theme, chaired by the NDMO. A key role of these consultative committees would be to oversight the custodianship and coordination arrangements for information.

It has been my experience that the institutional framework will tend to take on a nested hierarchical form. At the lowest level (the project level) the framework should be simple and can be largely informal. In the AGSO *Cities Project* Cairns case study, for example, it tended to reside in my head, my computer and in a few key documents. It only had to serve a couple of people within the project. At the next level up, our project information infrastructure is just one of many that go to make up the city information infrastructure; the city information infrastructure forms part of a regional information infrastructure, which in turn is part of a state information infra-

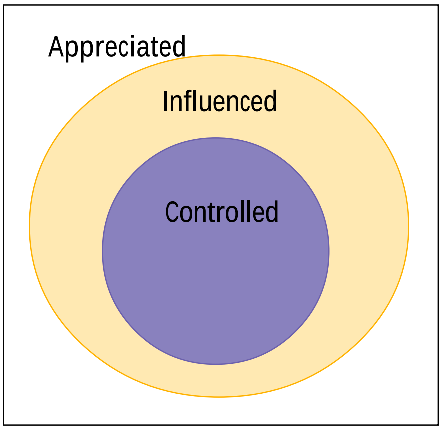

Figure 5a: 'Normal' power environment

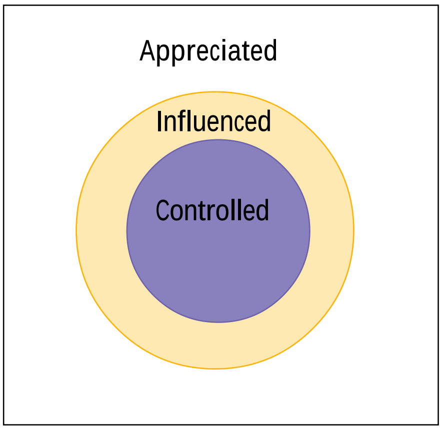

Figure 5b: 'Typical' GIS power environment

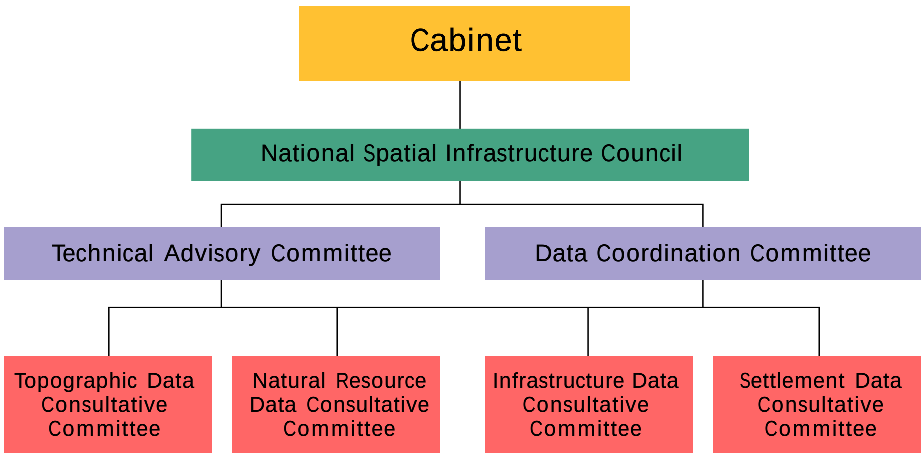

Figure 6: An institutional framework structure suggested for PNG *(Granger and others, 1998, fig.3, p. 16)*

structure and so on.

Custodianship

The concept of data custodianship is a key aspect of the institutional arrangements and hence, central to the creation of an information infrastructure. This concept is strongly developed in Australia and elsewhere and is based on seven principles as follows (condensed from ANZLIC 1998):

- Principle 1 *Trusteeship:* custodians do not 'own' data, but hold it on behalf of the community.
- Principle 2 *Standard setting:* custodians, in consultation with the national sponsor and users, are responsible for defining appropriate standards and proposing them for national ratification.
- Principle 3 *Maintenance of information:* custodial agencies must maintain plans for information collection, conversion and maintenance in consultation with the national sponsor and users.
- Principle 4 *Authoritative source:* the custodian becomes the authoritative source for the fundamental dataset in its care.
- Principle 5 *Accountability:* the custodian is accountable for the integrity of the data in its care.
- Principle 6 *Information collection:* collection or conversion of information can only be justified in terms of a custodian's business needs.
- Principle 7 *Maintain access:* a custodian must maintain access to the fundamental datasets in its care at the highest level for all users.

If an effective custodianship network can be established, the burden on individuals and organisations to collect and maintain their own information is greatly reduced. The most appropriate individual or organisation commits to maintaining their part or parts of the community's (region's or nation's) information resource. It may, however, take time for information users to develop confidence in a system based on custodianship given the long history in most places of people doing their own thing as far as information is concerned.

Some implementation strategies

The development of a disaster management information infrastructure need not be a difficult or expensive process, nor need it be dominated by the technical and bureaucratic considerations that appear to be so significant in other schemes such as NSDI and ASDI. The following thoughts may help PIC disaster managers (and their Australian counterparts) to ease into the task and build very robust information infrastructure to support their work.

Start with your existing material: The best place to start is with the information already held by disaster managers. Develop a metadata inventory ('library index') of existing material as the first step so that it is easier to identify where the significant gaps are.

Develop a plan: Sketch out an information management plan, as part of the disaster management plan, that clearly identifies the desired outcomes, benefits and likely costs.

Take your time: Given that an effective information infrastructure requires the development of strong networks of collaborators and the development, or strengthening, of an information culture, its evolution will take time. It is preferable to plan for the process to take five or even ten years, if necessary. It should be seen as an evolutionary process of constant improvement and enhancement – it may never actually provide all of the information needed, but it should provide the most important. It is important to be practical in setting targets, because if they are too ambitious at the outset and subsequently fail, the whole process of developing the information management process could be seriously set back.

Establish priorities: The so-called '80/20 rule' needs to be kept in mind. That says that 80% of the answers can be provided by 20% of the information. There are, consequently, themes of information that are much more significant and urgent than others.

History is important: In my experience, the best returns can be gained from investment in collecting detailed disaster histories, including community response. That material represents reality and can be used to generate both community and political support for disaster management and community awareness programs. It also contains lessons on past disaster management that can be built into present practice.

Document disaster experience: It is clearly much easier to document history as it happens than to search for information well after the event. The damage assessment forms already developed in PICs are a good start, however, it is most important to have in place the capacity to analyse and digest the results. The information management performance of the disaster management system should be reviewed as part of the post-disaster performance process.

International assistance: In the case of major disasters it is usual for PICs to receive assistance from the international community. This can take various forms, ranging from relief and humanitarian assistance to scientific input to the study of the disaster event. This input needs to be documented as part of the disaster experience. Most of these operations will need (and seek) access to local information and they will generate significant information from their own involvement. It is most important that arrangements for the flow of information in both directions be as smooth as possible. This may require the negotiation of standing bilateral or multi-lateral agreements with likely sources of assistance that addresses the information flow in both directions.

There is potential for some international assistance being the cause of tension, if not conflict. This is particularly the case where foreign scientists and others use the disaster event to further their own personal interests and do not provide information back to the host country. One international professional scientific association has seen the need to publish a protocol that sets out guidelines for professional conduct in disaster events for its members (IAVCEI 1999). This is a valuable and long overdue initiative.

Establish networks: The disaster management process can become rather isolated and inward looking, especially if it is not activated regularly. It can be difficult to maintain the level of 'profile' that guarantees attention or attracts support. That inevitably has an impact on the degree to which information management and disaster research programs can attract support. The development of partnerships with key data custodians and research agencies is, therefore, very important. Similarly, it is important to involve as wide a cross section of stakeholders as possible in the process. By involving agencies or businesses that control critical facilities such as hospitals, power supply or fuel supply, for example, in the total process, the chances of gaining access to their information and political support is greatly enhanced. NDMOs should aim to place themselves at the centre of their own web of networks, rather than being on the edge of everyone else's network.

Apply appropriate technology: Whilst the ultimate objective may be to employ Risk-GIS and other computer decision support tools, it is not necessary to have such technology in place before starting to either use information or to build an information infrastructure. Hard copy maps, manuals, reports and so on, will always be needed and used, regardless of how many computers are available. This is particularly the case with field operations under disaster conditions because computers may not be available or reliable under those circumstances. It is important, however, that the hard copy material provided is the most accurate and current available—hopefully produced from GIS and so on.

Information packaging: Not everyone needs access to all of the available information. It is, therefore, helpful to design specific information products or packages of products tailored for particular users. Agencies that have specified roles under the disaster management plan, be it transport and logistics, health, welfare and so on, should identify their requirements for information products as part of the overall disaster management information infrastructure development process. Those separate products, however, must be produced from the common set of core information to ensure that all participants are 'singing from the same sheet of music'.

By following the scenario modelling approach to risk assessment it is also possible to develop specific packages of information relating to various disaster scenarios (e.g. different flood heights) and to have them prepared *before* the disaster strikes.

Use case studies: It is much easier to 'sell' the message of information and information infrastructures if their benefits can be demonstrated in a real-world case study. Having a worked-through example to demonstrate is far more believable than a 'dummy' or artificial example. It is also human nature to want what the neighbour has, so being able to demonstrate what one village or town has done and the advantages that they have gained, tends to stimulate other villages and towns to want the same advantages. Case studies are also very useful for disaster managers to share their experiences and to exchange ideas that might be useful in other areas. The work completed by the *Pacific Cities Project* in establishing a broadly based information infrastructure for its case study cities provides an excellent starting point.

Cost/benefit: It is not always easy to demonstrate the costs and benefits of information. In disaster management terms, one useful approach is to demonstrate the potential savings that would flow from having the right information, or conversely, what the loss would be without the information. This can be illustrated by the following observation from a study undertaken by the Institution of Engineers, Australia (IEAust 1993).

> *The costs of data collection are usually readily identifiable. The dollar benefits are generally less so. However a simple method is now available which enables ready estimate of the benefits achieved through utilisation of data. This method is based on the concept that the value of data is the value of the reduced uncertainty which results from the incremental use of data to improve knowledge. Hence the dollar value of data can be directly determined as being the dollar value of the improved knowledge. The improved knowledge being quantifiable in terms of reduction in risk of failure or minimisation of over-investment of funds.*

Invest wisely: I have seen many GIS implementations that have turned out to be financial and management disasters, more often than not because they invested most of their resources in technology rather than spreading it across information and people as well. A good rule of thumb is to allocate 5 to 10% of the budget to technology, 10 to 20% to people and the remaining 70 to 85% for data.

There may be better long term returns from investing in the training of a couple of key NGO volunteers in the processes and benefits of information collection and management, for example, than in upgrading computers in the disaster management headquarters to the latest software. Providing a single computer for an NDMO office where no computer currently exists will probably return greater benefits than upgrading computers in an office which already has several machines.

Think risk management: The focus on disaster response is a natural and important aspect of the disaster manager's role. It will, however, be greatly enhanced by taking a broader view of their role to embrace the risk assessment and broader risk mitigation process as well. By taking a holistic view, disaster managers will be in a better position to influence the direction of scientific research into both the hazard phenomena and community vulnerability. It is important to acknowledge that it is a complex world that we live in and no single person, organisation or science has the complete solution.

Conclusions

The development of an information infrastructure to support disaster management in PICs has been identified as an important objective. This study confirms and reinforces the importance of:

- information, especially spatial information, as a critical decision making resource for disaster managers
- the information management process as a core disaster management activity
- the value of information management being supported by an information infrastructure, especially a SII
- building the disaster management information infrastructure from the ground up, but within the guidelines and structures established at a national level
- collaborating and cooperating with a wide range or partners and stakeholders in the disaster management and wider risk management process

Much has already been achieved in establishing disaster management information infrastructure in PICs, though a lot of that effort has been undertaken by agencies such as SOPAC and foreign researchers rather than by NDMOs and other national bodies. The foundations that have been established are sound and provide an excellent base on which to build an appropriate and sustainable information infrastructure to address issues from the village level to the level of the national capital and beyond. There are undoubtedly frustrations and problems that will need to be addressed along the way. However, it is clear that NDMOs are committed to embarking on this journey. It is also clear that they will make a good job of it because they are committed to the task.

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Obituary Notice

Mr Ludwick Kembu QPM

The head of disaster management in PNG, Mr Ludwick Kembu QPM, passed away unexpectedly on 25 March 20 00 after a short illness.

As Director-General of the National Disaster Management Office, Mr Kembu had been leading profound changes in PNG's disaster management system and arrangements. He was an Assistant Police Commissioner immediately before he was appointed as Director-General of the then National Disasters and Emergency Services in early 1998.

Mr Kembu led the organisation through a complete re-structure, its re-naming, the 1998 tsunami response, the revision of the National Disaster Management Plan, development of a five-year business plan, as well as participating in the final design procedure for the PNG Disaster Management Project. This project is expected to commence later this year.

A forthright and dynamic man, Mr Kembu will be sadly missed by those who knew him and worked with him, and particularly by him many friends and colleagues in Australia.