Using social indicators to measure community vulnerability to natural hazards

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The information explosion and proliferation of powerful computers and software over the last decade or so has allowed more complex exploration of community vulnerability and its measurement. This has come about in two ways as a consequence of the technological revolution. Firstly, the measurement of the impact and occurrence of natural hazards has developed to a high level of prediction. Hazard-proof built structures and infrastructure have responded alongside this development in information and research. As the prediction of hazard impact and the establishment of safer building codes and warning systems have been improved, it has been the vulnerability of the human beings in the community that has emerged as the least known element. Thus, the second consequence of the information explosion has been emphasis on readily available information about the population. There are numerous social, economic and demographic characteristics available to measure the vulnerability of the community, but the problem in using them is how to isolate appropriate characteristics or variables as indicators of community vulnerability. The fact is that we are using this information regardless, because it is so easily available, and we are basing mitigation and emergency management decisions on the databases that we have constructed. The purpose of this paper is to reflect on some of the rules and limitations of using social vulnerability indicators.

The context of indicator research

Social indicators have been used since the 1960's to quantify social characteristics that could influence public policy (Neuman 1997). Expansion of the use of indicators resulted in a journal of Social Indicator Research. A few examples of uses of indicators span a wide range from basic socio-economic indicators (Choguill 1993), urban social patterns (Kloosterman 1996, Gentilli 1997), community medical needs (Mackenbach 1992 and Mapelli 1993) and environmental sustainability (Fenton and MacGregor 1999). In all of these examples of uses, indicators have been selected and then quantified in order to rank or classify spatial and social patterns.

Determining useful indicators is not an end in itself. Indicators are simply tools that can be used to define or point to a more significant issue. Indicators are selected from a greater mass of information about the population (in the case of socio-economic indicators). They may be developed from either primary (e.g. questionnaires) or secondary (e.g. Census) data sources. Characteristics of the population, such as age or occupation, for example, are summarised as individual variables, such as an age group or an occupation category. Certain of these variables may be selected as useful indicators of a particular construct (Neuman 1997, Sarantakos 1994). The construct that we are interested in is vulnerability of communities to natural hazards.

Constructs are concepts or ideas, very often abstract, that define or categorise an issue or situation. The construct is what we are really interested in. It is very often theoretical, being presented as a model that aims to express a relationship, or a process or an issue. Thus the construct is what we are researching, and the indicator must be its servant.

Principles for developing social indicators

Definitions of social indicators are often determined by the research disciplines in which the social indicator research is being undertaken. However, a generally accepted definition of a social indicator is given by Andrews and Withey (1976), who state that indicators:

'can be monitored over time…can be disaggregated to the level of the relevant social unit…The set of indicators should be 'limited' so that a substantial portion of the most salient or critical aspects of society is included. They should be 'coherent' in that it would be helpful to our understanding if they hung together in some form that would eventually lead to a model or theory about how society operates'.

The Standing Committee on Agriculture and Resource Management (SCARM) also states that the selection of indicators, and in particular social indicators, should be grounded in a reasonable conceptual framework or model. To do otherwise is to simply revert to the selection of indicators on the basis of heuristics, the previous experience of the researcher, or 'what was thought important at the time' (Fenton and Macgregor 1999).

A review of social indicators undertaken by Fenton and MacGregor (1999) revealed five classes of indicators.

- *Informative indicators* (indicators used to describe the social system and the changes taking place e.g. social statistics subject to regular production as a time-series and which can be disagregated by relevant variables)
- *Predictive indicators* (these indicators are informative indicators which fit into explicit formal models of subsystems of the social system e.g. indicators such as family income and urban recreational facility location may be used in a model attempting to predict potential levels of juvenile crime in a neighbourhood)
- *Problem-oriented indicators* (these are indicators which point particularly toward policy situations and actions on specific social problems)
- *Program evaluation indicators* (indicators used to monitor the progress and effectiveness of particular policies)
- *Target delineation indicators* (variables describing the demographic, environmental, pathological or service provision characteristics which are useful in identifying geographical areas or population subgroups towards which policy is directed).

With suitable indicator selection, a model can be developed that provides clear directions for the development of specific policies. Indicators can be

selected with a variety of scales in mind, such as national, regional, local. The construct of intent determines the scale. Using the model together with socio-economic and socio-demographic data (such as those derived from the Australian Bureau of Statistics) it should enable extrapolation to other places, where an association has been demonstrated. In order to minimise measurement error it is also useful to use composite indicators. This means that rather than relying on a single indicator variable for a specific construct, construct validity can be improved by aggregating several indicator variables together, thereby yielding a composite indicator for a specific construct of interest (Fenton and Macgregor 1999). Usually this would require delivery of a reasonably high item reliability value as assessed though such indices as Cronbach's Alpha.

Developing useful social indicators

The Australian Bureau of Statistics (ABS) collects and examines a broad range of census data that can provide useful insights to community conditions. These include income, housing type and ownership, employment, crime rates, educational status, ethnicity, English proficiency, family structure to name but a few. One of the advantages of using indicators developed from such secondary data sources is that they are readily available and obtainable for a relatively small scale; the Census Collection District (CD). Simply combining the relevant CDs can then aggregate geographical areas, such as suburbs or whole towns.

The CD level aggregates all population and housing in the district. The Collection District is a block of streets in the city, or a subdivision, or outside the city a number of properties, farms or small communities. They are planned to contain approximately 200 households, which at a national/state average of just under 3 persons a household, is a population of about 600 people. As the 'workload' of one census collector, they also must have identifiable boundaries and should not change at every census, in order to facilitate the measurement of inter-censual change. Consequently Collection Districts are not homogeneous. Some are very small in population but cover an extensive area, some are in decline and others are expanding rapidly.

The Collection District therefore introduces an element of inaccuracy. Comparisons are constrained by unequal population sizes, and an aggregation that loses some of the precision and detail of the diversity within the Collection District. However, for total figures of specific variables this is not too much of a problem. For example, the number of over 65 year olds living alone gives a precise figure for an area of a few streets. The data therefore provide an indicator of the likely needs for emergency service intervention.

When variables in the Collection District are modified in any way, such as a statistic as simple as a percentage, the lack of homogeneity becomes a more significant problem. The statistic may allow relative comparison of communities, but in being standardised it creates an impression of homogeneity. More sophisticated manipulation of the data exacerbates the distortion. On the other hand comparison of Collection Districts on the basis of whole numbers is accurate in terms of the concentration of the problem, but also distorts on the basis of population size. A vulnerability index is affected in this way because larger populations will drive the vulnerability analysis. The biggest Collection District will appear to have the biggest problem, when in fact the proportion, of for example, households without access to a car, may be sufficiently low that the general community is able to deal with its vulnerability without significant emergency service intervention. These issues of unequal population size and aggregation of characteristics underlie some of the statistical problems of using more sophisticated techniques to group data in order to generate a vulnerability index.

The ABS has used census variables in order to produce indexes of urban and rural socio-economic disadvantage, urban and rural socio-economic advantage, and economic resources, which especially stress educational and occupational characteristics. The indexes rank order census collection districts, but cannot be further quantified, although ranks can be aggregated into larger spatial units. Variables were identified through a process of common sense and relevance, using principal components analysis to group the variables. From these groupings, strong indicators could be selected and given a weighting in relation to their strength as indicators. The indicators that finally formed the indexes contained some aspects of wealth, especially income, rent and mortgage repayments, but family structures are not strongly represented and community facilities not included at all. The ABS claims strong comparability between the 1991 and 1996 censuses for over 77% of collection districts, but because the index numbers are based on a ranked score, no quantification can be made between the rank in one census and the rank in another (McLennan 1998).

The resulting five Socio-Economic Indexes For Areas (SEIFA) are largely derived from different indicators (although indexes are not necessarily mutually exclusive of particular indicators). Consequently indexes that appear to be corollaries of one another may appear to be contradictory. For example the index of urban and rural socio-economic disadvantage is not necessarily the opposite of the index of urban and rural socio-economic advantage. Communities that rank highly on one index do not necessarily rank low on the apparent opposite. This is precisely the same with community vulnerability and resilience to natural hazards. In developing similar indexes of vulnerability for the Northern Beaches suburbs of Cairns, Melick (1996) found that there was no correlation between ranks on the vulnerability index and ranks on the resilience index. There are numerous reasons why an advantaged community is not necessarily the opposite of a disadvantaged one, and why vulnerability is not the opposite of resilience, but there is not space to address those issues here. More importantly this contradiction underscores the importance of only using a set of indicators for the single purpose for which they were selected.

However, it remains significant that when using census data the data is derived from virtually the entire population of the area in question so the representativeness of the sample population is extremely high. Census indicators go far in describing the socio-demographic and socio-economic conditions of towns or communities. Time series assessment of census data (i.e. considering changes in the data between census periods) can also help give some indication of trends but there is much that cannot be understood by examining such data alone. Time series cannot be used automatically (from the ABS Cdata census database) at the Collection District level, but only at SLA level or larger units, unless values are selected and added manually. Additionally, it is acknowledged that community life is more easily sustained when social networks are strong and there are people with common interests and who feel a sense of common future (Clark 1995; Berkowitz 1996). Assessment of these cannot be investigated by just examining census data (although correlations can be investigated). Unfortunately, many

communities do not have strong social networks and the members have little in common. Much of this discussion can be associated with the idea of 'sense of community'.

Clark (1995) offers some possible answers to this question when she emphasises that worldviews that promote a 'sense of belonging', by way of co-operation, neighbourliness, and unconditional acceptance, are those most likely to be more stable and to have lower levels of conflict. Such societies, she said, "usually offer members…physical and psychic security, sacred meaning and personal identity (Clark 1995:15). The concepts of cooperation, neighbourliness and acceptance (particularly ethnic acceptance) are all very important to northern Australian communities and can be measured using appropriate questionnaires. A sense of place and belonging is a very important aspect of community cohesion, and thus resilience to natural hazards. Berkowitz (1996) also notes the significance of levels of volunteerism and community participation, which he generally believes to be in decline. On a more political level, Berkowitz suggests that public money will be likely to diminish in the foreseeable future, ultimately forcing communities to rely more on their own local resources.

Attitudes as indicators of sustainability

A community's vulnerability or resilience to natural hazards can also be measured by the attitudes and values of its members. Rapport et al (1998) state that values can be considered as a set of philosophical, ethical, moral and emotional principles that order an individual or society. Rokeach (1973), however, points out that values and attitudes are significantly different. For example, he contends that a value is a single belief but an attitude is an organisation of beliefs about an attitude object. What is more, Rokeach argues that values drive motivation more strongly than attitudes. Despite the difficulties in clearly defining values and attitudes, it is none the less commonplace in social science to use attitude statements in questionnaires to determine an individual's value orientation.

The main purpose of developing a scale is to locate a person's attitudes to a particular object on an evaluative continuum, i.e. to determine how positive or negative those attitudes are. According to DeVaus (1985:83) a scale is 'a composite measure of a concept, a measure composed of information derived from several questions or indicators'. In attitude measurement, the questions are usually in the form of statements to which respondents can offer an answer on a continuum of agreement-disagreement, but, because of the positivistic nature of attitudinal scales they allow comparison of attitude 'scores' between individuals or groups of individuals e.g. communities (Ponte 1997).

When it comes to attitude measurement, there are a number of different types of scale that may be drawn upon; for example, Thurstone's (1928) equal-appearing interval scales, Osgood *et al's* (1957) semantic differential scale and Guttman's (1950) scalogram. These all have qualities that are useful in a variety of ways. However, one of the most widely used scales in social science is the one developed by Likert (1932). This is very a simple method of summation using ratings for measuring attitudes, generally known as the Likert scale. The scales list a set of items that are designed to elicit attitudes towards a particular attitude object. Each statement is answered on a continuous (often a 5-point) scale so that each item will have a score depending on how it is answered. Unfortunately, such scales deliver ordinal data and a common criticism is that it is not possible to distinguish between the responses on the basis of size. Nevertheless, the technique is a common one and it is quite possible to design the questions in such a way that persons with different points of view will respond to the statements differently (Likert 1932).

As useful as attitude indicators are, they are not available from the census and can only be collected by carrying out time consuming and expensive social surveys. However, research carried out by Berry (1996) and Melick (1996) showed that positive attitudes and behaviour towards awareness and preparedness for cyclone impct were totally separate sets of vulnerability measurements that did not necessarily relate well to socio-economic indicators such as those derived from the ABS. It is also conceivable that an indicator item may be more relevant in one locality than in another. While geography seems likely to influence 'relevance', one can also expect the relevance of the various indicators to vary according to where a community is in terms of its cohesion and spirit.

Indicators of vulnerability to natural hazards

Indicators have been used throughout the last decade to assess the vulnerability of communities and populations to natural hazards. There is a level of concurrence in the sorts of indicators that are appropriate. The socio-economic and demographic characteristics of vulnerability have been identified by Granger (1995), Smith (1994), Blaikie et al (1994) and Keys (1991) among others. The census provides thousands of such population variables, but there is a general group of vulnerability characteristics that are identified as particularly important. *Table 1*, summarises major groups that are agreed to be of significance as the sorts of people likely to be associated with high levels of vulnerability.

Specific groups of people may be identified as vulnerable, such as the elderly or single parent families, but the relative vulnerability of each is difficult to assess. Also an aggregation effect can occur as soon as more than one variable is selected, as several individual socio-economic characteristics may apply to one person or household; for example low income, single parent, lacking transport, poorly educated etc. At this time there is no rank or measure of sensitivity of each variable (Keys 1991, Granger 1995, Buckle 1995, Smith 1994). However, Granger (1999) has gone on in the multi hazard risk assessments of Cairns and Mackay to integrate social indicators with more easily identifiable physical and infrastructural facilities in the community.

Constructs and models

In reviewing how other researchers are using indicators, the most important message is that they must serve the needs of the research question. This is formulated as a construct, or a model or a theoretical framework. All uses of indicators are examining some kind of construct. The indicator is a tool. Before

The very young
The very old
The disabled
Single parent households
One person households
Newcomers to the community and migrants
People lacking communication and language skills
Low income earners

Source: Keys 1991, Salter 1995, Blaikie et al 1994, Buckle 1995, Smith 1995, Granger 1993, 1995

Table 1: significant socio-economic and demographic characteristics

social data became easily available, as recently as the 1990's, social indicators, even from the census, had to be painstakingly assembled. Researchers were consequently sparing in their use of the data and used small numbers of indicators. It is now possible to assemble enormous numbers of indicators for extensive areas, and carry out very powerful statistical techniques quite painlessly. One of the drawbacks of this is that it is too easy to randomly select sets of indicators, or to allow the indicators to drive the model. As empirical research this can sometimes be useful, but there is a great difference between exploratory use of indicators to identify patterns and relationships, and the selection of appropriate indicators to define the model that may have been developed, at least in part, from initial exploratory research.

Earlier assessments of vulnerability (Keys 1991, Salter 1995, Blaikie et al 1994, Buckle 1995, Smith 1995, Granger 1993, 1995) have already listed groups of characteristics as in *Table 1*. The problem in using indicators to predict the vulnerability of actual communities is that as we add or subtract indicators from the list the vulnerability ranking for any given community changes (Melick 1996). The ABS SEIFA indexes are standardised sets of weighted indicators. It is appropriate that the same standardisation could be applied to measuring community vulnerability. If the same indicators are used every time, comparability between areas and even times, becomes more realistic. For this to be appropriate though, the theoretical construct needs to be both defined and universally accepted.

The basic risk equation is a theoretical framework which, modified by Granger (1999) contains three sets of constructs.

risk = hazard x elements at risk x vulnerability

Hazards are increasingly quantifiable and accurately predicted, and the elements at risk are relatively easily quantifiable (although data gathering may be expensive) as they consist of buildings, infrastructure and facilities etc. Vulnerability remains the most difficult to quantify and relies heavily on indicators from available mass data such as the census.

Community vulnerability is also an extremely complex concept. For a start vulnerability includes resilience and the ability to recover from a disaster, both as a corollary and as a parallel of vulnerability. As with the SEIFA indexes, each construct needs its own set of overlapping indicators. For example we would include low income households as an indicator of vulnerability and high income households as an indicator of resilience, and yet probably rank trades occupations etc. as more important for resilience than highly paid, yet less 'practical' occupations. People with very different occupations may be equally resilient in totally different situations. Many indicators can be criticised in this way because they are only single characteristics of complex individuals.

Community vulnerability and community resilience then further divide into things about the population that make them vulnerable—the classical social, economic and demographic characteristics—and attitudes, behaviour and values. Each of these elements becomes a separate construct that is indicated by very different sets of indicators.

Researchers such as Buckle (1995, 1999) have examined the complexity of communities as overlapping networks that transcend spatial boundaries. Rhodes and Reinholdt (1998) proposed a vulnerability model based on the fire hazard. It contains some indicators that are different to those we might select for flood or cyclone hazards. However, it is interesting in separating vulnerability into three groups of indicators — reduced response capacity, increased fire risk, and circumstances contributing to the victim's response being ineffective — that feed into high risk groups, that are in themselves defined by specific indicators.

Community capability and vulnerability

If we want to know how vulnerable a community is we must begin with some level of expectation of what is required of the community in the face of a hazard. Zamecka and Buchanan (1999) list many expectations of what is required to mitigate against a disaster, by addressing needs such as insurance, community relationships, awareness, preparation, training, recovery, housing, planning laws and many more. As an example we could list the required behaviour and characteristics of a community in order to minimise vulnerability and maximise resilience. These could be listed as ability and willingness to evacuate, ability to protect home and property, having insurance, substantial structures, involvement with community and neighbours and family, having good mental and physical health, no dependency and no dependants, an ability to access warnings, instruction and advice, general and local knowledge, commonsense and caution, and youthfulness.

These characteristics could lead to an ability on the part of a community and its members to assess the acceptability or otherwise of the risk and their ability to

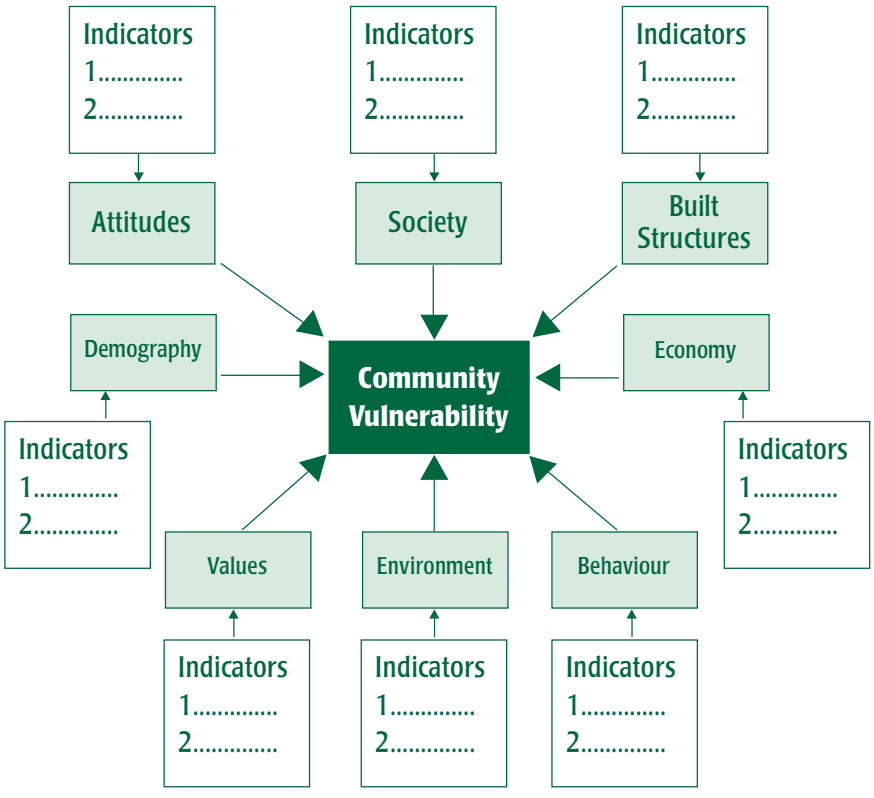

Figure 1: links between indicators, constructs and models

recover from a disaster. We could go on adding to a list of required behaviour, but related groups of characteristics would be repeated. The community can instead be divided up into a matrix of components. On this matrix we can insert individual indicators, or as in *Table 2*, the source of such indicators.

Census data are readily and cheaply available. All three of the other components of community may only be measured by carrying out targeted surveys and interviews. However, community networks and values can be ascertained to some extent by textual research (Gephart 1993) of papers, newsletters and community publications, and by understanding the constraints of social groups and the local political economy (Mustafa 1998). We do the latter categorisation by referring to 'working class suburbs', 'snob hills' or 'nappy valleys' and so on. Whole sets of community value assumptions flow from our social classifications of communities.

Thus the problem facing local and state emergency managers in measuring vulnerability is that significant elements of community vulnerability are not measurable without undertaking costly and time consuming household surveys. The census remains the primary source of easily available social indicators. In carrying out the multi hazard risk assessments in Queensland, Granger has made extensive use of census indicators based on analysis of the literature. His list of indicators has been refined as the studies have developed, but most importantly the indicators are grounded firmly in a model of vulnerability. Five elements of vulnerability are identified as the setting, shelter, sustenance, security and society. The setting is primarily made up of indicators that reflect external factors of the place and its infrastructure, but population variables such as total population, density and the sex ratio (because this indicates special purpose institutions like nursing homes and boarding schools) were incorporated. Shelter is primarily concerned with indicators of the structures and uses census indicators on houses and population to calculate ratios such as occupancy and uses census data to derive indicators on vehicle ownership. Sustenance is entirely concerned with lifelines and logistics. Security is concerned with community health, welfare and economy, alongside safety. Social indicators derived from the census include SEIFA indexes as individual indicators, demographic groups and things like renting and unemployment rates. Thus the society element which is primarily concerned with characteristics of the community and its members, is only one of the elements to use census derived indicators.

By combining the physical elements at risk with social and community vulnerability, into an interlinked set of five elements of vulnerability, Granger (2000) has established a carefully constructed model of indicators that are both physical and social, and composites of both. The advantage of this model for emergency managers is that it utilises easily available data. It is made up of information that should be in the disaster plan, plus the five yearly census.

The selection of the social indicators is based on the definitions of the elements of vulnerability in the model. Thus rather than debate the pros and cons of different variables, or attempt to weight some of the indicators, which we know will change the ranking of individual communities, it is worthwhile refining the Granger model towards adoption as a standard for measuring vulnerability. If we use a standard in all locations as a basis for vulnerability to multiple hazards, measurements can be recalculated and added to relatively easily, thereby maintaining a continually available classification of community vulnerability for all communities.

Conclusion

There are considerable complications and constraints surrounding the use of social indicators in measuring community vulnerability to natural hazards. Despite that, many types of indicators are readily available for use by emergency managers and councils. Therefore there are three basic conclusions that need stating. Firstly social indicators should not be developed without a theoretical model or construct. The idea must be defined and created first with the indicators selected as tools to serve the model. Secondly it is possible to generate a standardised working model that relies on a fixed set of tested indicators. Thirdly, such a model of vulnerability will necessarily be based upon existing data that can easily be updated. Inevitably this type of model will exclude the extremely important components of vulnerability that are encapsulated in awareness and preparedness. Surveys that ascertain people's attitudes and behaviour cannot be carried out by every council, and besides these should also be relatively standardised. However, it remains critically important to continue researching these components so that the relationship between a model of community vulnerability based on social and built structure indicators, can be linked to awareness and preparedness, and critical indicators developed that may be used to modify or qualify the model.

	Population Characteristics	Hazard Attitudes	Behaviour & Preparation	Community & Values
Individuals	Census	Quantitative Survey	Quantitative & Post Disaster Surveys	Qualitative research
Family/ Household	Census	Quantitative Survey	Quantitative & Post Disaster Surveys	Qualitative research
Community	Census	Quantitative Survey	Quantitative & Post Disaster Surveys	Qualitative research

Table 2: components of community and sources of indicators

References

Andrews F.M., & Withey S.B. 1976, *Social Indicators of Well-Being*, Plenum Press, New York, p. 4.

Berkowitz B. 1996, 'Personal and Community Sustainability' *American Journal of Community Psychology*, Vol. 24, No. 4, pp. 441-460.

Berry L. 1996, *Community Vulnerability to Tropical Coastal Cyclones and Associated Storm Surges: case study of the Cairns Northern Beaches townships*, TCCIP Report, Centre for Disaster Studies, Cairns.

Blaikie P., Cannon T., Davis I. and Wisner B. 1994, *At Risk: Natural Hazards, People's Vulnerability, and Disasters*, Routledge, London and New York.

Buckle P. 1995, 'A Framework for Assessing Vulnerability', *The Australian Journal of Emergency Management*, Vol. 10 No. 1, pp.11-15.

Buckle P. 1999, 'Redefining community and vulnerability in the context of emergency management', *The Australian Journal of Emergency Management,* Vol. 13, No. 4, pp.21-26.

Choguill C. and Solomon E. 1993, 'Social aspects of economic readjustment in Hungary: a consideration of the role of socio-economic indicators', *Social Indicators Research*, Vol. 29, No. 2, pp. 205-228.

Clark M. 1995, 'Changes in Euro-American Values Needed for Sustainability', *Journal of Social Sciences*, Vol. 51, No. 4, pp. 63-83.

De Vaus D. 1985, *Surveys in Social Research*, Sydney, Allen and Unwin.

Edwards A. 1957, *Techniques of Attitude Scale Construction*, Apple-Century-Crofts, New York.

Fenton D.M. and MacGregor C. 1999, *Framework and Review of Capacity and Motivation for Change to Sustainable Management Practices: Theme 6: Project 6.2.1.,* Social Sciences Centre, Bureau of Rural Sciences, Canberra.

Gentili J. 1997, 'Geographical patterns and some causes of spatial econoetic variations in Perth , Western Australia', *Australian Geographical Studies*, Vol. 35, No. 1, pp. 74-94.

Gephart R. 1993, 'The textual approach: risk and blame in disaster sensemaking', (Special research Forum: Methodological Issues in Management Research), *Academy of Management Journal*, Vol. 36, No. 6, pp. 1465-1515.

Granger K. 1993, 'Understanding Queensland's Storm Tide Hazard,' paper presented at *AURISA 93 - the 21st Annual International Conference of the Australasian Urban and Regional Information Systems Association*.

Granger K. 1995, 'Community Vulnerability: the Human Dimensions of Disaster', paper presented at *AURISA/SIRC'95 - the 7th Colloquium of the Spatial Information Research Centre*.

Granger K., Jones T. & Scott G. (eds) 1999, (Draft version), *Community Risk in Cairns: a multi-hazard risk assessment,* Cities Project, AGSO, Canberra.

Guttman L. 1950, 'The Basis of Scalogram Analysis' in Stouffer S. (ed) *Measurement and Prediction*, Wiley, New York pp 60-90.

Keys C. 1991, 'Community Analysis: Some Considerations for Disaster Preparedness and Response', *The Macedon Digest*, Vol. 6, No. 2, pp. 13-16.

Kloosterman R. 1996, 'Double Dutch: polarisation trends in Amsterdam and Rotterdam after 1980', *Regional Studies*, Vol. 30, No. 5, pp. 467-477.

Likert R. 1932, 'A Technique for the Measurement of Attitudes', *Archives of Psychology*, No. 140, pp. 5-53.

Mapelli V. 1993, 'Health needs, demand for health services and expenditure across social groups in Italy', *Social Science and Medicine*, Vol. 36, No. 8, pp. 999-1010.

Mackenbach J. 1992, 'Socio-economic health differences in the Netherlands: a review of recent empirical findings', *Social Science and Medicine*, Vol. 35, No. 3, pp.213-227.

McLennan W. 1998, *1996 Census of Population and Housing: Socio-Economic Indexes for Areas,* Australian Bureau of Statistics, Canberra.

Melick R. 1996, *Risk Assessment of the Cairns Northern Beaches to a Storm Surge: Testing the usefulness of ABS data to identify the vulnerability of communities*, TCCIP Report, Centre for Disaster Studies, Cairns.

Mustafa D. 1998, 'Structural causes of vulnerability to flood hazards in Pakistan', *Economic Geography,* Vol. 74, No. 3, pp. 289-306.

Neuman W.L. 1997, *Social Research Methods: Qualitative and Quantitative Approaches,* Allyn and Bacon, Boston.

Newton J. 1995, 'An assessment of coping with environmental hazards in northern aboriginal communities', *The Canadian Geographer*, Vol. 39, No. 2, pp. 112-121.

Osgood C., Suci G. and Tannenbaum P. 1957, *The Measurement of Meaning*, University of Illinois Press, Urbana.

Ponte F. 1997, *It has Nothing to do with Hunting: An Examination of the Attitudes and values Associated with the Recognition of Indigenous Hunting.*

Rights, PhD Thesis, James Cook University, Townsville.

Rhodes A. and Reinholtd S. 1998, 'Beyond technology: a holistic approach to reducing residential fire fatalities', *The Australian Journal of Emergency Management,* Vol. 13, No. 1, pp. 39-44.

Rockeach M. 1973, *The Nature of Human Values*, The Free Press, New York.

Salter J. 1995, 'Disasters as Manifestations of Vulnerability', *The Australian Journal of Emergency Management*, Vol. 10, No. 1, pp.9-10.

Sarantakos S. 1994, *Social Research*, MacMillan Education, Melbourne.

Smith D.I. 1994, 'Storm Tide and Emergency Management', *The Macedon Digest*, Vol. 9, No. 3, pp. 22-26.

Thurstone L. 1928, 'Attitudes can be Measured', *American Journal of Sociology*, No. 33, pp. 529-554.

Zamecka A. and Buchanan G. 1999' *Disaster Risk Management*, Queensland Department of Emergency Services, Brisbane.

Zerger A. 1996, 'Application of Spatial Analysis and GIS for Modelling Risk in Storm Surge Prone Areas of Northern Queensland', paper presented to *NDR96*, edited by Heathcote, R., Cuttler C. and Koetz J. Conference on Natural Disaster Reduction, Surfers Paradise.

Zimmerman G. M., Goetz H., and Mielke P. W. 1985, 'Use of an Improved Statistical Method for Group Comparisons to Study Effects of Prairie Fire', *Ecology*, Vol. 66, No. 2, pp. 606-11.