Review of the Methodology of the Community Vulnerability in the Cairns Multi Hazard Risk Assessment

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1. Review of the Literature on the Use of Social Indicators

The information explosion and proliferation of powerful computers and software over the last decade or so has prompted increased emphasis on comm

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 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.

1.3. Developing Useful Social Indicators

The Australian Bureau of Statistics (ABS), collects and examines a broad range of census data that can provide useful insights of community conditions. These include, incomes, housing type and ownership, employment, crime rates, educational status, ethnicity, English proficiency, family structure etc 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). Geographical areas, such as suburbs or whole towns can then be aggregated simply by combining the relevant CDs.

This 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 mber 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 collections 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 ranks 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 rational reasons why an advantaged community is not necessarily the opposite of a disadvantaged one, and why vulnerability i752 33cm

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. Never the less, 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 attitudes as expressed in awareness and preparedness 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.

likely to influence 'relevance' 353 the

1.5. 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 characteristic7 4510e998 110.4344 465.0247 Tm(m)Tj11.998 0y8 171.6626 576.9655 Tm(r.8458 590.9

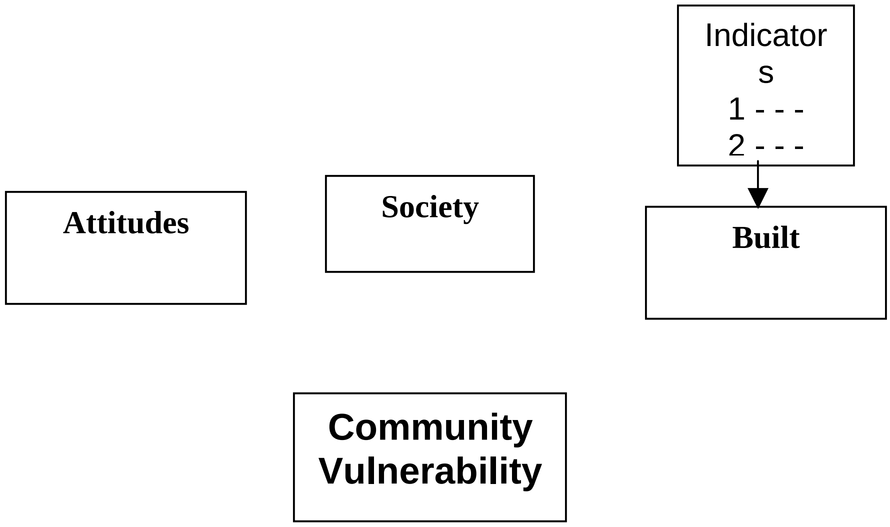
the multi hazard risk assessments of Cairns and Mackay to integrate social indicators with more easily identifiable physical and infrastructural facilities in the community.

1.6. 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 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 a 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, m


Indicators
1 - - -
2 - - -
Attitudes
Society
Built
Community Vulnerability

If we want to know how vulnerability 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, protection of home and property, insurance, substantial structures, involvement with community and neighbours and family, 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 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.

Table 2. Components of Community and Sources of Indicators.

	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

Census data are readily and cheaply available. All three of the other components of community may 9DCBT/TT3 1 Tf0 Tc 11.998 0 0 82tive 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 etc. and derives 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, dem and preparedness, and critical indicators developed that may be used to modify or qualify the model.

2. General Methodological Considerations

2.1. Ranking and Degrees of Freedom

If Cairns' vulnerability is assessed at the suburb level there are 43 spatial units (of which 40 contain a population), whereas at the Census Collection District (CD) level there are 183 units. A methodological question is whether or not the greater number of CDs is any more statistically robust than the smaller number of suburbs. There are three specific issues.

1. Forty or 39 degrees of freedom is adequate for most of the statistical tests that we commonly use. Furthermore the spatial units are not a sample. They are places in an absolute sense.
2. The methodology for vulnerability assessment is intended to be applied to any Local Governme.l G31 8 576.8454 Tm(Local Gove434 618.7782 61al Gove434 6188 146.0963 590.

make allowance for the total population size and the range of the data, and they are capable of taking account of both negatively and positively correlated variables. The major difference between them is the scale on which they operate.

The variables have been standardised by ranking them according to perceived vulnerability. The decision to rank in ascending or descending order is according to the negative or positive value of the correlation. Thus the ranking numbers can be aggregated etc. without the complication of a negative relationship (for example the SEIFA disadvantage index against the SEIFA education and occupation index).

Ranking is an equal interval ordinal scale that reduces all gaps between cases to the same value. It thus reduces the variability of the range of values and smooths out skews and clumps. It can be argued quite legitimately that if the application of the information is to deal with a hierarchy of needs, this is not a problem. On the other hand rank 1 is not necessarily twice as vulnerable as rank 2 or 3 times as vulnerable as eate.

Statistical Analysis

3.1. Research Plan

1. Examine the structure of the data and look at the ability of the groups to distinguish groups that are significantly different at a multivariate level (MRPP).
2. Describe the different possible methods.
3. Compare the different methods at a ranking level, and calculate correlations and residuals. Establish what sites come out regularly, and what variables seem to drive this. What aspects of the methods make them vulnerable?
4. Compare the different methods at a group level, the proportion of suburbs that disagree, what suburbs disagree, and why?
5. Cluster the different methods of ranking. Wh

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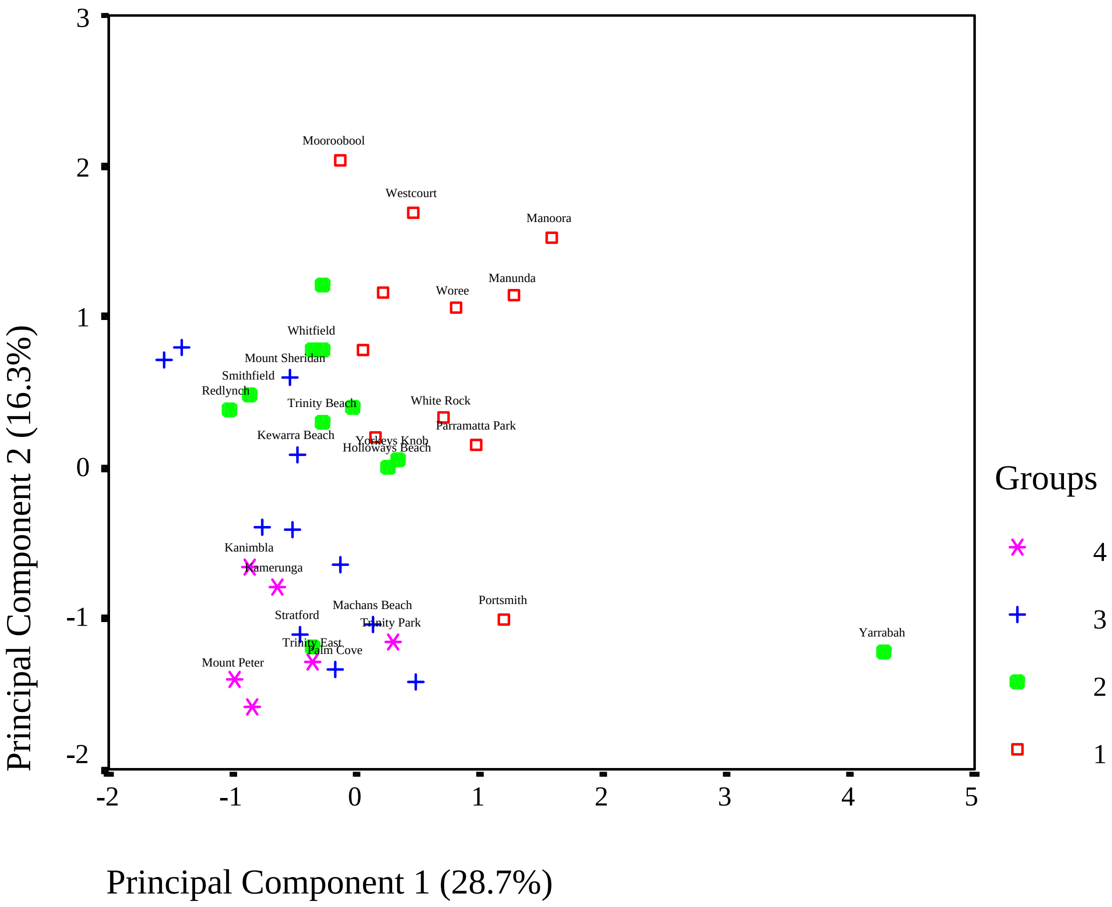

Mooroobool
Westcourt
Manoora
Manunda
Woree
Whitfield
Mount Sheridan
Smithfield
Redlynch
Trinity Beach
White Rock
Parramatta Park
Kewarra Beach
Yorkeys Knob
Holloways Beach
Kanimbla
Kamerunga
Machans Beach
Portsmith
Stratford
Trinity Park
Trinity East
Palm Cove
Mount Peter
Yarrabah
Groups
4
3
2
1
Principal Component 2 (16.3%)
Principal Component 1 (28.7%)
3
2
1
0
-1
-2
-2
-1
0
1
2
3
4
5

3.3. Research Question

Do the four groupings derived by Granger significantly differ in a multivariate sense. In other words, do the added-up ranks of weighted variables create groups that are truly different from one-another when one uses all original variables.

To test this we used Multi-Response Permutation Procedures (MRPP). MRPP is a non-parametric procedure for testing the hypothesis of no difference between 2 or more groups of entities (in this case, it is the difference between groups of suburbs). Software used was PC-ORD, version 2.05. MjM Software, Oregon. The data were standardised by z-scores, the Euclidean distance measure was used, and groups were weighted by the default (n/sum{n}). Strictly speaking, groups should be derived a priori and groups should not be derived from the same data that is being tested (Zimmerman et al. 1985). However in this instance the grouping technique (Granger's method) was very much removed from the multivariate distance measures used in MRPP. Unlike MRPP, the former uses ranks rather than standardised variable values, weights variables, and simply adds variables to create a univariate measure. It was therefore felt that a conservative interpretation of this method is justified.

Initially, all 4 groups were compared. The result was highly significant (Table 3), so pairwise tests were then conducted. To guard against Type I error, however, Bonferroni corrected significance levels were used (alpha{.05} = 5/p%, where p is the number of tests). With 6 separate tests, the significance level then becomes (5/6)% = 0.83%.

The two most vulnerable groups (1 and 2) were not significantly different, and neither were 2 and 3. All other comparisons showed strong multivariate separation. Therefore, Granger's method (when applied to the Cairns data at least), results in vulnerability groups that are not significantly different in a multivariate sense, except for group 4, which is probably driven by the outliers (Kamma, Lamb Range, McAlister Range and Wright's Creek).

Table 5.: Results of the MRPP analyses on the groups of suburbs as derived by Granger's method of ranking.

Groups	Test statistic	Significance	Comment
1, 2, 3, 4	-10.273293	0.00000001	Significant
1,2	-1.9226888	0.05158740	Not Significant
1,3	-7.8465550	0.00002367	Significant
1,4	-8.5864207	0.00001185	Significant
2,3	-1.3271290	0.10169209	Not Significant
2,4	-5.4940555	0.00103581	Significant
3,4	-4.2924948	0.00400251	Significant

3.4. Summary Of Alternative Methods Tried

Although there is no 'real' value for vulnerability, the method of Granger is used as the 'standard' against which to compare a series of other, potentially valid measures of community vulnerability.

1. Granger's way. Rank each variable. Add ranks within a group. Derive aari.998m( )TjETEMC/P <MC

9. Reduced variables from the PCA. Weighted, and thus again derives a selection of representative variables to summarise the whole dataset. It is similar to 6, but uses real variables most closely correlated to the component, rather than the component itself.
10. Same

3.5. Comparing different methods at the ranking level.

The different methods were compared to Granger's method at a ranking level, as distinct from the level of vulnerability group. The resulting ranks from Method 1 (Granger's method) were correlated against the ranks from each of the other 9 methods using Spearman Rank Correlations, which are appropriate for this type of data.

All correlations are significant, with method 5 and method 10 having the highest coefficients (not surprisingly, since they are the methods that also rank each variable. Also correlating very closely with Method 1 are the three techniques using z-scores (Method 2,3 and 4). This indicates that very little useable information is lost in the process of transforming actual data into ranks.

The weakest correlations result from the unweighted Principal components, and the two methods which use selected original variables. Therefore, it is unlikely that selected variables can be effectively used without losing valuable information.

The suburbs that show the most deviation from the line of best fit are Palm Cove, City, Kamma, Cairns North, Wright's Creek and Yarrabah.

Table 6: Spearman's rank correlation coefficients between the ten alternative methods of calculating community vulnerability.

	Meth1	Meth2	Meth3	Meth4	Meth5	Meth6	Meth7	Meth8	Meth9
Method2	0.954								
Method3	0.956	0.97							
Method4	-0.956	-0.97	-1						
Method5	0.973	0.937	0.969	-0.969					
Method6	0.932	0.951	0.978	-0.978	0.94				
Method7	0.9	0.911	0.917	-0.917	0.861	0.94			
Method8	0.813	0.87	0.805	-0.805	0.764	0.78	0.803		
Method9	0.726	0.792	0.708	-0.708	0.677	0.671	0.678	0.925	
Method10	0.992	0.945	0.954	-0.954	0.979	0.938	0.889	0.794	0.708

Note: Method1 is the ranking method (Granger 1999).

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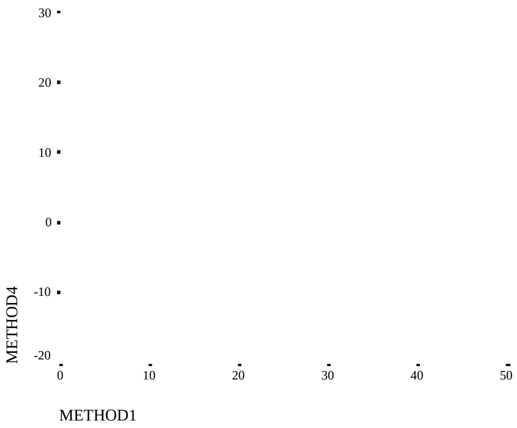
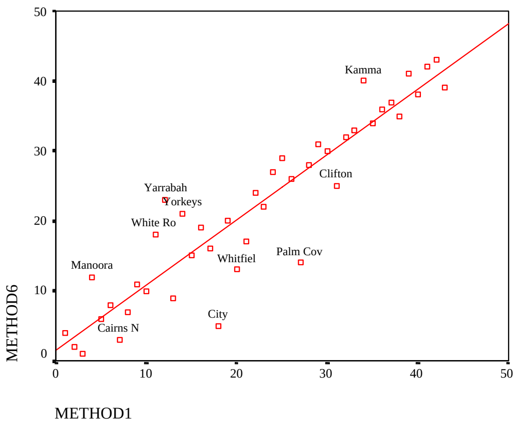


e.



50
40
30
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10
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METHOD6
Kamma
Clifton
Yarrabah
Yorkeys
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Manoora
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City
Cairns N
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20
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40
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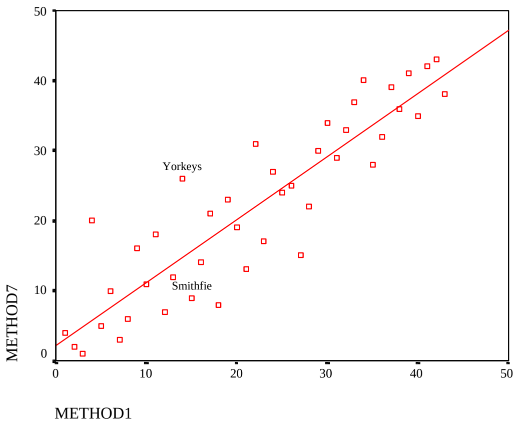
METHOD1

f.



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30
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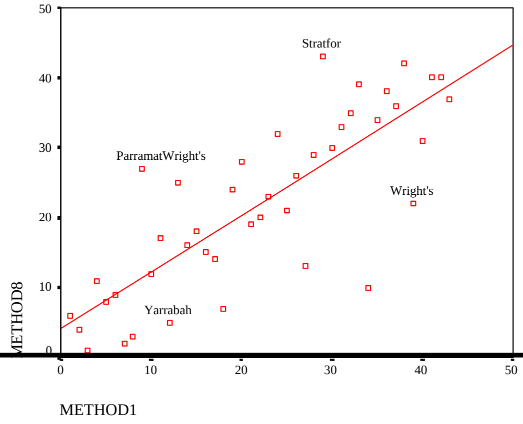
METHOD7
Yorkeys
Smithfie
0
10
20
30
40
50
METHOD1

g.



50
40
30
20
10
0
METHOD8
Stratfor
ParramatWright's
Wright's
Yarrabah
0
10
20
30
40
50
METHOD1

This section looks at the effect of different methods on the placement of suburbs into groups as per Granger (1-4 = most vulnerable - least vulnerable). This is an important level of analysis, as this grouping level may be used in a more practical way by local councils. The degree of matching was examined by crosstabulation, whereby each alternative method was compared to the existing method (Method1). Percentage disagreement was measured, and suburbs which are placed in different groups were identified for each method.

Method 10 is in perfect agreement with Method 1, although this may not be the case for all towns. It is not surprising, however, that they are closely matched, as the sole difference between the two is the manner in which the group ranks are treated. Other Methods with high levels of agreement include Methods 5, 4 and 3, with 90.7% agreement. Methods 7, 8 and 9, relate most poorly to the groupings from Method 1, reflecting the general trends found in the above correlations. Methods 2 and 6 resulted in moderate agreement with Method 1 (76.74% and 81.4% respectively).

Therefore, the methods that are variations of the rank system agree most strongly with Granger's method, with close agreement from the ungrouped z-score techniques (Methods 3 and 4). The z-score method which maintains the variable groupings (Method 2) differed from Method 1 to an unexpected degree, considering that there is a strong correlation between the ranks (Figure #, above).

Table 11

	Method 6 groups					Total
		1	2	3	4	
Method 1	1	9	2			11
Groups	2	2	7	2		11
	3		2	9		11
	4				10	10
Total		11	11	11	10	43

Percentage disagreement = 18.60%. Overscores include Edge Hill, Palm Cove, City, Kamma, Wright's Creek, and Aeroglen, whilst underscores are Yarrabah, Manoora, Holloways beach and White Rocks.

Table 14

	Method 9 groups					Total
		1	2	3	4	
Method 1	1	8	2	1		11
Groups	2	2	5	4		11
	3		2	5	4	11
	4	1	2	1	6	10
Total		11	11	11	10	43

Percentage disagreement = 51.16%. Overscores include Kamma (3), Wright's Creek (2), MacAlistister Range (2), Yarrabah, Palm Cove, City, Brinsmead and Lamb Range. It is largely the outliers that are overscored. Underscores include Clifton Beach, Redlynch, Holloways Beach, Edge Hill, Stratford, Whitfield, Caravonica, Mooroobool, Machans Beach, White Rock, and Parramatta Park (2).

Table 15

	Method 10 groups					Total
		1	2	3	4	
Method 1	1	11				

3.7. **Research Question. How do the different methods of calculating overall suburb rankings compare in a multivariate sense?**

To approach this question a classification was carried out of the various methods of ranking the suburbs based on the ranks that they allocated. Therefore, each method represents a case, while each suburb represents a variable. Each variable therefore has a value out of 43 (the rank) for each method. The classification method used was hierarchical cluster analysis with group average linkage and Euclidean distance measures. Variables were standardised by z-scores to ensure equal influence by differently scaled variables. Method 4 results in a final score rather than a rank, so is not directly comparable with the other techniques. It was therefore removed prior to this analysis. Software used was PC-ORD, version 2.05. MjM Software, Oregon.

Cluster analysis was carried out on methods, and based on how the suburbs rank out. Three copies of the same analysis are included, but with different aspects of the methods identified in each dendrogram.

The cluster analysis (Figure 3) shows that Methods 1 and 10 lead to identical results, (although this may not occur in other towns). Most closely related to these are method 5, which is also a ranking method. Of the different characteristics of the methods (whether variables are grouped, whether suburbs are ranked, and whether PCA is used), whether or not suburbs are ranked appears to be the only one that results in close grouping (Figure 16). Methods 2, 3 (both z-score methods) and method 6 (weighted PC scores) form a reasonably tight group. Methods 7, 8 and 9, however (the other PCA methods) are not closely related to each other or other methods.

Table 15.

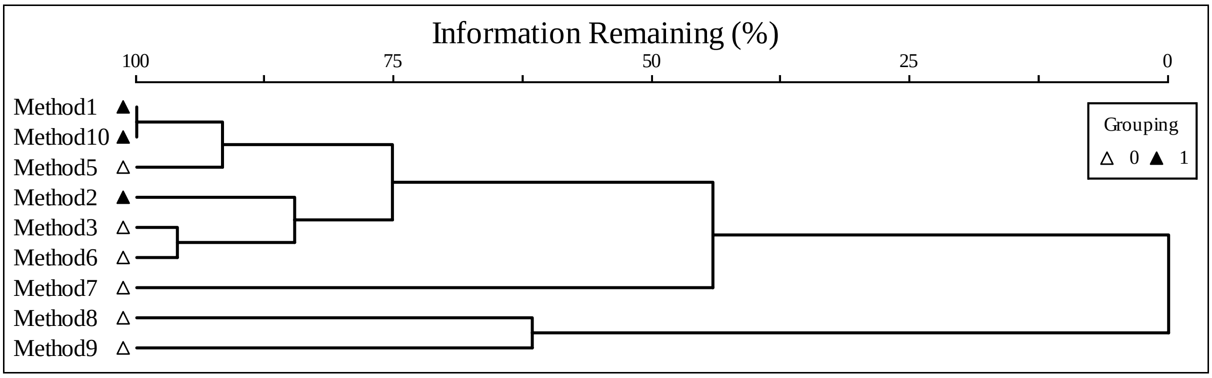
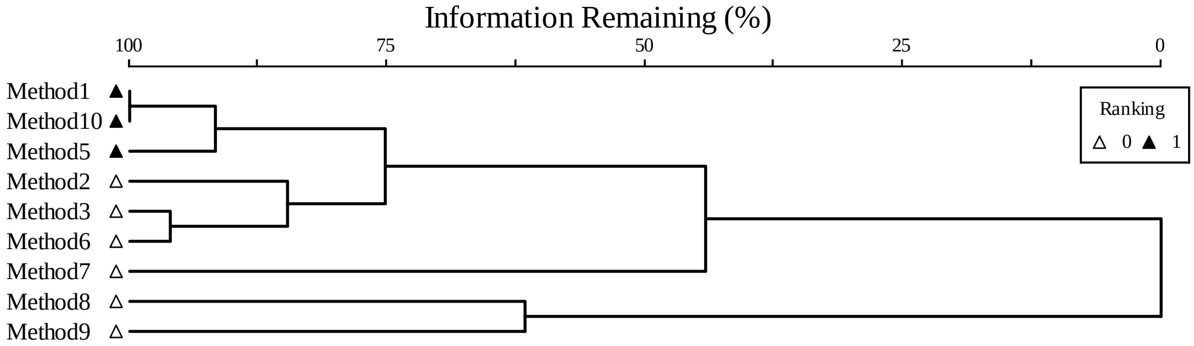


Table 16.


Information Remaining (%)
100
75
50
25
0
Method1
Method10
Method5
Method2
Method3
Method6
Method7
Method8
Method9
Ranking
0
1

4. Locality: Census Collection Districts and Suburbs

4.1. The Collection District Problem

The mapping of vulnerability characteristics is at the level of the census Collection District. This level aggregates all population and housing in the district. The Collection District is a block of streets in the city, or a sub-division, 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 some expanding rapidly.

The Collection District therefore contains 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, car-less households, may be sufficiently low that the general community is able to deal with the problem, without significant emergency service intervention.

A pilot survey was started to test whether or not people could identify with the Collection District. It was inconclusive because people had no idea what we were even talking about, although relating the Collection District to a block of streets made it clearer. The Collection District is an artificial bureaucratic creation of the ABS. Some Collection District boundaries are logical and identifiable but many are not. In Brisbane, Gold Coast and Townsville the Statistical Local Area corresponds to the suburb (at least in the older, established parts of the cities). Collection Districts are nested entirely within SLAs. In other towns, including Cairns and Mackay there is no planned linking of suburbs and Collection Districts. The ABS defines the boundary of the Collection Districts, and the Department of Natural Resources defines and gazettes suburb boundaries. Thus Local Government Councils adhere to suburb boundaries and plan in relation to those suburbs.

Table 18. Congruence between Census Collection Districts and Suburbs in Cairns

Suburb Name	Number of CDs Wholly within suburb boundary	Number of CDs Overlapping suburb boundary
MacAlister Range	1	1
Palm Cove	2	
Clifton Beach	3	1
Kewarra Beach	3	3
Trinity Beach	5	3
Trinity Park	0	2
Yorkeys Knob	5	2
Holloways Beach	5	2
Machans Beach	5	2
Smithfield	4	3
Kamerunga	0	1
Barron	1	3
Aeroglen	0	1
Caravonica	2	3
Stratford	0	3
Freshwater	4	1
Redlynch	1	3
Brinsmead	4	2
Whitfield	4	2
Edge Hill	7	1
Manunda	11	
Manoora	8	Small portion

that 160 of the 183 Collection Districts in Cairns are wholly within a suburb boundary, or share the general pattern of its boundary (there is one additional Collection District on the rural southern edge of Gordonvale which has been excluded). The second column lists the 84 overlaps of the other 23 Collection Districts. On average each Collection District overlaps 3.7 tim (finer scale) to the overall vulnerability grouping of the same collection district when calculated by suburb (coarser scale). The overall vulnerability grouping is achieved by splitting the overall ranks into quartiles (n=184 collection districts, and n=39 suburbs), whereby group 1 = most vulnerable and group 4 = least vulnerable. The percentage of mismatched collection districts using the suburb technique was then calculated.

It could be expected that the greater the number of collection districts within a suburb, the greater the range of collection district ranks. However if the number of collection districts mirrors the overall size of a suburb, as it does in Cairns (Pearson correlation coefficient: $r^2 = 0.8356$), then perhaps the standard deviation of collection district ranks should also rise. This may reflect the increasing chance of larger suburbs encompassing more than one socio-economic group. This is an important issue, as we may want to know when relative vulnerability measures (calculated by suburb) are least likely to represent the real risk for communities contained within. Therefore, we examined the relationship between the numbers of collection districts within suburbs, and the standard deviation of the ranks of the collection districts within them.

Overall, the standard deviations of collection districts within suburbs range from 0.7 ranks (Palm Cove) to 68.4 ranks (Whitfield). Figure 5 shows that, overall, large numbers of suburbs have high variability among their collection districts, with collection districts in 14 suburbs varying by an average of over 40 ranks from the mean within that suburb. It should be noted that of the seven suburbs with close to zero standard deviation, six of those in fact contain only one census district. Of the 39 suburbs in this dataset, only nine deviated by an average of less than 12.5 places from the mean. In other words, a large proportion of suburbs are quite heterogeneous in nature, and subsequently (with respect to the five variables examined), overall suburb ranks do not adequately represent the real vulnerability more accurately identified through the collection districts. The most heterogeneous suburbs include Whitfield, Caravonica, Mooroobool, Trinity Beach, Gordonvale, Manoora, White Rock and Edmonton. The most homogenous suburbs, apart from those with one collection district, are Palm Cove, Portsmith, Machans Beach, Bentley Park, City and Bayview Heights.

The high variability within suburbs is also reflected at the vulnerability group level in Table 19. When grouped through suburb rankings, collection districts fall into the same vulnerability group as when they are ranked as collection districts 42.9% of the time. In other words, 57.1% of the time, by aggregating collection districts up to the suburb level before ranking, the community within the collection district will be allocated to a different vulnerability group. Suburbs with high group differences include Caravonica, Edmonton, Gordonvale, Holloways Beach, Mooroobool, Paramatta Park, Trinity Beach, Trinity Park and Whitfield.

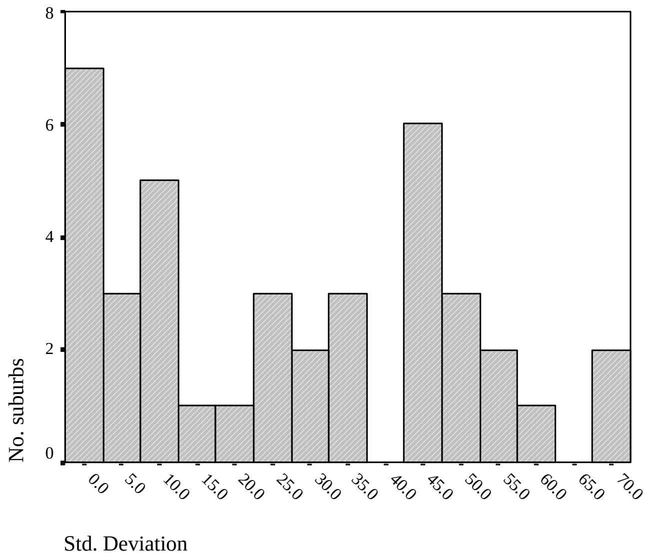


Figure 5: Histogram of the numbers of suburbs by the standard deviations of collection district ranks.

Collection district ranks (1-184) are calculated using the following variables: level of disadvantage, proportion of new residents, level of education, proportion of residents with no religious conviction, and proportion of children under 5 years old. These were selected as a sub set in order to test the differences between the spatial units. The logistical and infrastructural indicators are very small in value at the CD level, such that a comparison of the spatial units may be distorted. The inclusion of more social indicators would probably increase heterogeneity.

Table 19: Cross tabulation of groupings of collection districts calculated by census district ranks (columns) and groupings of collection districts calculated by suburb ranks (rows). Matched pairs are identified by bold type.

		Group determined by census Collection District				Total
		1	2	3	4	
Group determined by suburbs	1	18	13	9	1	41
	2	22	21	11	7	61
	3	5	10	18	16	49
	4	1	2	8	22	33
Total		46	46	46	46	184

Percentage of collection districts differently grouped by the two me

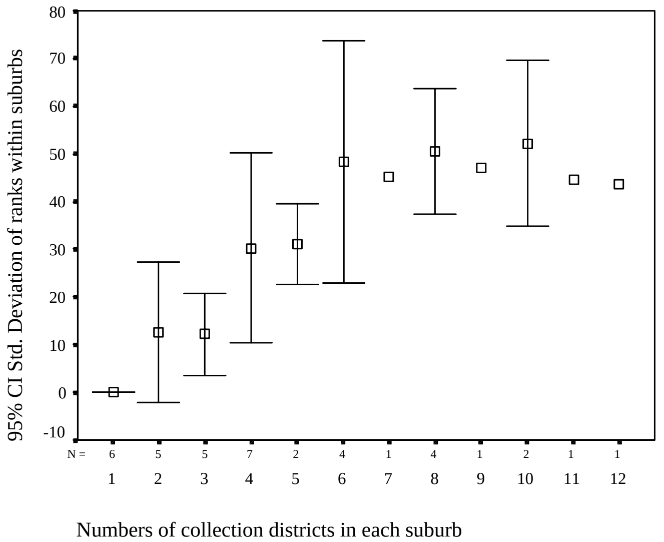


Figure 6: Bar chart illustrating the variation within suburbs (measured as the average standard deviation of collection district ranks) as a function of the number of collection districts within each suburb.

4.3. Summary

The statistical analysis shows that a vulnerability assessment based on Collection Districts will be significantly different from one based on suburbs and that detail and accuracy of that assessment will be lost through aggregation of spatial units. The lack of congruence between Collection District and suburb boundary results in a level of error in manipulating those spatial units and creates additional costs for the LGC and Emergency Managers who attempt to create and maintain the assessment and its database. On the other hand the Collection District is not a meaningful place. People identify with suburbs.

As the ideal spatial unit from a statistical and database manipulation and maintenance point of view is the Collection District there may be some modifications that can improve its useability. The assignment of a name to each Collection District, by suburb and location, such as a street, local neighbourhood name or other feature, will improve their recognition as places. Maps, and especially the functioning database, should therefore be overlain with suburb boundaries and a part of the street network, especially those streets (and creeks etc.) that form the Collection District boundary.

community councils. The ranking method on the other hand, can be carried out simply, it requires few statistical skills or expensive software, and it measures up as statistically valid.

The same concerns impact upon the level of spatial unit that may be used. The Collection District is the finest detail available for social indicators, but it may distort some of the infrastructural indicators. Tests show that suburbs are not representative of the range of vulnerability on the composite assessment. Detail is lost. Additionally many Collection Districts do not fall neatly into suburb boundaries, thereby introducing another level of error. Most significantly, though, the Collection Districts are not meaningful places as they are extracted from Cdata. However, it may be much easier and quicker to make them meaningful by giving them suburb and local neighbourhood/main street names, than dealing with the error, lack of boundary congruence, and loss of detail that is entailed in using suburbs as the main spatial units.

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