Assessment of socioeconomic vulnerability of Coastal Areas from an indicator based approach

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1. Introduction

There are growing concerns along urban coastal areas with respect to the risks associated with climate change. Among all the possible impacts of climate changes, sea level rise is one of the most well, and is projected to rise continuously during the 21st century.

There are various threats on the coastal areas from increasing sea level rise including coastal flooding and erosion. These physical threats are expected to be more common in areas with particular geomorphologic characteristics, such as low-lying and low-sloped areas. There have been numerous assessments and management plans to identify these particular areas with higher susceptibility to rising sea level and other associated coastal hazards, however, the number of disasters and scale of impacts are increasing and causing even larger damage. This leads to the realisation that it is necessary to investigate not only the physical nature of hazards, but also the interaction between hazards and socioeconomic vulnerability such as exploitation of coastal resources, over-growth of coastal cities, poorly planned property development and wetland destruction.

More than 80% of the Australian population reside within 50km of the coastline and the trend has been continuously increasing every year. As one of the fastest growing coastal areas in Australia, coastal population and properties along the coastline of Melbourne metropolitan area are more exposed to the climate change related hazards than ever.

This is a discussion paper based on work in progress for the methodological approach towards the coastal vulnerability assessment, particularly from the socioeconomic perspective. A particular emphasis will be made for the vulnerability assessment using indicators. The method will be applied in one of the coastal municipalities in Melbourne metropolitan area to assess socioeconomic vulnerability in particular.

2. Coastal hazard and vulnerability

The Australia and New Zealand standard defines hazard as "source of potential harm" and vulnerability as a function of susceptibility to loss and the capacity to recover (Handmer, 2003; AS/NZS 4360:2004). A hazard can either remain as a hazard, or it can end up harming 'things' which have potential to become a disaster. The transformation of hazards to a disaster depends largely on the vulnerability of those at risk, particularly where natural hazards and human presences/activities interact (ISDR 2004: xi).

The definition of vulnerability implies there are two opposing views. The 'susceptibility to loss' indicates a negative impacts whilst the 'capacity to recover' implies a positive impacts. From the climate change perspective, more emphasis is put on the positive impacts associated with vulnerability because of the increasing recognition that the potential for adverse effects from climate change is not only depending on the hazard, but the policies and treatments that are available to a system to respond to the hazard.

2.1 Vulnerability assessment

As the definition suggests, assessment of vulnerability involves measuring the susceptibility to loss from a hazard and estimating the system's resilience or the capacity to recover from the hazard. Many past vulnerability assessment studies have been criticised that too much emphases have been put on the physical affects, which results in separation of physical and socioeconomic elements within vulnerability studies (Blaikie et al. 1994; Gough et al. 1998; IPCC 2001; Nicholls and Small 2002). Recent coastal vulnerability studies have attempted more integrative assessment approach by measuring both physical and socioeconomic vulnerability and pursuing effective means of combining these together as an overall vulnerability index system (Cutter et al. 2000; Wu et al.2002; Boruff et al. 2005; Preston et al. 2008).

Vulnerability of things at risk is not always easily measurable or quantifiable especially for those of socioeconomic origins. For example, one of the most common problems in undertaking flood vulnerability assessment is identifying all the potential things at risk. In order to determine things at risk from inundation, a classification scheme was suggested to help in identifying the things at risk (Smith and Ward 1998) (Figure 1). In this scheme, things at risk are categorised depending on the way they are affected from the hazard and also their measurability. The things at risk are also determined by the study context and the objectives.

There are several approaches for measuring vulnerability such as the value-category approach which is more appropriate for assessment of tangible damage, whereas indicator-based approach that is more suited for intangible elements (Kaiser 2006).

2.2 Indicator-based vulnerability assessment

The Organisation for Economic Co-operation and Development (OECD 2003) defined indicator as a value derived from parameters, which points to, provides information about, and describes the state of a phenomenon or environment of area, with a significance extending beyond that directly associated with a parameter values.

An indicator-based approach to vulnerability assessment enables a complex and intangible reality to be captured in a single measurement. This is often done by summarising the total number of complex and intangible things at risk either through expert opinions or statistical analysis.
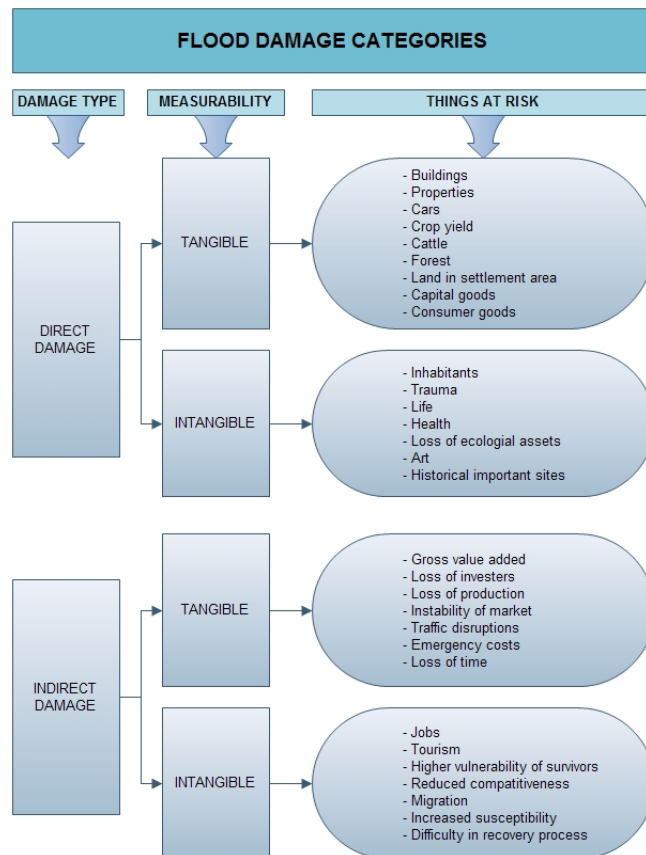
Figure 1. Flood damage categories (Modified from Smith and Ward 1998:35)

Climate change research adopted the indicator-based approach particularly for assessing the significance of sea level rise associated risk (Nicholls 1995; Nicholls and Leatherman 1995). There are a few important reasons for using indicators in climate change researches. Firstly, 'adaptive capacity', 'vulnerability' and 'resilience' were introduced as useful integrative concepts for evaluation of the potential effects of climate change on both physical and socioeconomic environments. However, these concepts are complex and difficult to be measured and quantified directly. As a result, it is necessary to identify proxy variables, or indicators, for the use in modelling or observation of climate change risk such as sea level rise. Secondly, the initial investigation into climate change mainly focused on the physical processes. However, this has changed to look more into the socioeconomic issues such as how different socioeconomic groups have different degree of vulnerability where indicator-based approach can be used.

3. Method
The choice of appropriate coastal vulnerability indicators for a particular coastal hazard is dependent on many factors. The indicators should include the hazard characteristics, but from the socioeconomic perspective, indicators should also be ones that can show the degree of development in the area, typical cultural and social characteristics and economic situation.

The selected indicators will be reduced down to an appropriate number depending on the number of sample areas. Factor analysis and Principal Component Analysis (PCA) was used to achieve this and the resulting matrix provided with factors that can be incorporated with the data in each of the sample area.

The following table shows a result from a pilot study on one of the municipal areas in Melbourne's outer suburb called Kingston City (Table 1). Factor analysis was applied to the socioeconomic data of smallest level (e.g. Census Collection District) from Australian Census 2006 where total of 54 variables were selected. The correlation matrix was applied and Varimax with Kaiser Normalization was used for rotation method. Principal Component Analysis (PCA) extracted 8 factors with engenvalues greater than 1.0. These factors accounted for nearly 80% of the variance in the data, and only 4 factors were extracted for vulnerability mapping since they accounted for more than 50% of the total dataset variance.

Factor	Variables with highest loadings (loadings)	Rotation sums of Squared Loadings		Factor Name
		% of Variance	Cumulative %	
1	• Poor English speakers (0.85) • Asian / African (0.84) • Lower education (0.74) • Unemployed (0.61)	15 %	15 %	Poor Migrants
2	• Age between 0 and 14 (0.92) • Education attending status (0.88) • Coupled families with children (0.77) • Partly-owned Tenure (mortgaged) (0.71)	14 %	29 %	Young Families (Financial Burden)
3	• Employed (-0.83: High negative) • Median individual income (-0.82: High negative) • No internet available (possibly phone as well) (0.79) • Lower education (0.7) • Age 60 and over (0.63)	13.7 %	43 %	Elderly, retired but less financial burden (possibly poor excess to technological resources)
4	• Renting population (0.85) • - Population living in current address less than 1 year (0.74)	9.4 %	52 %	Frequent Movers
5	• Median monthly homeloan repayment (0.73) • Single parent families (-0.73: High negative loadings)	7.4 %	59 %	Settled families
6	• People involved in health industry (0.7) • Total female labour force (0.65)	7 %	66 %	Female Professionals
7	• People who have done unpaid assistance for disabilities (0.79) • Fully-owned tenure (0.73)	6.8 %	73 %	Affordable
8	• People committed for childcare for other children (0.69) • Population require assistance in their core activities (-0.65: High negative)	5 %	78 %	Community committed

Table 1. Results of factor analysis on socioeconomic vulnerability (Data source: ABS Census 2006).

4. Result and discussion

Those factors with highest percentages of variance (e.g. Factor 1~4 in Table 1) were mapped using their factor scores. All factor scores were classified into the same number of categories using natural breaks (Figure 2). The resulting map shows a relative measure of most significant vulnerability factors for each Census Collection District.

For factor 1, it shows higher vulnerability on the north eastern part of the city where there is a large community of working class immigrants mainly of Asia and Africa origins. Along the coastline to the western part of the city where more expensive properties are concentrated, it shows higher vulnerability for factor 3. This is where older population is also concentrated who generally have less financial burden, but physically more vulnerable than younger people in the case of emergency situation.
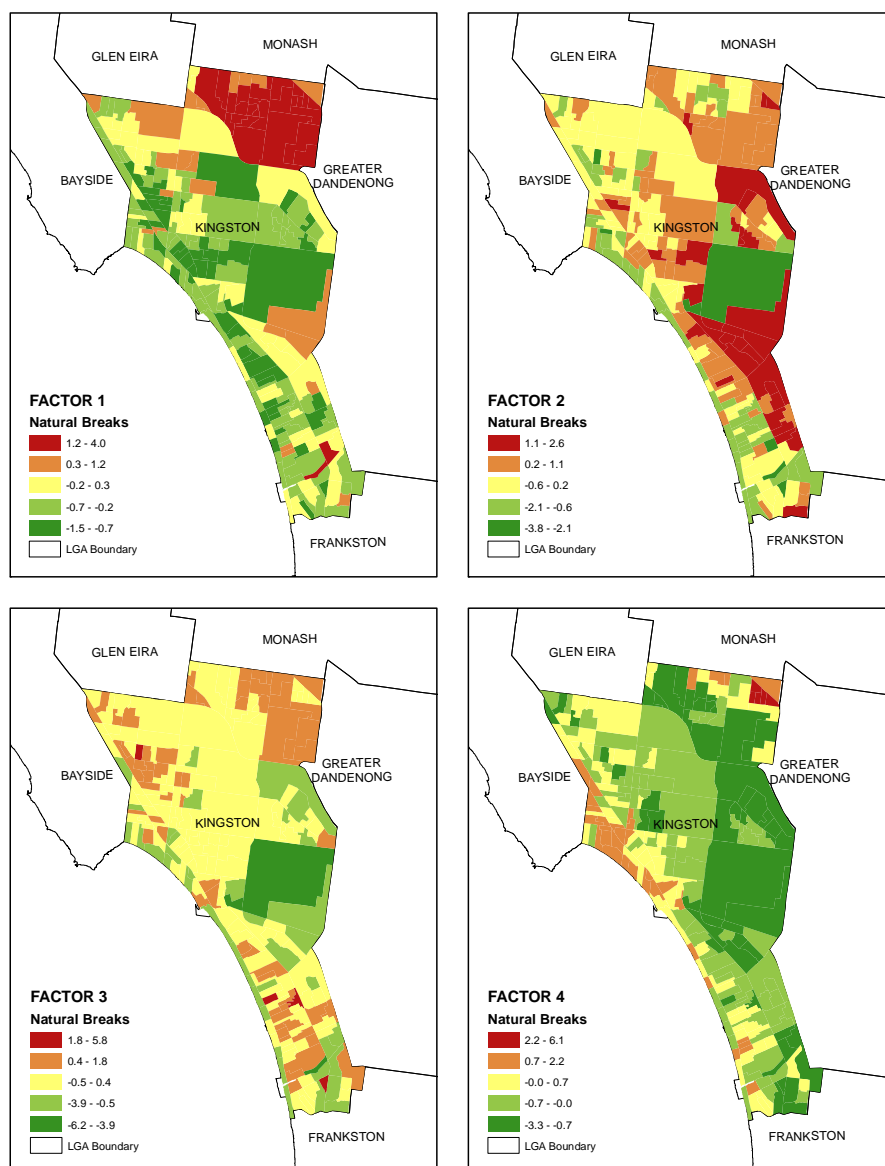

Figure 2. Socioeconomic vulnerability in City of Kingston, Melbourne

There are some issues in using indicators in vulnerability assessment. These include agreement on how to quantify vulnerability and limited availability of high-resolution socioeconomic data. Despite the relatively good availability of socioeconomic data in Australia at the local level, there still is significant number of socioeconomic information unavailable from a various reasons. Data with privacy issues, such as mobile phone usage data, public health, and housing information, are only available to regional scale.

Despite the drawbacks shown, indicator-based assessment is useful that it shows representation of correlations between variables which may not be apparent. This is particularly true when dealing with complex and intangible things at risk, and indicators can represent complex relationships that are easy to assess.

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