3 Reducing vulnerability following flood disasters:

Issues and practices

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Disaster reduction and sustainable development in the 21st century

Two inter-related concepts achieved world-wide attention in the closing years of the 20th century, and look certain to be central to the disaster reduction agenda of the next century. The first is the International Decade for Natural Disaster Reduction (IDNDR). The Decade concept was adopted by the United Nations General Assembly in 1987 to draw attention to the global importance of more effective hazard and disaster management, and to highlight slowness and failure to incorporate many research findings into practice. In the same year the Bruntland (World Commission on Environment and Development, 1987) drew global attention to sustainable development as a criterion for wise choice about the environment. Disaster reduction and sustainable development are closely linked - this is especially evident in the Third World. The rising incidence of disasters throughout the world (International Federation of Red Cross and Red Cross Societies, 1993, p 33), is one of most commonly cited indicators of non-sustainable development (Mitchell, 1994). Many of the major disaster problems in the Third World are caused or deeply intensified by development problems, as in the case of drought and famine in the African Sahel. One of the principal ways of alleviating vulnerability to these disasters is to encourage economic and social development within sustainable limits.

Although societal processes are fundamental to human vulnerability to disasters the Decade has, in the eyes of some commentators, assumed the status of a 'technofix', in which those promoting technology and hard science use it as an argument for more of the same (Alexander, 1993, p.617). As Handmer (1995) points out, the division between those approaching hazards from a technical perspective and those approaching them from a socio-economic, institutional and political perspective, is part of the history of the field. Early and subsequent research on flood hazards by Gilbert White, first at the Department of Geography at University of Chicago (e.g. White, 1945) and later at the Institute of Behavioural Science at the University of Colorado in Boulder, was premised upon the need to approach hazard reduction from a multi-disciplinary perspective, rather than from a narrow engineering one, but this fundamental message has frequently been ignored. Through addressing the long-term effects of engineering structures on flood losses in the United States, and focusing upon the problem of progressive development of flood hazard zones, this research also took on an early sustainability perspective, questioning the sustainability of hazard-prone development and policies which encouraged it. The links between hazard reduction and sustainable development are now being addressed afresh through further questioning about, and distinguishing between, hazard reduction policies which are non-sustainable or compatible with sustainable development objectives (e.g May *et al* , 1996). This has led, for example, to Burton *et al.* (1993, pp.262-263) suggesting that sustainability, with respect to environmental hazards, should focus on reducing the risk of catastrophic losses, while enhancing the community's resilience to less dramatic events. Resilience is the opposite of vulnerability and needs to be cultivated and shaped to achieve both hazard reduction and sustainability.

This chapter does not set out to provide a comprehensive overview of the closely-to-be-linked fields of disaster reduction and sustainable development, although some further comments on their links are incorporated. The above introductory discussion is intended only to highlight the importance of certain issues including the 'technofix', the 'sustainability frame' and socio-economic, institutional and political 'contexts' of reducing vulnerability to flood disasters. Rather this chapter focuses principally upon (a) a framework for thinking about disaster vulnerability in the context of floods, and (b) practical problems and solutions leading in various ways towards resilience-building.

Definitions, concepts and related issues

A combination of definitions and concepts is useful in developing a framework for thinking creatively about reducing vulnerability towards flood disasters in the post-disaster phase. However, it is instructive to begin by considering reconstruction and its relationship to other phases of disaster.

Reconstruction

The reconstruction phase of disaster management is by definition a post-disaster one in which devastation and loss of life has usually already occurred. Although problems and issues exist which are more or less unique to the reconstruction phase, there are others which are common to several other phases (e.g. prevention, preparedness) and reconstruction. This is because disasters frequently occur in series and because it is in reconstruction that the seeds for future prevention and preparedness must be sewn. In the reconstruction phase there is often a strong desire amongst victims and their political representatives to return the damaged and scarred community to something approaching 'normality' Here lies an initial problem because in many Third World communities normality is already an unacceptable condition for thousands, maybe millions, who suffer daily deprivation and risk which amounts to a continuous form of disaster (Kelly, 1995) In such circumstances reconstruction takes on a different meaning and relates to somehow propelling the damaged community upwards towards some new state characterised by a lesser degree of daily vulnerability and a greater degree of daily security and resilience: returning to normality is not an acceptable goal.

The most important aspect of reconstruction after disaster is that the beginning of this phase presents a host of new opportunities for governments, communities and individuals to avoid re-creating the conditions that led to disaster in the first place. Once settlements are established in hazard-prone areas, this 'window-of-opportunity' rarely presents itself, until a major disaster occurs permitting a fresh start. One exception is where a progressive urban renewal programme is seized upon to reduce hazard vulnerability either by removing development from the hazard-zone or by radically altering the design of new developments to enhance their hazard-resilience. Typically the onset of the reconstruction phase will present many new opportunities, only one of which will be hazard reduction. For example, developers are presented with opportunities to redevelop perhaps in a manner in which hazard-proneness may be increased (rather than reduced) since higher-density replacement development is likely to be profitable. In this context hazard reduction may take a back seat. The pressures to reconstruct following disaster may be intense as national and international commercial firms working in partnership with relief agencies seek to redevelop (Blaikie *et al.*, 1994, p.207) In such circumstances, there is sometimes little interest in seeking data (which often takes time to collect) to more adequately measure and define the hazard, and local knowledge is likely to be brushed aside as being 'unscientific'. Reconstruction to avoid re-creating the mistakes of the past is also limited by the informal economy, through which buildings may be reconstructed in situ without permit and to a low standard.

Flood impacts

The impacts of floods on society are complex, making them difficult to trace and measure. Floods are likely to affect both the formal and informal economies and, by definition, tracing the effects on the latter is problematic. Flood damages are usually categorised into tangible and intangible, direct and indirect and primary, secondary and tertiary ones (Table 3.1). Tangible damages are usually perceived to be those which can be measured in monetary terms, such as the damage to a dwelling, although such measurement is hardly ever precise and relies heavily upon estimation procedures. By contrast, intangible losses are those which either defy monetary measurement (e.g. the loss of an archaeological site through erosion caused by powerful flash flooding) or for which monetary estimates are considered undesirable and unacceptable. In some countries placing a monetary value on life is acceptable, while in others it is not. As monetary measurement techniques improve, losses previously regarded as intangible may become tangible. Direct flood losses are those caused by the physical contact of flood water with damageable property, whereas indirect losses are those caused by the consequences of physical contact of flood water with property. When floods drown livestock this is a direct loss, but when the income from livestock product sales is lost this is a consequential indirect loss.

Primary impacts are considered to be the 'first round' of impacts of flooding - the immediate effects. Typically these impacts lead to further 'knock-on' ones which are termed secondary ones. For example, the physical damage to a grain storage depot is a primary loss, whereas the food shortage which may follow is a secondary loss. A feature of models of flood impact, which attempt to include all categories of impact, is that they envision flood damages extending well beyond the area physically affected by the flood. This is because in practice, as with all disasters, floods set off a series of ripple socio-economic effects which extend well beyond secondary impacts and which economists may attempt to measure as 'multiplier effects' within the economy.

In reality the effects of flood hazards go well beyond the effects which flow from a severe flood event. Because hazard is an ever-present phenomenon in hazard-prone areas, where it and its potential consequences are well understood (perhaps because of the regular occurrence of extreme events), hazard may have a long-term negative impact upon the development process by presenting uncertainty and insecurity.

Table 3.1
The typical range of flood impacts in a developing country

PRIMARY IMPACTS

Tangible, direct flood damage
Damage to all building structures: homes, shops, manufacturing premises, public buildings etc.
Damage to the contents of buildings, including food stocks
Physical damage to infrastructure: roads, rail lines, bridges, water supply and sewerage plants and networks, electricity installations and power lines, hospitals and health care facilities, other communication networks

Tangible, indirect flood loss
Loss of industrial and agricultural production
Disruption of communications: by road, rail etc.
Disruption of utility supplies: electricity, water, sewerage
Disruption of health care services
Loss of crops and livestock

Intangible losses
Acute effects: mortality
Physical and mental impairment and morbidity
Destruction and loss of communities

SECONDARY IMPACTS (mainly intangible)

Food shortages
Increased mortality and morbidity
Homelessness
Shortage of clean water: reduced hygiene, contamination of water supplies
Disease epidemics: water-borne diseases, increased incidence of malaria
Disruption of health care and social services

TERTIARY IMPACTS (largely tangible)

'Knock-on' effects: refugees, migrations
Loss of exports; significant reduction of GDP

In the human ecological approach to hazards (Burton *et al.*, 1993), interaction with the natural environment results in positive and negative outcomes. In the case of floods, the positive consequences of the interaction are income flows from resources such as flat and moist soil, while the negative consequences are threats to property and life and damages to them, as well as losses to environmental assets such as sites of special scientific or environmental importance and valued by humans. In the context of examining a household's vulnerability to floods, Green *et al* (1994), model household vulnerability as a function of (a) the socio-economic characteristics of the household (b) property infrastructure variables (e.g. the susceptibility of building fabric to damage) (c) flood characteristics (e.g. depth of flooding) (d) warning variables (e.g. warning time provided) and (d) response variables (e.g. number of people assisting). However, most definitions of vulnerability take a much broader view.

Hewitt (1983b) says that hazard refers to the potential for damage that only exists in the presence of a vulnerable human community, although this could be extended to components of the non-human environment valued by humans on the basis of the previous argument. However, the usefulness of Hewitt's conception lies in the idea that harmful events, which arise in hazardous environments (i.e. disasters), may be reduced by altering the vulnerability or the coping capacity of the exposed population.

The concept of vulnerability is the subject of intense debate and alternative definitions representing different disciplinary and ideological positions, and different end purposes. Blaikie *et al.* (1994, p.9) define vulnerability as 'the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard'. Environmental managers may criticise this definition for being anthropogenic, and those researching the vulnerability of infrastructure (e.g. food production systems and processes, roads and public utilities) to disasters have applied the concept of vulnerability to non-human, urban infrastructure to expose the human consequences of flood disaster (Parker *et al.*, 1987, p.33). For example, the vulnerability of urban economies to disruption from flooding has been modelled as a function of a number of key factors, as shown in the following formula:

$V = f(D, T, S)$ where V = vulnerability to flood disruption

D = dependence - the degree to which an activity requires a particular good as an input to function normally (an example of indirect flood impacts)

T = transferability, the ability of an activity to respond to a disruptive threat by overcoming dependence, either by deferring or using substitutes or relocating

S = susceptibility, the probability and extent to which the physical presence of water will affect inputs or outputs of an activity (i.e. direct flood impacts)

In this formula, vulnerability is maximised where dependence is high, transferability is low and susceptibility is high, and is minimised by the opposite circumstances. For example, if food security is highly dependent upon bread availability and bread production is highly dependent on availability of flour *and* there is no substitute for, and no alternative source of, flour, *and* floodwater in the baker's premises is highly likely to stop ovens, then vulnerability is high. On the other hand, if food security can be guaranteed by alternatives to bread, or there are many sources of flour and baker's premises have been made resilient to floodwater penetration, vulnerability will be low. In reality, vulnerability of people and their support systems involves a large combination of physical, human, psychological and institutional factors which together determine the degree to which something or someone is put at risk (Blaikie *et al.*, 1994; Winchester, 1992b). Some of the principal factors contributing to high vulnerability are poverty, warfare and the denial of basic human rights.

Types of vulnerability

Several types of vulnerability may be distinguished which provide a broad framework for examining how vulnerability might be reduced in the post-disaster phase (Table 3.2). This framework demonstrates how vulnerability extends well beyond the initial and obvious effects of disaster. These types of vulnerability are similar to Foster's (1995) 'dimensions' of resilience: since greater resilience is what is achieved when vulnerability is reduced, the two concepts are highly complementary.

Table 3.2
The principal types of vulnerability

- Social vulnerability
- Institutional vulnerability
- System vulnerability
- Economic vulnerability
- Environmental vulnerability
- Vulnerability caused through unsustainable practices

High *social vulnerability* frequently promotes and exacerbates disaster and is often closely associated with under-development. Blaikie *et al.* (1994) provide a full analysis of the causes of social vulnerability which lie in social processes and differential access to resources. Although vulnerability and poverty are not synonymous, social vulnerability is often promoted by poverty and through related low response and recovery capacity. Social vulnerability may be reduced in a variety of ways. For example, Chan (1995) demonstrates how the vulnerability of poor, rural Malays to floods in eastern Peninsular Malaysia is much reduced by close kinship systems which exist in the flood-prone 'kampungs'. Rural Malays who migrate to flood zones in urban areas may have higher incomes, but often lose the support provided by kinship ties, which may make them more vulnerable than their rural counterparts In seeking to analyse 'social resilience', Foster (1995) argues that a further form of social vulnerability exists. Under unstable political and social conditions in which power changes hands rapidly, social goals are frequently redefined and former achievements are re-evaluated as failures and vice-versa. In these circumstances Foster claims that resilience is best achieved by projects which have been designed to satisfy a diversity of social goals and objectives, so that when power shifts, current policies may be supported because they have relevance to the new regime. Resilience may also be promoted by accessibility to knowledge - widespread public understanding of policies and projects, but may be undermined by technologies which are perceived as complex, remote and threatening. Social vulnerability may actually be reinforced in situations in which there is little integration between formal and informal means of reducing hazards. For example, formal flood forecasting and warning systems imposed upon communities often have limited effectiveness, because the designers and operators of many such systems tend to ignore public preferences, and the potential offered by local knowledge and informal flood warning processes Instead of attempting to find ways of integrating the best aspects of both formal and informal systems - to reduce social vulnerability - the common mindset is to supplant and replace the informal with the formal (Schware, 1982). Foster quotes a similar example of warnings of the November 1970 tropical cyclone in the Bay of Bengal being blocked in Bangladesh by officials, who were unhappy with the recent 'top-down' streamlining of the warning network, which contributed to at least two-hundred and twenty-five thousand deaths (Burton *et al.*, 1993; Foster, 1995, p.3).

Institutional vulnerability This is most the important cause of failure to effectively implement flood hazard reduction policies and strategies. For example, in analysing gaps in the implementation of hazard mitigation policies in the USA, Australia and New Zealand, May *et al.* (1996) identify institutional (a) capacity and (b) commitment, as two fundamental factors in determining the effectiveness of policy implementation. Where the capacity and commitment of implementing agencies is low, policy implementation tends to be weak. However, institutional resilience can be raised by enhancing capacity (e.g. the capacity to give technical assistance), or commitment to hazard-reduction objectives. Institution-building (e.g. introducing new legal requirements, capacity-building etc.) is therefore an important approach to reducing institutional vulnerability and increasing resilience to flood disasters.

System vulnerability This may be analysed in various ways using the vulnerability formula above. One approach is to reduce dependence on single sources of production or services. For example, instead of towns relying upon a single large water supply system, it is preferable to have a series of small-scale, self-contained water supply systems which offer the possibility of isolating damaged components and supplying flood affected areas from flood-free ones. Reliance upon simple, low-cost intermediate technologies to dispose of sewage may be preferable to more modern methods. For example, sewage removal by modernised cartage equipment for emptying household vaults, or bucket latrines, may be preferable to more sophisticated city-wide networks of sewerage systems, which may break down more easily in flood disasters' conditions (Parker and Thompson, 1991; UNDRO, 1982a).

Where possible, treatment plants, related installations and roads should be sited on relatively high ground. Here their exposure to flooding is generally lowest, thereby reducing their *susceptibility* to water damage. *Transferability* can be increased to raise resilience in many ways, usually by building-in a degree of system '*redundancy*'. For example, to reduce the possibility of food shortages in flood-affected areas, arising through their isolation owing to bridge losses and road closures, it is necessary to plan to store food in high locations within those areas likely to be affected, so that demands on food-carrying road transport to the affected area can be deferred in time. Similarly, constructing a road network with redundant linkages, some of which are over high ground, will reduce vulnerability to floods. Foster also identifies redundancy as one of the most important system characteristics (Table 3.2) required for resilience in the face of disaster. Following the Kobe earthquake in January 1995 the weakness of Japanese manufacturing systems was exposed: many manufacturers relied on a 'just-in-time' parts delivery system. As Foster (1995, p 6) points out, production is closely co-ordinated between plants, and components are provided as needed by a sophisticated, high speed transportation system. However, there is little redundancy in this system, which is *dependent* upon the continuous, efficient functioning of every component.

Resilient systems are also efficient and reversible ones. Inefficient systems commonly produce large amounts of waste, often producing a source of hazard too (e g. hazardous waste), and are incompatible with environmental sustainability. Resilient systems also contain processes which may be readily halted and reversed. The organisational sociologist Perrow (1984), identified a number of problems which are endemic in the day-to-day operation of many socio-technical systems, such as advanced industrial production plants. These systems commonly display 'interactive complexity', which is unthought-of interdependence between components, and 'tight-coupling'. Tight-coupling describes the condition in which the failure of one system component leads very rapidly to the failure of others in a way which cannot be controlled, reversed or retrieved, such that an accident or disaster is bound to occur. Perrow categorised chemical plants, such as the one at Bhopal which caused disaster following gas leakage in December 1984, as complex and tightly-coupled.

Economic vulnerability This may reveal itself in various ways which promote disaster and/or a less than optimal response to hazard reduction. Lack of necessary analytical methodologies, knowledge and data associated with floods are all indicators that important hazard reduction investment decisions may be being made on the basis of poor information. An important advance in hazard reduction methodologies is to acquire sufficient data and modelling techniques to enable the capacity for benefits and costs of various mitigation options to be compared This requires high quality data on hydrological and hydraulic parameters, damage potential (because damages which may be avoided are potential benefits) given events of different magnitude, and data on cost of mitigation projects. Economic resilience is likely to exist where disaster mitigation projects provide a high benefit-cost ratio and an early return on investment. Unfortunately, many large scale projects, such as flood control projects, do not display these characteristics according to Foster (1995). Often their costs escalate, leading either to abandonment and loss of investment, or they are completed with dubious viability. On the other hand a series of well co-ordinated, smaller projects provide greater flexibility (to change decisions) and less risk, thereby generating greater resilience.

Vulnerability caused by non-sustainability This has become a major cause of global concern (World Commission on Environment and Development, 1987). Resilient, sustainable development depends upon converging intra and inter generational equity, and upon the long-term sustainability of environmental systems. Environmental resilience exists where ways of life and disaster reduction projects are compatible with environmental sustainability. Many disasters, particularly those in the Third World, have a complex causation which importantly includes environmental degradation caused by misuse of natural resources. Overgrazing leading to loss of vegetation and soil erosion, and subsequently to desertification is one common example. Because they often affect the poor more than the rich, floods and flood mitigation projects may widen the income gap which is incompatible with goals of sustainable development (World Commission on Environment and Development, 1987). The challenge is to reduce floods in a manner which is compatible with reducing the income gap over time.

In the context of disasters, *technology* is a double-edged sword because it confers benefits to society and it also introduces risks or threat of harm. Sometimes technological responses to flood disasters, which are designed to increase resilience, actually increase vulnerability. Whether the net effect of a technological response to a flood problem is beneficial or harmful often depends upon the time-frame of the evaluation, and upon its geographical boundaries. For example, engineered flood control structures, such as flood embankments, may well reduce flood losses in a protected community in the years immediately following their completion. However, research indicates that such flood mitigation projects often induce further flood vulnerable development on flood plains, which in the long-term may lead to greater annual average flood losses (Parker, 1995; Thompson *et al.*, 1991). Similarly, the local effect of erosion and flooding prevention projects along the coast is often assessed to be beneficial, but when the spatial boundary of evaluation is enlarged, these projects are demonstrated to have significant adverse impacts in the 'downdrift' zone, often causing or contributing to coastal erosion and flooding problems there.

Flood protection and residual hazard

Floods can hardly ever be totally prevented yet flood protection projects often give the impression that the hazard has been removed. Where an area is protected by the construction of a flood embankment, the embankment will be built to a particular design-standard. This may, for example, be the 1:50 year standard which means that a flood of a magnitude which can be expected, on average, once in 50 years will be protected against, *providing* that the flood embankment is not breached (through inadequate construction or maintenance for example). However, the flood embankment will not totally protect against floods of a higher magnitude, or lower probability, than the 1:50 flood. Such floods present residual hazard which is often poorly understood and prepared for. Resilience can be increased by recognising and addressing residual hazard, perhaps through emergency preparedness measures designed to cope with the extreme breaching or overtopping flood event.

Range of choice and vulnerability

An important means of reducing vulnerability to flood disasters in the reconstruction period is to consider the full range of choice available for reducing future loss. The 'range of choice' concept was perhaps first introduced by White (1945), and its application is an important contribution to disaster decision-making processes. All too often key options for hazard reduction - particularly combinations of options - remain unconsidered and choice is rapidly narrowed, with the effect that disaster mitigation projects are less effective than they might be. This is particularly the case when single-disciplinary project teams are set to work on a disaster mitigation problem.

A critical problem afflicting the translation of the 'range of choice' concept into practice is limited definition of 'knowledge' of hazards. Taking a broader view can significantly increase the resilience of counter-disaster planning. Although attempts are now often made to utilise 'local knowledge' in disaster planning, there is at the same time a strong and common tendency to solely consider knowledge generated by the scientific community. Only that knowledge generated by 'experts' and 'professionals' interpreted as useful, and there is a great deal of difficulty in perceiving how local knowledge may be captured and used. Similarly knowledge from non-western, pre-industrialised societies tends to be over-ridden by knowledge derived from western industrialised society. However, as Handmer (1995) points out, there is now an increasing interest in 'traditional or local knowledge' and 'folk wisdom' (Correia *et al.*, 1994, pp.167-193; Parker *et al.*, 1994, p.164; Schware, 1982) and the use of consultative and participative methodologies to reveal it. Indeed, Wisner (1995) urges taking a wider view of the potential contribution which such knowledge can make to successful hazard reduction. He stresses that even when local knowledge is perceived to be useful, it is often only 'indigenous technical knowledge' which is perceived in this way. He argues that local 'social knowledge', for example about why hazards are perpetuated and in whose interest it is to perpetuate and reduce them, is valuable; as is local 'critical knowledge', for example, about why problems are either neglected or addressed at particular points in time.