Hurricane 07B in the Godavari Delta, Andhra Pradesh, India: vulnerability, mitigation and the spatial impact

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Few hurricane impact studies provide robust spatial parameters of damage or relate geographical patterns of destruction accurately to storm trajectories or agencies. A detailed spatial analysis is, therefore, presented of the destruction caused by tropical hurricane 07B which made landfall on 6/7 November 1996 over the Godavari Delta region, Andhra Pradesh, eastern India. Patterns of destruction by storm surge, wind and flood water are quantitatively mapped for death tolls, house destruction and agricultural damage using local administrative (mandal) data bases. Results show that most impact occurred near the coast, but a well-defined path of destruction across the central part of the delta can be identified. Such mapping studies fail to indicate the types of individuals and social groups most affected by the storm hazard and their response to it. An investigation of landowning farmers, female migrant rural labourers and fishing communities in the delta shows that poverty and social ordering in Indian society puts differential limits on the risk reduction abilities of individuals and social groups in the face of the cyclone hazard. The paper also demonstrates that ‘top down’ institutional measures to reduce the effects of storm damage such as those introduced in the aftermath of hurricane 07B, including early storm warning and evacuation procedures and rehabilitation programmes, remain largely ineffective. It is suggested that the introduction of more ‘bottom up’ community-based programmes which seek to improve the risk awareness and risk avoiding abilities of affected individuals and groups would be much more beneficial. The case material on hurricane 07B and its effects are placed in context by reviewing and updating long and medium-term time series records of storm frequencies and impacts in the Bay of Bengal and particularly along the eastern coastline of India.

KEY WORDS: India, hurricane, spatial impacts, vulnerable groups, coping strategies, hazard mitigation

There is increasing realization that current mainstream approaches to managing the impact of natural hazards cannot be sustained indefinitely. Spiralling economic costs from hazard impacts particularly in the developed world allied to unacceptably high human losses in developing countries have alerted us to the need to seek new approaches to hazard mitigation and the reduction of vulnerability. Alexander (1993) has shown that economic losses attributed to disasters have risen from several billion dollars in 1960 to over 20 billion in 1990, with much of this rise coming from increasing population densities in coastal communities (Diaz and Pulwarty, 1997). Numbers of deaths attributed to hazards in the developed world have declined as a response to better warning systems and evacuation procedures falling by half from 38 deaths per hazard during 1947–67 to 19 deaths per hazard in 1969–89. In contrast, hazard-related death tolls in the developing world are considerable. In the absence of effective warning systems and institutional response programmes, the average loss of life per hazard impact in the Third World has doubled.

Despite the concerted efforts made to reduce disaster impacts during the 1990s through the activities of the United Nations International Decade for Natural Disasters Reduction (1990–1999), damage to property and loss of life from natural hazards continue to increase. With respect to atmospheric related disasters (e.g. flooding and severe storms) where more people are killed and property lost than by any other type of natural hazard (Blakie et al., 1994; Smith, 1997), higher death tolls were recorded during 1997–2000 than during 1990–1997. Though there is little real evidence as yet for increasing storm frequency or intensity in a globally-warmed world (Houghton et al., 1996; Burroughs, 1997; O’Hare, 1999) there is little doubt that storm impact by cyclones, thunderstorms and tornados on lives and property are intensifying. Hurricane Mitch (27–29 October, 1998) was one of the most intense hurricanes to impact over central America this century, but the environmental and human destruction it caused were almost unparalleled (McCown et al., 1999).

In recent years, increasing populations, growing poverty, poor land-use planning, and environmental disturbance, including deforestation, have conspired to exacerbate the effects of storm damage the world over (Comfort et al., 1999).

Contrasting hazard-society models

Two very different perspectives of hazard-society relationships exist (Pulwarty and Riebsame, 1997). The traditional viewpoint emphasizes a homeostatic or self-regulating balance between environmental hazards and society (Burton et al., 1993). It infers that an acceptable balance is eventually achieved between environmental disturbance and society since people and institutions are uniformly and unambiguously committed to removing known manageable risks from life and only fail to do so when the hazard is highly uncertain (Hewitt, 1983). This perspective emphasizes a ‘top down’ approach to the disaster problem, and sees solutions (since the Industrial Revolution and more particularly since the 1950s) through the application of physical measuring and monitoring techniques, and the use of structural management programmes involving large engineering works and architectural design.

Such dominant technocratic/technofix approaches have been transferred to developing countries, often through Aid/development schemes. However, from the late 1970s, they have come in for increasing criticism for being inappropriate (environmentally, socially, economically) in many development contexts, and for reinforcing the dependency of recipient upon donor, leading to the development of under-development (Hewitt, 1983). One of the main reasons why externally-imposed approaches to disaster management tend not to work is because nature and disasters are social constructions, in the sense that meanings given to them are different in different societies. People and communities develop their own view of the world and of nature and their responses to disaster are governed by this (Jacqueline Homan, Univ. Birmingham, pers. comm.). ‘Top down’ or external influences can override these feelings and can escalate vulnerability to loss, perpetuating and even exacerbating the disaster issue (Oliver-Smith, 1994; Comfort et al., 1999). Western governments are now reassessing their approach to disaster management not least because of the escalating costs of traditional technological approaches to mitigation.

The second perspective, increasingly promoted from the mid-1980s, sees little evidence of negative or dampening feedbacks and the development of equilibrium between hazards and human development. It envisages a more open-ended positive feedback process between society and hazard where the cumulative process of human development and rising populations (especially in poor societies) inevitably leads to greater vulnerability and growing potential for disaster. This more people-centred or ‘bottom up’ perspective calls for greater community awareness and participation in vulnerability reduction. It claims that vulnerability and impacts should be considered more in terms of what people do and greater consideration should be given to the effects of disasters on social and community groups (Morren, 1983; Maskrey, 1989; Degg, 1998; Comfort et al., 1999). These changes in perspective mirror the general trend in overseas Aid/development programmes towards empowering people to help themselves – building on the ideas of Schumacher (appropriate technology, self reliance) in the late 1960s and early 1970s. In the face of global environmental change, societies are thus increasingly being encouraged to learn to live with nature rather than fight against it with ever bigger technology, necessitating a greater community awareness of, and involvement in, environmental processes and their mitigation. With this view, non-structural solutions to disasters are recommended including careful land-use planning, risk assessment and management, and insurance.

Vulnerable groups and survival strategies

Modern perspectives, that call for the greater involvement of and responsibility by communities and individuals in hazard mitigation are structurally linked to the notion of reducing vulnerability.
Vulnerability is usefully defined 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 (Blaikie et al., 1994). There is much evidence to show that certain social and demographic groups are more vulnerable than others to disaster or face greater difficulties during recovery from disaster (Bolin, 1986; Cutter, 1995; Peacock et al., 1997; Enarson and Morrow, 1998; Fordham, 1998; Comfort et al., 1999; Morrow, 1999). These groups include peoples marginalized by factors such as class, gender, race and ethnicity, age, income and geographical location. Examples of these include:

- low caste communities (such as tribal or scheduled castes in India);
- ethnic minorities;
- women, especially those who may be widowed or deserted;
- aged men and women;
- children particularly female;
- the disabled;
- people dependent on low or daily incomes;
- those in debt; and
- those most isolated from infrastructures including transport, communications, health services (Dina Abbott, Univ. Derby, pers. comm.).

An important related area of consideration involves the types of survival strategies these vulnerable groups might adopt in the aftermath of a hurricane or other disaster (Blaikie et al., 1994; McMichael et al., 1996). Agarwal (1990) illustrates five main survival strategies used by the rural poor in India. These include:

1. diversifying sources of income, including seasonal migration;
2. drawing upon communal resources;
3. drawing on social relationships including patronage, kinship, friendship, and informal credit networks;
4. drawing upon household stores (food, fuel etc.) and adjusting current consumption patterns; and
5. drawing upon assets.

As this paper will show aspects of these broad survival strategies can also be applied to understanding disaster management strategies of the rural poor in the Godavari Delta region of eastern Andhra Pradesh, India.

Methodology and approach

This paper provides a review of the annual frequency, spatial occurrence and impact of intense tropical cyclones in the Bay of Bengal. Intense tropical cyclones are defined here as comprising:

1. ‘cyclonic storms’ with sustained wind speeds between 17 and 28 ms\(^{-1}\);
2. ‘severe cyclonic storms’ (wind speeds \(>28–33\) ms\(^{-1}\)); and
3. ‘tropical hurricanes’ (with wind speeds \(\geq 33\) ms\(^{-1}\)).

The general terms ‘tropical cyclone’ and ‘cyclonic activity’ are used to incorporate all tropical cyclone behaviour including the less intense tropical cyclonic low (wind speeds \(<8\) ms\(^{-1}\)) and the tropical cyclonic depression (wind speeds \(8–17\) ms\(^{-1}\)).

Storm decadal frequency data by Mooley (1980) showing a gradual increase in the number of severe cyclonic storms and hurricanes in the Bay of Bengal during the period 1877–1977 is extended to 1996 by the present author and re-evaluated. A more detailed investigation follows of the timing, spatial incidence and socio-economic effects of intense tropical cyclones impacting along the coast of Andhra Pradesh in eastern India between 1976 and 1996. This work provides contextual material for the paper’s main focus – an analysis of the socio-economic impact of and human response to hurricane 07B (the name designated by the Indian Meteorological Department) that made landfall over the Godavari Delta in Andhra Pradesh, eastern India, on 6/7 November 1996. Three main categories of socio-economic damage caused by this storm comprising house destruction, agricultural damage and loss of life are analysed spatially and explained in relation to the differential effects of tidal wave, storm wind and flood across the delta. Hurricane 07B also had an impact that was differentiated by the type of people it affected, so that an analysis is also made of the vulnerability and response of different social groups and communities in the delta to the hurricane disaster. Finally, an assessment is made of the effectiveness of traditional ‘top down’ government and non-government disaster mitigation policies in the delta, including early warning and evacuation procedures and ‘after the event’ rehabilitation programmes.

Bay of Bengal cyclones

The most comprehensively studied area of tropical cyclonic activity by far is the Atlantic/Caribbean Sea region. There is a wealth of cyclone data for this basin with many excellent publications as well as sites available on the Internet (e.g. www.ncdc.noaa.gov/ol/climate/severe_weather/hurricanes.html, 1999; www.nhc.noaa.gov/pastdeadly.html, 1999). Information on tropical cyclone activity from other world regions is much less accessible, including that from the seas around India. Analyses of Indian basin (Bay of Bengal and Arabian Sea) cyclonic activity from 1877 onwards have been carried out by a number of workers, using cyclone data...
data from the Indian Meteorological Department in Delhi. Because the Indian Government is generally reluctant to provide meteorological information for security reasons, the author has used good quality comparable data sets on intense tropical cyclones and their tracks in the seas around India from the US National Climatic Data Center (NCDC, 1996).

Cyclone frequencies
Recent studies of cyclonic activity in the Bay of Bengal over the 100-year period 1877–1976 reveal that the majority of intense tropical cyclones form over the Bay of Bengal in the pre-monsoon and post-monsoon phases with May, October and November being the months when their greatest frequency is recorded (Subbaramayya and Subba Rao, 1981; Mooley, 1980; Pant and Rupa Kumar, 1997: 93). O’Hare (1997) and Pant and Rupa Kumar (1997) maintain that these high non-monsoon period cyclone frequencies are the result of weak upper air easterly circulations in Spring, Autumn and Winter.

Mooley (1980, 1981) using times series data from 1877–1976 has shown that the frequency of severe cyclonic storms and hurricanes in the Bay of Bengal increased throughout the period, with the highest decadal frequency of storm action during 1967–76 (Figure 1). A 1976–1995 update of this time series by the present author using comparable NCDC (1996) data on tropical storms and their tracks in the Bay of Bengal, indicate that storm frequencies in general over the Bay have declined in recent decades to levels similar to those identified in the latter part of the nineteenth century by Mooley (1980). Mooley (1981) attributes the increased mean annual frequency of severe cyclonic storms and hurricanes in the Bay after 1964 to better facilities for detection and more favourable meteorological conditions allowing the intensification of cyclonic activity. The significant reduction in the annual frequency of such storms in recent decades suggests that despite the possible enhancing effects of global warming, meteorological conditions alone are responsible for the observed rates of decline.

Storm trajectories and landfalls
Studies of NCDC (1996) storm trajectories reveal that the coast of Andhra Pradesh has experienced 65 severe cyclonic storms and hurricanes in the last 100 years confirming Nath’s (1994) observation that the zone is the most cyclone-prone region in

![Figure 1: Decadal frequency of severe cyclonic storms (wind speed 28-33 ms⁻¹) and hurricanes (wind speed >33 ms⁻¹) making landfall in the Bay of Bengal. Severe storms and hurricanes failing to make landfall and dissipating at sea are shown as clear sections. Sources: 1877–1976 Mooley, 1980; 1977–1995, O’Hare]
India. A good proportion of these storms, especially when they develop in the post-monsoon season (Oct./Nov.) move towards the southern parts of Andhra Pradesh State with the Nellore District alone having experienced 19 severe cyclones in the last 100 years. Other Bay cyclones have shown a tendency to travel more or less directly west and head for the Godavari Delta region of northern Andhra Pradesh. For instance, East Godavari district has experienced 11 severe cyclonic storms and hurricanes in the last 100 years. Current analyses of storm trajectories in the Bay of Bengal for the last two decades (1977–86, 1987–95) further highlight the Andhra coast as being particularly susceptible to cyclone impact. Of 59 intense tropical cyclones forming over the Bay during this period, 25 made landfall along the coast of Andhra Pradesh, 9 over Bangladesh and the Eastern Territories of India, 10 over Tamil Nadu and Sri Lanka, 8 over Myanmar, with 4 along the coast of Orissa and West Bengal and 3 dissipating at sea.

**Cyclonic impacts: Bangladesh and Andhra Pradesh**

Damage to life and property from intense tropical cyclones in developing countries is enormous, with death rates far exceeding those, for instance, in the Caribbean (Smith, 1997: 307). High death tolls and property losses are to be expected when severe cyclonic storms and hurricanes impact over poor regions with high rural population densities. Inadequate advanced warning systems and minimal evacuation procedures are largely to blame, but spectacular storm surges, for instance, as along the coast of eastern India and particularly Bangladesh (Figure 2a) can contribute to the high mortality rates. Bangladesh has experienced some of most intense tropical cyclones on record. One of the earliest known killer cyclones of 7 October, 1737 killed or drowned over 300,000 people in Bangladesh (Sensarma, 1994). Also noteworthy in this respect are the Bangladesh cyclones of 13 November, 1970, which killed or drowned almost 500,000 people and that of 29 April, 1991 that caused 139,000 deaths.

The scale of tropical cyclone impact along the Andhra coast has been relatively well documented. Winchester (1992) reports that a major storm in 1679 drowned as many as 20,000 people in the Machilipatnam region. Das (1997) points to widespread destruction from two major storms in 1706 and 1787 in the Godavari Delta. In more recent times, the greatest cyclone disaster occurred in November 1977 when a category 5 (62.5–69.5 ms\(^{-1}\) or 225–250 kmhr\(^{-1}\)) 1000-kilometre diameter hurricane impacted over southern Andhra Pradesh (Machilipatnam area) killing over 10,000 people. One estimate of the nature and scale of the climatic hazard from 19 tropical cyclones making landfall over Andhra Pradesh since 1978 is shown in Table 1 (Radhakrishna, 1996). Not all the listed cyclones are of storm strength (i.e. > 17 ms\(^{-1}\)). Those occurring during the Summer monsoon (July and August) are tropical depressions (wind speeds 8–17 ms\(^{-1}\)) but nevertheless when lasting from 3–12 days can release heavy rainfall over an area resulting in extensive inundation and high death counts. The cyclones of July 1989 and October 1996 were of this type, releasing copious supplies of rainfall (more than 500 mm) over a very wide area. With the July 1989 system, the whole state of Andhra Pradesh—all 22 districts and almost 9 million people—were affected, mostly by serious flooding. Table 1 as presented, has some notable omissions such as the absence of the 9–15 November 1984 hurricane which caused 430 deaths and was among the worst storms to hit the coastal zone of Andhra Pradesh in the 1978–95 period.

Despite these limitations, a striking feature of Table 1 is the large and varied extent of damage associated with the storm list. Nine of the storms shown are associated with more than 100 deaths, with those of May 1979, May 1990 and November 1996 causing 706, 817 and 1059 fatalities respectively. Property losses are also considerable. The category 5 (62.5–69.5 ms\(^{-1}\) or 225–250 kmhr\(^{-1}\)) 1000-kilometre diameter hurricane of May 1990 which made landfall over Machilipatnam (which was similar in intensity and location to the 1977 hurricane) apparently destroyed more than 1.4 million houses, killed over 27,000 cattle, damaged over half a million hectares of cultivated land and caused an estimated economic loss of Rs 21,373 million.

**Hurricane 07B: impact and response**

This investigation explores the impact of and the human response to Hurricane 07B, which made landfall over the Godavari Delta of central Andhra Pradesh during 6/7 November 1996. As shown in Table 1, this hurricane had a devastating effect on the delta region, being responsible for over 1000 deaths and incurring heavy economic loss. The study presented here is based on data collected during a three-week field visit by the author to the Godavari Delta in April 1998. Three main sources of information were collected. Twenty informal field interviews with villagers, farmers and fishermen were carried out to ascertain their views of the storm, as well as their feelings regarding post-storm relief measures by government and non-government organizations. A second main source of data, was accessed in the district capitals
of Kakinada (East Godavari) and Eluru (West Godavari), and included government (Andhra State) statistical information on storm damage and compensation payments. Particularly useful in this respect were 103 village- (mandal) based data sets of death tolls, house destruction and agricultural loss, since these allowed various types of damage across the delta to be accurately mapped. Finally, visits were made to documentation centres in Hyderabad and Bombay (Mumbai) to access journal, newspaper and other media reports of the storm and its effects.

Figure 2 (a) Typical height of storm surges (tidal waves) from severe storms and hurricanes along the eastern coast of India: (b) the development of hurricane 07B in the Bay of Bengal showing main trajectory, energization rates and landfall position.

Source: Indian Meteorological Department
The Godavari Delta

The Godavari Delta is centrally located along the east coast of India (Figure 3) and is over 175 kilometres from north to south and east to west. For administrative purposes the region is divided into two districts (East and West Godavari), with each district being further divided into local administrative or village areas called mandals (Figure 3).

The Godavari Delta is a fertile agricultural area with extensive paddy fields, coconut gardens, banana groves, sugar cane fields and horticultural crops. East and West Godavari have a combined population of over 9 million with an average population growth rate of 1.8 per cent per annum: 77 per cent of the population is classed as rural, and more than 67 per cent of the active population is engaged in agriculture or agricultural processing. The population is widely but unevenly distributed across the region (figure 4a) in many small villages and towns. Population densities vary from less than 150 people per square kilometre in the higher drier interior mandals to 1000–1400 per square kilometre in the more seaward, more fertile lower-lying regions (i.e. in the Konaseema region between the towns of Amalapuram, Polavaram and Rajamundry) where two and often three rice crops can be grown and harvested per year. The dense and relatively fast-growing populations of the more remote coastal areas are critical, as will be seen, in terms of hurricane impact and the management of vulnerability reduction.

The development of hurricane 07B

The critical development and intensification stages of cyclone 07B are shown in Figure 2b. The cyclone intensified into a severe cyclonic storm with core strength hurricane winds ($>33 \text{ ms}^{-1}$) by 9.00 a.m. on 6 November, and by 12.00 noon lay positioned just off the coast of Andhra Pradesh. It then moved quickly in a west-north-west direction and crossed the Godavari Delta region about 50 kilometres south of Kakinada at about 5 p.m. on 6 November. The system was now at its most intense with sustained core wind speeds of up to 175–220 kmhr$^{-1}$ and a vortex diameter of around 400 kilometres. The system then raged for six hours over the Konaseema delta area before dissipating into a severe cyclonic storm by midnight on 6 November. The system then changed direction again and travelled across East and West Godavari districts in a westward direction rapidly weakening into a deep depression by 3.00 a.m. on 7 November in north-west Guntur district. During the hurricane event, most of the southern half of East and West Godavari districts received over 100 millimetres of rainfall and the area around Kakinada

<table>
<thead>
<tr>
<th>Year of cyclone heavy rains and floods</th>
<th>Districts affected</th>
<th>Population affected (000s)</th>
<th>Human deaths</th>
<th>Livestock loss</th>
<th>Houses damaged</th>
<th>Crop area damaged (000s ha)</th>
<th>Estimated loss (Rs million)</th>
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<tr>
<td>Aug. 1978</td>
<td>16</td>
<td>49</td>
<td>52</td>
<td>1465</td>
<td>22 000</td>
<td>951</td>
<td>1500</td>
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<td>10</td>
<td>n.d.</td>
<td>706</td>
<td>n.d.</td>
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<td>n.d.</td>
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<td>58</td>
<td>1726</td>
<td>94 218</td>
<td>714</td>
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<tr>
<td>Feb. 1984</td>
<td>3</td>
<td>1900</td>
<td>7</td>
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<td>8244</td>
<td>192</td>
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<td>110 550</td>
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<td>10 905</td>
<td>227 000</td>
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<td>14</td>
<td>7781</td>
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<td>27 625</td>
<td>1 439 659</td>
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<td>50</td>
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<td>42 665</td>
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<td>229</td>
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<tr>
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<td>1059</td>
<td>6845</td>
<td>646 000</td>
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<td>61 264.7</td>
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Source: Nilratan Maity cited in Radhakrishna, 1996; O’Hare
over 200 millimetres of rainfall. In contrast, neighbouring Machilipatnam, 70 kilometres to the south, received 10 millimetres and Visakhapatnam 100 kilometres to the north received no rainfall at all.

General impact of the hurricane
Although slightly less intense and much smaller than the super hurricanes of November 1977 and May 1990, this hurricane killed around 1000 people, i.e. as many as the 1990 hurricane and caused enormous economic damage at over 60,000 million rupees (Rs) (Table 1). Altogether, around 7.12 million people (over 80% of inhabitants of the delta) were affected by the storm in 484 villages in 34 mandals in East Godavari and 901 villages in all 46 mandals of West Godavari.

According to the Indian Meteorological Department in Hyderabad, one of the reasons for the high death toll was the atypical nature of the cyclone itself. With its unusually rapid development and highly organized form, the cyclone did not present...
the normal atmospheric precursors such as increased cloudiness, high winds and heavy rainfall one or two days in advance of landfall. In other words, there was practically no dispersed cloud formation surrounding the main vortex to give adequate advanced warning to people of the approaching storm. Another reason for the significant death toll was that meteorologists had predicted wind speeds at landfall of 120–150 kmh$^{-1}$ (33 ms$^{-1}$–41.5 ms$^{-1}$) though wind speeds of almost twice that (175–220 kmh$^{-1}$ or 48.5 ms$^{-1}$–61.0 ms$^{-1}$) were actually recorded allowing high tidal surges (2 to 2.5 m) to sweep five to six kilometres inland (Das, 1996). The hurricane also arrived much earlier than expected at around 5–6 p.m. The storm’s arrival caught many people unawares since the cyclone was forecast to descend on them by around midnight (Rao, 1996). The main power supply was disrupted plunging the area into darkness. Power was shut down in 34 out of 57 mandals of East Godavari and 18 out of 46 mandals of West Godavari (Radhakrishna, 1996).

Spatial incidence in hurricane damage

Death tolls

Indian death counts from natural hazards are never precise especially when large numbers are involved. More than 2000 people were initially reported to have been killed though roughly half that total (around 1000) has been confirmed. Part of the explanation for the large number of reported deaths may be related to expectations concerning the relatively high amounts of compensation promised to families for lost members from the State Government of Andhra Pradesh (i.e. Rs100 000 or about £2000 per family).

The 40 or so low-lying island villages (the Lankas) strung along the 75-kilometre coastline of East Godavari took the worst beating in terms of loss of lives. Many of the 1000 or so confirmed deaths and the several hundred who were seriously injured were fishermen or their families. West Godavari reported 98 fatalities, but as shown in Figure 4b most of the dead were recorded from the low-lying coastal villages in East Godavari. The devastating impact of the storm surge can be clearly identified in the high concentration of deaths in the coastal mandals, especially those immediately south of the mouth of the main channel (Polavarum, Katrenikona, Ainvilli Districts) where 07B made landfall. Though less in number, notable death counts occurred further inland beyond the storm surge. These fatalities can be attributed to drowning from rising floodwaters caused by prolonged heavy precipitation over the lower reaches of the delta, though high wind damage (falling masonry, electric pylons, coconuts) also produced a number of fatalities.

House damage

While the coastal villages suffered the greatest number of fatalities, the mainland villages suffered higher losses to property and standing crops. Across the delta, around 314 000 houses were seriously damaged and a further 332 000 partially damaged. East Godavari accounted for around two-thirds of all house damage (433 000 housing units) compared with 213 000 in West Godavari. This pattern is shown in Figure 4c illustrating the spatial distribution of damaged houses over the study region. House damage from wind and storm surge are clear being greatest (20–30 000 units) in the coastal mandals but comparable damage by wind and flood waters also occurred inland near the centre of Konaseema (Amalapuram District) and to the north of the main channel (Mandapeta, Ramachandrapuram districts). When the mandal number of damaged houses is normalized by the population of each mandal (to average the number of houses by unit area) a very dramatic imprint of the storm’s devastation is found. It can be seen from Figure 4d that most house destruction occurs within a narrow 40–50-kilometres wide zone across the delta, clearly indicating the west-north-west trajectory of the storm. The progressive dissipation of the storm over land from hurricane to cyclonic storm is also evident in the stepwise landward reduction in house damage across the delta.

Agricultural and other damage

Despite widespread damage to housing with reconstruction costs calculated at around Rs 6420 million, agricultural losses were far greater. Hurricane 07B came at the most inappropriate time when paddy rice, the main crop of the region, was ready for harvest. Around 174 000 hectares of paddy in East Godavari and 162 000 hectares in West Godavari were severely damaged as a result of three to four days flooding and submersion in the southern part of the delta. The loss in paddy yield for the region was estimated at around 450 000 tonnes and Rs 3360 million. An impression of the extensive impact and heavy agricultural losses incurred by farmers over the delta are shown in Figure 4e. Government subsidies paid to farmers in proportion to their crop losses (except coconuts) prevail not just over the Konaseema area but also across most of the southern part of East and West Godavari.

Coconut trees, occupying over 30 000 hectares, and one of the most important cash crops forming
an important source of livelihood for 75 per cent of the people of the delta (Radhakrishna, 1996), were also severely damaged. Most destruction suffered by this crop was the result of strong winds that literally beheaded the coconut palms or uprooted stems, rather than from tidal surges or flooding. Figure 4f shows that most coconut palm damage occurred in the coastal and lower deltaic lands. This pattern is consistent with both the greater density of coconut palms in the more seaward delta areas and strong wind velocities in the vicinity of the coastal and near-coastal zones. The loss sustained as a result of the damage of around five million coconut trees was initially put by government sources at Rs 30 000 million although this figure is now seen to be a gross exaggeration. The loss of other commercial crops including bananas, coffee, vegetables (on 83,536 hectares) and other fruits has been estimated at Rs 10,920 million bringing the total loss under the agricultural sector to around Rs 44,280 million.

The cost of damage to fisheries (Rs 267.7 million) and animal husbandry (Rs 136.8 million) appears relatively low but masks severe human costs in terms of loss of lives and livelihoods. Fishermen’s property such as craft and tackle were lost. Many cattle (reported at 68,45), and 2.2 million poultry also perished. According to government reports over 350 irrigation works were damaged at a cost of Rs 73.5 million and flood banks have suffered extensive erosion. There was also extensive sand casting of coastal villages and clogging of drainage outfalls close to the sea.

Hurricane 07B: people at risk

The spatial patterns of destruction and loss across the delta so far described provide only a partial picture of the types of people most affected by the disaster and the reasons why. The most vulnerable sectors of society to hurricane impact in the Godavari Delta include many of the social and demographic groups already identified as being more at risk to disaster than others. For instance, the highest risk group in general is men, women and children marginalized by poverty i.e. the rural poor of the delta. Many poor rural families (the landless, those without regular employment) living in insubstantial village dwellings with mud walls and thatched roofs had their houses torn apart by the hurricane. Much less affected by house damage in almost every village were smaller numbers of higher-income landowning farmers and their families who occupy more substantial brick and concrete dwellings.

One of the most vulnerable specific groups is rural landless labourers, especially scheduled (low) caste women and girls who have migrated from distant regions. Such migrants do not have a permanent home or stable social environment and contrast for instance with the more affluent landowning farmers of the region. Dependent on a daily wage, such female migrants are often unable to build up food reserves or other assets with which to survive in times of disaster. A second highly vulnerable group includes the aforementioned fishing communities of the coastal villages. Their vulnerability is a function of general poverty, physical and social isolation and unfavourable location in relation to the hurricane hazard.

Land owning farmers and female migrant labourers

Land ownership in the delta is highly varied in territorial extent and geographical distribution. Most farmers in the delta are small-scale farmers holding less than five hectares, though many farmers own upwards of ten and 100 hectares. Qualitative interviews with several farming families revealed that a small number of landowning farmers in the delta were bankrupted by the severe agricultural losses they suffered. However, the great
majority were able to rely on savings and other resources to tide them over to the next harvest. Much more affected were the rural poor especially landless agricultural labourers reliant on a meagre daily wage. The most vulnerable group in this sector were migrant, scheduled (low) caste women from the state of Orissa who perform most of the agricultural work in the rice fields of East and West Godavari (Raju et al., 1999). The destitution wrought on these women after the destruction of the rice crop was revealed in the range of mostly individual strategies they had to adopt in order to survive the disaster. With the penetration of global capitalism in India in recent years and the rise of cash cropping, the traditional obligation of farmers to feed their workers in times of hardship has diminished. Thus, while some scheduled caste women could rely on handouts of food from considerate landlords, most had to subsist by other means, by begging, or by selling what possessions (mostly jewellery) they had. Others entered domestic service in the towns and villages where they could find such work, while others migrated temporarily either to neighbouring agricultural districts in southern Andhra (e.g. Mellor) or even back to their home village. The plight of these migrant women worsened even further if they were on their own (many were unmarried or with their husband gone or working elsewhere) and with young children. It can be seen that in relation to Agarwal’s (1990) coping strategies, the migrant female labourers of the delta tended to adopt non collective, individually based survival methods i.e. (1) diversifying sources of income, including (seasonal) migration, and (5) drawing on assets where possible.

**Fishing communities**

Despite the vulnerability of the rural migrant labourer, there is little doubt that the social group most seriously affected by the hurricane was the fishermen and their families. We have already seen that the greatest loss of life (reported and confirmed) attributed to the hurricane was overwhelmingly concentrated in the low-lying fishing villages along the coast of East Godavari. Qualitative informal interviews conducted by the author in the fishing villages of Balusutippa and Bhairavapalayam have demonstrated that although several hundred people, many of them children, were drowned in the coastal villages as a result of the hurricane’s storm surge, the highest reported death tolls numbering over 1000, were caused by fishermen (and their sons) being drowned at sea, who heedless of the danger went out into the Bay of Bengal before the rapidly advancing storm. Many livelihoods were also destroyed or seriously damaged in the coastal villages as many fishing boats were destroyed or lost in the storm together with a good deal of ancillary fishing tackle.

Strategies adopted by fishermen and their families in the face of disaster appear to be similarly fatalistic, but more collective and less diverse geographically/economically, than those taken up by other groups such as farmers or the female migrant rural labourer. This is almost certainly a reflection of the strong sense of social cohesion and community spirit found in the coastal villages, where fishing communities are regarded as being the most fiercely independent and closely-knit in the whole delta. For instance, despite considerable losses, most people did not move but remained in the same fishing village as before and tried to recover their lives. This is also related to the fact that fishing activity though greatly reduced in the coastal villages did not cease altogether in the aftermath of the hurricane. Some fishermen who lost almost everything, simply carried on their trade by going to work for other fishermen who were more fortunate in terms of disaster losses. Many of the worst affected victims of the hurricane relied on highly-developed community support strategies with families and individuals helping others with house rebuilding and food sharing. Thus, it is clear that the fishing communities tended to adopt Agarwal’s (1990) more collective strategies i.e. (2) drawing on communal resources i.e. ocean fish stocks, (3) drawing on social relations; and (4) drawing on (where possible) surviving household stores while also adjusting consumption patterns (see page 23). This analysis of social vulnerability in the delta supports the findings of Winchester (1992) by revealing that poverty and social ordering in Indian society puts differential limits on the risk reduction abilities of individuals and social groups in the face of the cyclone hazard.

While the coastal location of the fishing villages greatly enhances their exposure to the full force of any hurricane, these villages and many others in the southern parts of the delta are also poorly served by transport and other communication systems. As a result, their inhabitants are more vulnerable to hazard impact because they are less able to take advantage (if they wish) from early warning systems and evacuation procedures, as well as from rehabilitation programmes. It is to these issues that the paper now turns.

**Mitigation strategies**

Very severe damage caused to Calcutta by a hurricane in 1864 prompted the government of the
day to set up a Meteorological Service for India in 1865. Since then, three largely ‘top down’ institutional approaches have been employed to lessen the destructive impact of the tropical cyclone, especially along the coast of eastern India.

**Physical approaches**

Physical methods comprise the construction of stronger and more fortified defences and embankments, and surge-proof buildings capable of withstanding the hurricane-force winds and storm floods. Hundreds of hurricane shelters built in high cyclone/flood risk locations along the coast of eastern India are an example of this technical approach. Hurricane shelters (many of them over 50 years old) can be found in most villages along the east coast of India, for instance there are two in Balusutippa fishing village in East Godavari. Residents, however, do not take refuge in them, partly because they are not provisioned with food, water and other services and partly because they are afraid that the dilapidated disused structures might collapse. They may not be used simply because, as suggested previously, most externally introduced technically-based mitigation measures are viewed with some suspicion by local societies. Despite hurricane shelters not being generally used in the aftermath of hurricane 07B, the state government is nevertheless building a new one in Balusutippa village.

**Early warning and evacuation procedures**

Human avoidance systems represent another approach and include the installation of satellite-based cyclone forecasting and evacuation procedures. The implementation of INSAT-based Cyclone Warning Dissemination Systems (CWDS) at Vizakapatnam, Kakinada and Nellore in 1978 have been generally credited with reducing the death toll from major hurricanes along the Andhra coast. Before such systems were introduced, the category 5 hurricane of November 1977 at Machilipatnam caused 10,000 deaths, while after their installation, the equally severe category 5 hurricane at the same location in May 1990 took 1000 lives (Table 1). Nevertheless, a number of criticisms have been levelled at storm warnings given out by the Indian Meteorological Department in Andhra Pradesh.

Despite the many cyclone forecasts given by the Cyclone Warning Centre at Kakinada and elsewhere during the onset of hurricane 07B, most of them appear to have been ineffective. This has less to do with the unique nature of the storm and its rapid advance than to the inappropriateness of applying advanced technical solutions in simple developing societies. Warning bulletins given up to 24 hours ahead of the expected time of the cyclone’s arrival by phone, teleprinter, telex and TV are beyond the reach of the poor fishermen of the Konaseema region. So too are the hourly warnings given by coastal radio stations at the onset of the storm. In a recent survey carried out in the Machilipatnam region by The Indian Meteorological Department (cited in Chandrashekar, 1996) on the human response to cyclone warnings, only 30 per cent of the Konaseema fishermen carry radios, and many of these are either tuned to a music station, not working or are too weak to receive the warning signals beyond about four kilometres distance from the shore. Reception of messages over the radio is usually disturbed in stormy weather, and other complaints are that the messages are read too fast and need to be given in a language closer to the one spoken locally. It is often difficult preventing fishermen going out to sea just before a cyclone makes landfall: 20 per cent of fishermen prefer to venture out to sea in stormy waters as schools of fish swim closer to the surface and are easy to catch (Chandrashekar, 1996).

There is also a problem in removing people from an area because of poor communications and transport systems. Nearly half the roads in the Godavari Delta region are not all-weather surfaced, and as many as 20 per cent of villages are not connected by road. Such poor communications also of course slow down central government, state, and non-government Aid getting to villages (Prasad and Sivanand, 1996: 30). Nevertheless, Das (1996) maintains that much of the loss of human life from cyclone 07B could have been avoided if timely efforts had been made by the state government and the district authorities to evacuate people from the low-lying coastal villages, and to at least attempt to restrain fishermen from venturing out to sea. This latter point may not be as straightforward at it seems, however, in view of the deep suspicion of institutional authority held by the fishing communities. Fishermen of the delta often pay little attention to storm warnings claiming that when they do nothing happens (Prasad and Sivanand, 1996). Moreover, many closely-knit fishing communities have long spurned external rehabilitation attempts. For instance, a pledge to build over 2000 pucca (brick, cement built) houses for fishermen and their families in the lanka villages of Balusutippa and Masanitippa by the then Minister B. Subba Rao was rejected by the fishing communities. They have found from experience that institutional promises of help rarely materialize, or that when they do, new and constraining conditions are often attached to them.

Social structures (or the Indian Government’s reluctance to understand them) in the coastal
villages and fishing coves have also been identified as a problem for early cyclone warning systems where the village leader is often the only person the community pays heed to. It is not surprising that 80 per cent of educationalists, farmers, fishermen and other town traders in the Machilipatnam region voiced the need for educating people more about cyclones and their potential impact (Chandrashekar, 1996). Most people in the region were actually unaware that early warnings were issued by the Indian Meteorological Department.

**Government rehabilitation policies**

India has a long tradition of rulers and governments providing public relief measures following natural disasters (Brammer, 1996). Disaster mitigation schemes by central and state government are seldom very effective because, by their very nature, they fail to tackle the actual causes of disasters and seldom address and alleviate the risk of the most vulnerable people involved. Another reason is that they are often seriously under-resourced (Prasad, 1996).

The November 6/7 cyclone put a severe strain on the physical and financial resources of the Andhra State Government to deal with the calamity. The storm occurred only three weeks after another disaster hit the state when major flooding in the three southern coastal districts of Prakasam, Nellore and Cuddapah caused the deaths of 338 people and produced massive crop losses (Table 1). Early claims by the state’s chief minister, N. Chandrababu Naidu, that cyclone 07B damage in the Godavari Delta was a ‘national disaster’ that it would incur Rs 53 750 million losses and take 20 years to recover from, have been seen as an exaggeration to attract foreign Aid and thereby improve the state’s poor economic position (Radhakrishna, 1996; Prasad and Sivanand, 1996; Prasad, 1996).

**Basic relief**

With respect to state-organized disaster mitigation, some basic relief was provided to the inhabitants of the delta with the provision of 25 kilogrammes of rice and three litres of kerosene to each affected family. However, with poor roads and other communications, rice donations took from several days to as much as two weeks to arrive in some remote coastal fishing villages. According to many people questioned by the author in the coastal fishing villages of Balusutippa and Bhairavapalayam, most other elements of the initial government rehabilitation programme have not been met or only partially realized. This includes promises of relief of:

- Rs 10 000 to each of the injured;
- Rs 2 000 to those suffering minor injuries;
- Rs 1 000 for house damage;
- Rs 1 000 for boat damage or loss; and
- Rs 500 for poultry loss.

Moreover, _ex gratia_ payments of Rs 100 000 promised to families for each dead member have rarely materialized. As late as March 1998, numbers of people who actually died in the storm had yet to be finalized with over 1250 people still listed as missing. Without being able to confirm these deaths, families cannot expect to receive the promised Rs 100 000 for each deceased family member. Even the 656 families who have members confirmed as dead have not received full payment. Some residents in Balusutippa and Bhairavapalayam maintain that they have recently been given a Rs 30 000 bond from the district cooperative bank which will not mature for ten years. In addition, the Rs 35 000 which the Fisheries Department promised to release to the families of fishermen who perished in the storm has not been paid. The meagre compensation of Rs 1 000 promised to surviving fishermen whose boats and fishing gear were lost in the cyclone has also not been paid universally.

Government programmes to construct concrete/brick houses for families whose houses were seriously damaged (314 000 in total across the southern delta) have not started and foreign Aid for housing is still being sought. Only around 4300 housing units were built in the region after the storm by private companies (e.g. Tata Industries, Jamshedpur) and non-government organizations (e.g. Jesus Voluntary Service) whose enthusiasm for building soon tailed off after one year. Houses that were built were not always provided completely free. Consequently many tended to go to the already better-off families of the delta.

**Summary and conclusions**

A 100-year time series (1876–1977) of the frequency, seasonal distribution and geographical location of severe cyclonic storms and hurricanes in the Bay of Bengal has been updated to 1995/6. Results show that while there is some evidence of storm reduction over the Bay as a whole during the last several decades, the 1050-kilometre coast of Andhra Pradesh continues to be a major cyclone-prone region. Data on the effects of 19 cyclones which made landfall over the Andhra coastline between 1977 and 1995 have shown that the hazard presented by individual storms varies substantially, with several storms associated with considerable losses to both life and property.

A detailed spatial analysis of the impact of hurricane 07B which made landfall over the
Godavari Delta region on 6/7 November 1996, has shown that the pattern of damage varies in accordance with the impact criteria chosen (crop damage, death tolls, house destruction) and with the agency of destruction, whether by storm surge, wind, flooding or some combination of these. Agricultural damage caused by high winds and flooding is widespread over the southern half of the delta while most deaths caused by high storm surges are concentrated in the coastal mandals. Certain carefully selected criteria such as that of house damage normalized by population give valuable clues to the precise trajectory of the storm across the delta and its dissipation landwards. Altogether, most loss of property and lives took place in the southern half of the delta just where population densities are highest, and where poor rural populations are currently growing quite rapidly.

The quantitative mapping of death tolls and property loss across the Godavari Delta fails to account for the types of individuals and groups of people most affected by the hurricane disaster. Qualitative questionnaire surveys in the region revealed that while landowning farmers were a low-risk group, scheduled caste migrant female rural labourers and fishermen and their families were two of the most vulnerable groups in the region. It was found that these three groups adopted coping strategies in the aftermath of the hurricane that collectively conformed to Agarwal’s (1990) classification of coping behaviour used by the rural poor of India. Each group, however, adopted a rationally different set of coping strategies. While migrant female rural labourers assumed individualistic survival strategies, the people of the fishing communities tended to adopt much more collective approaches. The differential response of the three selected groups supports the contention of Winchester (1992) that poverty and social ordering in Indian society puts differential limits on the risk reduction abilities of individuals and social groups in the face of the cyclone hazard.

The vulnerability of different groups of people to hurricane impact is also reflected in ‘top down’ institutional programmes designed to alleviate risk and rehabilitate affected disaster areas. The apparent ineffectiveness of early storm warning systems with regard to hurricane 07B, together with half hearted post-disaster government rehabilitation measures supports much of the current literature (hazard-society model) which stresses the inappropriateness of using advanced externally-based technological systems to solve hazard problems in simple Third World rural societies. The inappropriately application of technofix measures not only increases peoples’ risk level to disaster but also prevents preparedness for evacuation procedures, even though these are also pretty inadequate in eastern India. Inadequate hurricane relief programmes simply serve to reinforce and differentiate the vulnerability of individuals and groups to disaster. Weak and late attempts by state government to supply the delta’s hurricane victims with food and water mean that only those areas with good communications (i.e. where the better off groups are mostly located) received support Aid. Many poorer groups, including the regions’ poor fishing communities, living in remote areas with poor road systems, in the extreme southern part of the delta received food Aid late or did not receive any Aid at all. These findings illustrate that the social status of people together with their type and place of work determine to a large extent their vulnerability to disaster impact and their ability to recover from storm damage (Comfort et al., 1999). It would also appear that poverty and social position in Indian society strongly influences the success or failure of organized programmes in disaster relief.

It seems clear that until government and other institutions begin to move away from large-scale technical solutions of hazard management and begin to tackle the real issues such as why disasters occur in the first place and which groups are most affected by them, then major hurricane disasters along the eastern coast of India will continue to occur (witness the massive hurricane disaster in Orissa during late October–early November, 1999). The failure of institutional mitigation procedures and disaster relief highlighted in this paper suggests that effective hazard mitigation strategies need to depend more on improving the risk awareness and risk avoiding abilities of affected individuals and groups. In other words only by developing more ‘bottom up’ community-based rehabilitation schemes in the Godavari Delta and elsewhere in the developing world (Maskrey, 1989) can the hurricane hazard be seriously reduced.

References


Burroughs J 1997 Does the weather really matter: the social implications of climate change Cambridge University Press, Cambridge
Burton I, Kates R and White G 1993 The environment as hazard Oxford University Press, New York
Chandrashekar S 1996 Very few lend ears to weathermen 18 June The Economic Times, New Delhi
Das A 1996 Unparalleled destruction 24 November The Hindu Times, Delhi
Das G N 1997 Cyclones then and now: misery remains the same 10 January The Indian Express, Delhi
Diaz H F and Pulwarty R S eds 1997 Hurricanes: climate and socioeconomic impacts Springer-Verlag, Berlin
Enarson E and Morrow B eds 1998 The gendered terrain of disaster: through women’s eyes Praeger, Westport CT
Fordham M H 1998 Making women visible in disasters: problematising the private domain Disasters 22 126–43
Hewitt K 1993 Interpretations of calamity from the viewpoint of human ecology Allen and Unwin, Boston
Maskrey A 1989 Disaster mitigation: a community approach OXFAM, Oxford
— 1981 Increase in annual frequency of the severe cyclonic storms of the Bay after 1964— possible causes Mausam 32 35–40
Morren G 1983 A general approach to the identification of hazards and responses in Hewitt K Interpretations of calamity from the viewpoint of human ecology Allen and Unwin, Boston 284–97
Morrow B H 1999 Identifying and mapping community vulnerability Disasters 23 1–18
O’Hare G 1997 The Indian monsoon, part 2, the rains Geography 82 335–52
— 1999 Global warming and extreme weather: a cautionary note Geography 84 87–91
Pant G B and Rupa Kumar K 1997 Climates of South Asia Wiley, Chichester
Prasad R J R 1996 Polemics over flood relief 29 November The Hindu, New Delhi
Prasad K and Sivanand S 1996 The day disaster struck 28–30 November Outlook 27
Pulwarty R S and Riebsame W E 1997 The political ecology of vulnerability to hurricane-related hazards in Diaz H F and Pulwarty R S eds Hurricanes: climate and socioeconomic impacts Springer-Verlag, Berlin Chapter 9 185–214
Radhakrishna G S 1996 The politics of relief 15–21 December Focus 26–29
Rao M M 1996 Death and devastation 29 November Frontline 113
Sensarma A K 1994 The great Bengal cyclone of 1737 — an inquiry into the legend Weather 49 90–6
Winchester P 1992 Power, choice and vulnerability: a case study in disaster mismanagement in south India James and James, London