

Differential vulnerability in coastal communities: evidence and lessons learned from two deltas

M. Marchand

Delft University of Technology, The Netherlands

Abstract

Flood risk management requires a sound understanding and assessment of flood vulnerability of society and households. A key issue in assessing flood vulnerability is its differential nature: not all people and communities are equally vulnerable to flooding, even if they live in the same hazard zone. The concept of differential vulnerability is illustrated by two case studies with a more or less comparable physical environment but entirely different socio-economic setting: New Orleans in the Mississippi Delta, USA and the Godavari Delta in coastal Andhra Pradesh, India. The results of this comparison show that in both countries the less advantageous sections of society are the most vulnerable. However, macro-economic resilience tends to be greater in India than in the United States. Both examples show that vulnerability is intricately entangled with the fabric of social life itself, with politics, power, history and environment. Reducing vulnerability to flooding therefore requires an integrated approach taking into account not only aspects of disaster management but also of equitable development.

Keywords: vulnerability, flood risk management, cyclone, hurricane Katrina, USA, India.

1 Introduction

Tragic events such as Hurricane Katrina in 2005 and the Asian Tsunami in 2004 have highlighted coasts as being hazardous places to live. Many low lying coasts have a track record of natural disasters due to their dynamic environment, while at the same time have attracted human occupation because of their natural resources. This apparent paradox is likely to increase in view of future climate



change, causing sea levels to rise and storms to intensify, in combination with population growth. This calls for an active policy of governments to reduce vulnerability against natural disasters, such as floods and storms [1]. Hence there is a need for knowledge about vulnerability, how is it defined, what are the characteristics and which are the main causal factors determining vulnerability. A key aspect which has gained increasing attention is its differential character, i.e. the difference in vulnerability between individuals, households or communities being exposed to the same risk. Social vulnerability assessments, household resilience and recovery studies as well as individual vulnerability based on age, race and health all focus on differential vulnerability [2–5].

In this paper I explore the differential vulnerability during and after two disasters that occurred in two different deltas of the world: the Mississippi Delta, USA and the Godavari Delta, India. I will make a comparison using the following questions: i) who were the most vulnerable and why?; ii) how does differential vulnerability differ between the two deltas? and iii) what can we learn from both examples for disaster management and vulnerability reduction?

2 Factors determining differential vulnerability

Disaster management usually discerns three different phases in a disaster [6, 7]:

- i) preparedness and prevention;
- ii) response during or immediately after the disaster;
- iii) recovery and rehabilitation.

During each of these phases vulnerability shows a different face. For instance, the need for preparedness and prevention depends on susceptibility of people and households living in a hazardous area, which is determined by factors such as housing quality, location and occupation. Vulnerability during disaster conditions mainly depends on the relative ease to evacuate, be rescued or find

Table 1: Differentiating factors based on three distinguished conditions.

Phase	Factors determining vulnerability	Differentiating factors
Preparedness and protection	Susceptibility	Housing condition and location Income and occupation
	Preparedness	Access to information Financial resources
Response	Evacuation	Penalties incurred by different courses of action Mobility/risk of looting/relatives outside hazard area
	Rescue	Swimming ability
	Shelter	Access to and availability of shelters, safe havens
Recovery	Relief	Access to government and information
	Rehabilitation	Proof of assets (e.g. land property rights) Non-fixed capital Borrowing power



shelter. Post-disaster conditions include relief and rehabilitation and are important aspects that determine the time needed to recover from damages. The specific ways in which these factors influence the differential character of vulnerability is presented in Table 1. Each of the differentiating factors listed in column 3 of the table can work out differently for different people and households. Ultimately vulnerability depends on a combination of characteristics such as gender, age, health, race and relative wealth. Disabilities can also hinder taking action in any of the phases of vulnerability, minorities may encounter discrimination when seeking post storm aid or they may be confined by housing discrimination to certain hazard-prone neighbourhoods [2].

I will use these categories of factors determining vulnerability in order to compare vulnerability to coastal storms for the Mississippi Delta / New Orleans and the Godavari Delta. In the next two sections a description is given of a recent disaster that has overcome each of these deltas.

3 New Orleans and hurricane Katrina of September 2005

On 29 August category 5 hurricane Katrina created havoc in New Orleans and surrounding area. Flooding from Katrina covered approximately 80 percent of the New Orleans Metropolitan area. It led to the loss of life of at least 1,800 people, while still many people are missing. Data provided by FEMA indicate that over 1.2 million people along the northern Gulf coast from south-eastern Louisiana to Alabama were under some type of evacuation order [8]. Based on data on the identity and cause of death of 727 victims the following picture emerges [9]:

- The age distribution of the fatalities was distinctly skewed towards older people. 59 % of the victims were 70 years or older.
- No significant difference between male and female numbers was found.
- Just over half the fatalities were among African-Americans, which should be compared with the fact that 68% of the New Orleans metropolitan area was African-American prior to the hurricane.

The report of the US Army Corps of Engineers [9] concluded that the poor in all 5 parishes were disproportionately affected. What were the reasons for this? Masozera *et al.* [10] examined whether neighbourhoods in New Orleans were impacted differently based on pre-existing social, physical and economic vulnerabilities. Analyses of spatial distribution of population by median household income showed that Hurricane Katrina caused severe flood damages in the majority of New Orleans neighbourhoods, regardless of income, elevation and other social factors. However, their findings do suggest that lower income groups were more vulnerable to Hurricane Katrina during the response and recovery phases [10]. Their ability to respond was for instance greatly hampered due to a lack of transportation, a factor that was also acknowledged by Yarnal [6]: the city's poorest residents had far less access to transportation during the onset of the disaster than did their richer white or black counterparts. For some of these residents, by the time they heard about the coming storm, cheap or subsidized ways out of the city had dwindled [6].



Besides the disproportional high risk poorer people faced in New Orleans during the storm, their vulnerability is also illustrated by the problems they face in the aftermath. Media reports indicate that many displaced residents have moved either temporarily or permanently to other areas in the United States. A large number of these people might never return to live in their pre-Katrina homes. Some people remain separated from other family members and/or are unable to determine if their family member(s) survived the storm [8]. Rehabilitation of the city is hampered by a range of problems. A deadlock seems to occur as people are not returning because of the lack of public facilities, schools and other social infrastructure, while these facilities are not being restored because there are too few people returning. If nobody is able to return to the damaged neighbourhoods, New Orleans is at risk of losing more than 80% of its black population [11]. Another factor that influences the recovery process is the difficulty low income disaster victims face in getting access to disaster recovery assistance [10].

Long term recovery for the city of New Orleans is shrouded with uncertainty. Taking into account the more than \$ 17 billion of residential damage (representing a 25% percent loss to exposure value) and roughly \$ 3 billion in non-residential damage, complete recovery will take many years. Important in this respect is the question how many people will eventually return to the city. Economic model results prepared by the Interagency Performance Evaluation Task Force (IPET) of the US Army Corps of Engineers, show that in the case of a return to pre-Katrina population numbers the Gross Regional Product of Metro New Orleans in 2010 still remains 9% below the forecast of economic growth without Katrina. Under a pessimistic scenario that all remaining displaced will not return, GRP in 2010 is expected to be 12% below non-Katrina forecasts [9].

4 The Godavari delta in Coastal Andhra Pradesh: a history of cyclones

The Godavari Delta is situated on the east coast of the State of Andhra Pradesh, India. With an area of 9,260 km² it is the second largest delta of India and includes a population of approx. 7 million people. With a population density of over 500 people per km², the region can be characterised as intensively utilised. Nearly every hectare of area is used in one way or another and there are very few areas that still have a relatively natural character. The economy is dominated by agricultural production although there are a number of urbanised centres with a diverse industry.

Coastal Andhra Pradesh belongs to one of the most cyclone prone coasts of India, with more than 65 severe cyclonic storms in the last 100 years, of which 11 went over the Godavari delta. The latest cyclone creating havoc in the Delta was cyclone 07B on 6 and 7 November 1996, causing 1,000 deaths and incurring heavy economic loss. Over 300,000 houses were fully damaged, 14,600 cattle lost and 346,000 hectares of paddy land destroyed. Many of the deaths were fishermen or their families, living in villages close to the shore [12].



Despite the substantial losses incurred in cyclone 7B, there has been a general reduction in the number of casualties due to cyclones over the past decades. After the November 1977 cyclone that struck the Krishna Delta (south of the Godavari delta) and left 10,000 casualties, most of the cyclones that made landfall along the Andhra Pradesh coast were characterised with much smaller human losses (see Figure 1). Most probably this reflects an improved contingency planning system put in place by the Government of Andhra Pradesh after the November 1977 disaster in which the development of warning systems and evacuation procedures were made a priority. As a result, there were ten times fewer casualties after the cyclonic storm of May 1990 than after the Nov. 1977 cyclone although the May cyclone was recorded as being more intense. In the May 1990 cyclone early warnings and the evacuation of 650,000 people restricted the number of casualties to 967 [13]. In contrast, economic damage has tended to increase over the years rising from 38 million US\$ in 1977 to more than 500 million US\$ almost 20 years later.

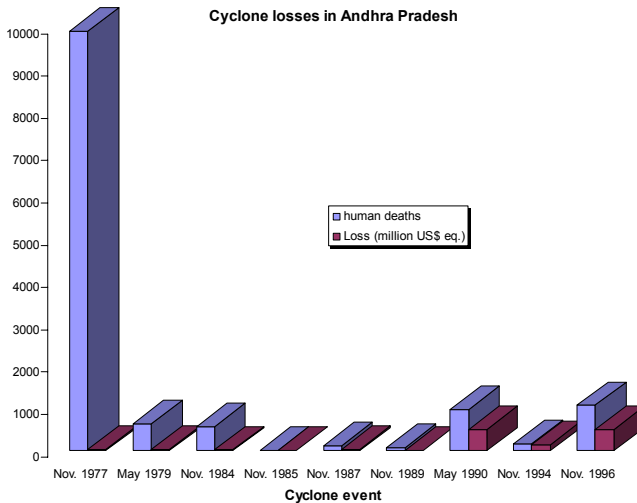


Figure 1: Cyclone losses in Andhra Pradesh from 1977 till 1996 [13].

Poverty has been identified as one of the main factors influencing vulnerability to natural disasters in India. The Godavari Delta with its recurrent cyclones is no exception to this. Unfortunately, detailed statistical data on the distribution of human casualties and economic losses among social strata are lacking. But housing conditions are a good indicator for direct susceptibility to damage and injury. Many poor rural families living in insubstantial village dwellings with mud walls and thatched roofs had their houses torn apart by the cyclone. Much less affected by house damage in almost every village were smaller numbers of higher-income landowning farmers and their families who live in more substantial brick and concrete dwellings [12]. Based on the census

housing data of 1991 stratified by roof and wall material a picture can be made of the housing types in the Godavari Delta at the time of the 1996 cyclone. Huts made of grass, leaves and wood walls and roofs from mostly natural material like wood and reeds comprised around 18 % of all houses. The majority (70%) of the housing stock consisted of '*katcha*' houses that were built of mud, wood or (un)burnt brick walls and grass, tiles or iron roofs. The remaining 12% included '*pucca*' houses made of burnt brick, cement or other durable wall materials and durable roof material [14]. These figures show that at the time of the cyclone about 90% of the households along the coast were living in highly vulnerable housing conditions.

Based on qualitative interviews with several farming families, O'Hare [12] found that a small number of farmers in the delta were bankrupted by the severe agricultural losses they suffered from cyclone 7B. However, the great majority were able to rely on savings and other resources to tide them over to the next harvest. Considerably more affected were the rural poor, especially landless agricultural labourers reliant on a meagre daily wage [12]. This picture is corroborated by a longitudinal analysis over 20 years of economic development in the similar Krishna Delta in Andhra Pradesh conducted by Winchester [15, 16, 17]. Whereas the rich and medium households were able to increase their assets (land, ploughs and animals), the poor households could not. After cyclones and floods the government compensates those who can prove their losses but compensation takes time to administer and further differentiates between those who can afford to wait the necessary 6 months on average and those who can or cannot pay the necessary 'handling charges'. The most successful households (the rich) are large and multi-occupational and most of their family members are educated. They live in thick walled well-built houses on relatively high ground. They have a network of family members who live nearby or in an inland town or city well outside cyclone range, any of whom who can provide financial assistance after a catastrophic flood or cyclone. These households have a variety of income sources and, over the years, have accrued enough surplus money to make them resilient to shocks such as from cyclones, mainly from assets and money lending. Almost the opposite is true in all respects for the least well off, who can barely help each other even after some natural calamity or other [17].

Considering the long term macro-economic consequences of cyclones in the Godavari region, there is reason to believe that these are relatively small. The first and foremost argument is that evacuated people return to their house or house sites as soon as possible, even if these have been damaged or destroyed by the storm. Most people simply have no choice. Some fishermen who lost almost everything carried on their trade by going to work for other fishermen who were more fortunate in terms of disaster losses [12]. Farmers pick up their work again and start preparing the land once it is free from the effects of the flood such as salinisation, siltation or vegetation and other detritus. Long existing coping strategies for natural disasters are used to regain original livelihood levels in a relatively short period for at least the majority of people.

Cyclone impacts, while serious, do not significantly inhibit development of the Delta and indeed are not the principal causes of poverty. Cyclones are only



just one of several natural and man-made hazards in a climatically drought prone area that is subject to soil degradation and salt water aquifer intrusion resulting in unsanitary conditions and the poor health of a significant percentage of the population [16].

5 A comparison between two deltas

Using the general typology of differential vulnerability described in Chapter 2, we can now compare the two deltas (Table 2). An important observation is the commonality between the two deltas with respect to individual or household vulnerability: in both societies the poor and disadvantaged groups are significantly more vulnerable than others. But there are different causes: for instance the susceptibility to damage because of location and housing conditions seems a less important discriminating factor in New Orleans than in the Godavari Delta. In New Orleans much went wrong during the response phase instead, from which especially the most vulnerable groups suffered most. For several days after landfall, evacuation of New Orleans proceeded slowly, compounding the misery of residents stranded by the storm. Federal, state and local authorities knew long before the storm that at least 100,000 residents would lack the means to evacuate. Nonetheless, the city failed to take the necessary preparations [18].

Preparedness, evacuation and rescue operations are comparatively better organised in the Godavari Delta than in New Orleans. This is a striking observation considering the difference in economic development between the two countries. A more detailed analysis is required in order to fully explain this difference, which is beyond the scope of this paper. Possibly, the difference in flood frequency between the two deltas could play an important role. New Orleans citizens and government agencies probably relied too much on the flood protection scheme, that – however fragile it proved to be – had kept the water out since 1927. Two generations grew up with hardly any experience of flooding. Instead, cyclones and storm surges are regularly battering the Andhra Pradesh coast which has no coastal protection scheme of any significance. Besides these surges, the people are exposed to river floods and droughts. In other words: natural disasters are part of life rather than an anomaly. The November 1977 cyclone with more than 10,000 victims in the Krishna Delta of Andhra Pradesh has become a turning point in cyclone disaster management, which – however much improvement still can be made – has significantly increased over the years.

Perhaps one of the most remarkable differences between the two deltas is the long lasting economic impact of a disaster. Considering vulnerability on the scale of a society, one must conclude that Katrina has a more pronounced impact on New Orleans than Cyclone 07B had on the Godavari Delta. Economic disruption plays an important role in both deltas, but the social and demographic changes that seem to have a long lasting effect on the city of New Orleans are beyond comparison to the social and economic impacts of Cyclone 07B.



Table 2: Comparison of vulnerability between New Orleans and Godavari Delta.

	New Orleans	Godavari Delta
Preparedness and protection		
Susceptibility	Large residential areas in low lying parts of city; Variable housing conditions; Existing flood protection scheme; Flooding frequency in the order of 1:100 year	Most areas are rural; Most housing conditions are highly susceptible to damage; Virtually no coastal flood protection scheme; Flooding frequency in the order of 1:10 year
Preparedness	Limited sense of awareness to risks leads to minimal preparedness	Relatively good sense of awareness; Preparedness can be inadequate by the poorer households due to lack of resources
Response		
Evacuation	Proved to be highly insufficient	Evacuation is routinely carried out on warnings of an approaching storm. In some cases there is reluctance to obey evacuation orders. Condition of the roads network is critical
Rescue	Started with significant delays	Timely mobilisation of the armed forces (troops & police)
Shelter	Superdome overcrowded	Cyclone shelters are in place but their safety depends on their condition which depends heavily on maintenance
Recovery		
Relief	Dollars meant for relief and recovery were lost to waste and fraud	Official procedures do not always reach those in greatest need
Rehabilitation	Unclear perspective because return of displaced persons is highly uncertain	People return to their work but in the case of the poorest this can be delayed by cleaning up operations. There is a large involvement in the rehabilitation process of NGO's
Differential vulnerability	Poor and disadvantaged groups proved to be significantly more vulnerable	Poor and disadvantaged groups proved to be significantly more vulnerable

6 Conclusions

6.1 Who were the most vulnerable and why?

In both cases poor and underprivileged people are the most vulnerable. However, it is relative wealth and inequality that are more important than absolute income levels. Especially the combination of disadvantages seems to be of paramount importance: being black and poor in the case of New Orleans [6] and belonging to a lower caste and poor in the case of Andhra Pradesh [19].

6.2 How does differential vulnerability differ between the two deltas?

The actual mechanism by which disadvantaged people suffer more is different from place to place, as shown by the two examples: in New Orleans there was great suffering in the response phase, whereas in Andhra Pradesh the cause of differential vulnerability lies more in variations in susceptibility (bad housing conditions at hazardous places) and resilience (lack of financial resources). Interestingly, the pre-existing differential vulnerability in New Orleans is significantly influencing the rebuilding of the city at a scale that is unthinkable in Andhra Pradesh. Future class and racial diversity will probably significantly deviate from the pre-Katrina situation [20].

6.3 What can we learn?

Natural disasters highlight the inequalities of societies. Hurricane Katrina has shown that this phenomenon is not restricted to underdeveloped or developing nations. Although poverty is often seen as a root cause of vulnerability, the two are not identical. Income levels are only part of the story that explains vulnerability. Socio-cultural conditions are equally important. For instance, poor people living for generations in a hazardous environment are usually better prepared for natural vagaries than those that have migrated recently to a place unfamiliar to them. Economic growth can help reducing vulnerability by raising the living standard of the population. But social cohesion and equality are probably even more important, as they can tackle the root causes of vulnerability, that reflect the distribution of power in a society [21]. A good example is the similarity in stories regarding the difficulties to get access to relief funds, compensation or loans. As the loans from the Small Business Administration that have been approved appear to be flowing to wealthy neighbourhoods in New Orleans but not to poor ones, there is a need for easy access to loans and financial incentives [10]. Similarly, Winchester et al. [17] plea for self help users such as saving groups, thrift societies and so on in Andhra Pradesh through which the poorer people can better face uncertainties such as natural disasters.

Both examples from a country on its way to development and from a highly developed nation show that vulnerability is intricately entangled with the fabric of social life itself, with politics, power, history and environment. Reducing vulnerability to hurricanes therefore requires an integrated approach taking into



account not only aspects of disaster management but also of social equity and sustainable development. While doing so comes a point at which disaster management touches upon broader policy domains, such as spatial planning, integrated coastal zone management and economic development in general. Preparing a vulnerability assessment with due account of its differential character provides the best interface between disaster management and sustainable development, enabling effective iteration between the two.

References

- [1] UNISDR. *Hyogo Framework for Action 2005-2015*. World Conference on Disaster Reduction. 2005. United Nations.
- [2] Clark, G. E., Moser, S.C., Ratick, S.J., Dow, K, Meyer, W.B., Emani, S., Jin, W., Kasperson, J.X., Kasperson, R.E. & Schwarz, H.E., Assessing the vulnerability of coastal communities to extreme storms: the case of Revere, Ma., USA. *Mitigation and Adaptation Strategies for Global Change* **3**: pp. 59–82, 1998.
- [3] Rygel, L., O'Sullivan, D. & Yarnal, B., A method for constructing a Social Vulnerability Index. *Mitigation and Adaptation Strategies for Global Change* **11**: pp. 741–764, 2005
- [4] Cutter, S. L., & Emrich, C.T., Moral hazard, social catastrophe: the changing face of vulnerability along the hurricane coasts. *Annals, AAPSS* **604**: pp. 102–112, 2006
- [5] Amendola, A., Management of change, disaster risk and uncertainty: an overview. *Journal of Natural Disaster Science* **26**: pp. 55–61, 2004.
- [6] Yarnal, B., Vulnerability and all that jazz: Addressing vulnerability in New Orleans after Hurricane Katrina. *Technology in Society*, 29 (2), pp. 249–255, 2007.
- [7] Hohenemser, C., Kasperson, R.E. & Kates, R.W., Causal structure (Chapter). *Perilous Progress: managing the hazards of technology*, ed. R.W. Kates, C. Hohenemser & J.X. Kasperson, Westview Press: Boulder, CO, pp. 43–66, 2006
- [8] Knabb, R.D., Rhome, J.R. & Brown, D.P., *Tropical Cyclone Report Hurricane Katrina 23-30 August 2005*. National Hurricane Center, 2006.
- [9] IPET, *Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System. Vol VII - The Consequences*. US Army Corps of Engineers, 2006.
- [10] Masozera, M., Bailey, M. & Kerchner, C., Distribution of impacts of natural disasters across income groups: A case study of New Orleans. *Ecological Economics*, **63**, pp. 299–306, 2007.
- [11] Logan J.R., *The impact of Katrina: Race and Class in Storm-Damaged Neighborhoods*. Brown University, 2006.
- [12] O'Hare, G., Hurricane 07B in the Godavari Delta, Andhra Pradesh, India: vulnerability, mitigation and the spatial impact. *The Geographical Journal* **167**: pp. 23–38, 2001.



- [13] Reddy A. V. S., Sharma, V.K. & Chitoor M., *Cyclones in Andhra Pradesh*. BOOKSLINE: Hyderabad, 2000.
- [14] Marchand, M. & Mulder, P., *Resource and Environmental Management Plan for the Godavari Delta Region in Andhra Pradesh*. Draft Technical Report No. 13 of the Andhra Pradesh Cyclone Hazard Mitigation Project. Delft Hydraulics: Delft / Hyderabad, 2003.
- [15] Winchester P., *Power, choice and vulnerability - a case study in disaster mismanagement in South India 1977-1988*. James & James Science Publishers, Ltd.: London, 1992.
- [16] Winchester, P. J; Penning-Rowsell, E., *Socio-economy of the Coastal Areas & Cyclone Vulnerability*. Technical Report No. 3 of the Andhra Pradesh Cyclone Hazard Mitigation Project. Delft Hydraulics: Delft / Hyderabad, 2001.
- [17] Winchester, P., Marchand, M. & Penning-Rowsell, E., Promoting sustainable resilience in coastal Andhra Pradesh (Chapter 10). *Managing Coastal Vulnerability*, ed. L. McFadden, R. Nicholls, and E. Penning-Rowsell, Elsevier: Amsterdam, pp. 159–176, 2006.
- [18] Committee on Homeland Security and Governmental Affairs, *Hurricane Katrina: a nation still unprepared - Special report. S. Rept. 109–322*. United States Senate - U.S. Government Printing Office: Washington, 2006.
- [19] Boshier, L., Penning-Rowsell, E. & Tapsell, S., Resource accessibility and vulnerability in Andhra Pradesh: caste and non-caste influences. *Development and Change*, **38**, pp. 615–640, 2007
- [20] Laska, S. & Morrow, B.H., Social vulnerabilities and hurricane Katrina: an unnatural disaster in New Orleans. *Marine Technology Society Journal*, **40**, pp. 16–26, 2006
- [21] Blaikie, P., Cannon, T., Davis, I. & Wisner, B., *At Risk - Natural hazards, people's vulnerability, and disasters*. Routledge: London, 1994.

