

Need for setback lines in coastal zone management: A meteorological point of view

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Abstract

Hydrometeorological events are the greatest coastal hazard for the Indian people. The Coastal Regulation Zone (CRZ) Notification which includes areas likely to be flooded by sea level rise due to global warming should, as well, have protected lowlands prone to inundations due to storm surges. This crucial issue has been overlooked in the CRZ Notification. Surges have recorded a height of up to 12 m, followed by persistent sea water invasion as far as 35 km inland. Loss of life and destruction of property has been staggering. Monetary losses run into crores and are thus prohibitive. Therefore, coastal managers have to consider whether it is economically viable to rebuild as before, whether to abandon the impacted coast and move inland, or, whether to consider larger setback distances before rebuilding. In the long term, considering the intrinsic value of coastal landforms, functional and protective value of coastal wetlands, the third alternative is expected to be cost-effective and less vulnerable, more so, if it is brought within the ambit of the CRZ.

1. Introduction

Meteorological information shows that more than 1000 cyclonic disturbances occurred in the Bay of Bengal during the last century, out of which over 500 were either depressions or deep depressions, and over 400 were either cyclonic storms or severe storms. These high intensity wind systems that originated around the Bay of Bengal have, some time or the other, struck each of the eastern coastal states, the coast of Andhra Pradesh being the worst affected over the last century. The catastrophic super cyclone that struck Orissa in November 1999 is a grim reminder of these natural hazards which invariably lead to recurring disasters. The coastal population ultimately pays the price.

Taking into account the adverse impacts of hydrometeorological events on coasts and people, and considering the apathy of coastal managers in admitting the detrimental effects of natural hazards, we need to decide whether vulnerable coasts are to be occupied and/or urbanized. Therefore, an attempt has been made in this paper to examine the crucial issue of setback distances and "no development zones" for the effective management of the Indian coasts.

2. Vulnerability of the east coast of India

Of the severe cyclones about which records are well documented, 55 crossed the coast of Tamil Nadu, 69 hit Andhra Pradesh, 58 affected Orissa, 33 struck West Bengal (Shreshtha, 1998). Table 1 displays statistical details of historical occurrences of various types of cyclones over a century. It may be noted that about 10 cyclonic disturbances of different intensities occur during August - December of every year in the Bay of Bengal. The east coast experiences an average of 6 depressions, 3 cyclonic storms and 2 severe cyclonic storms each year. In terms of landfall, available records indicate that the Andhra Pradesh coast is the most vulnerable

to tropical cyclones. About 32% cyclones that form in the Bay of Bengal make landfall along the Andhra coast every year (Shrestha, 1998).

Historical records indicate that the West Bengal coast is highly vulnerable to attack by storm surges with heights ranging from 2 to 12 m. The coast of Orissa has witnessed maximum storm surge heights of 7 m. Andhra Pradesh and Tamil Nadu (Table 2) are also in the list of vulnerable coasts as the surge heights observed are in the range of 1 to 6 m. The susceptibility of the region has been classified according to coastal geomorphic units (Murty et al., 2001) and as such each unit can be categorized by its own vulnerability (Marchand and Valk, 2001).

3. Threats to coastal population and infrastructure

Over the last century, confirmed historical reports of cyclones along various coasts indicate that a single event can produce wind speeds exceeding 250 km/h, and the associated storm surges can attain a height of 12 meters. Hydrometeorological phenomena result in considerable destruction of life and property and, more particularly, lead to extensive and persistent inundations of low-lying coastal plains. The advance of bodies of seawater resulted in tidal inundations as far as 8 kilometers in the hinterland of Tamil Nadu (Mani, 2000) (Table 2).

The catastrophic super cyclone that ravaged Orissa in October 1999 is a recent example of the agony brought about by these natural hazards which turn into killer events. Observations conducted during the event indicated a maximum sustained wind speed, which exceeded 252 km/h. A storm surge of the order of 7 m (9 m according to some post-cyclone estimates) was reported at Paradip. The surge penetrated inland resulting in a tidal inundation as far as 35 km in the hinterland (Thapliyal et al., 2000). Since the magnitude of the cyclone was unprecedented, it caused very heavy devastation along the coastal districts of Orissa and West Bengal. According to reports, 12 districts along Bhubaneswar - Balasore - Paradip coastal strips suffered severe damage, 9885 persons died, 2142 people were injured, 12 lakh houses were damaged, over 2 lakh cattle perished, and crops over 13 lakh hectares were affected (Thapliyal et al., 2000).

The worst impact of a storm surge is when waters get trapped due to the blockage of traditional drainage channels by human activity. A low coast, based on its morphology, is by itself susceptible to invasion by high water. Consequently, flooding often lasts for days resulting in impacts on ports, harbors and associated infrastructure, isolation of villages, and disruption in the movement of people that are marooned.

Monetary losses incurred due to hydrometeorological phenomena over the years are staggering (Shrestha, 1998). In October 1983, Bheemunipatnam was struck by a cyclone which resulted in a loss of 520 crores, whereas the severe cyclone which ravaged Machilipatnam in May 1990 incurred a loss of 2248 crores in terms of irreversible damage to property. *Every major cyclone that strikes the Indian coast creates a considerable impact on the economy which in turn slows down the economic activity of the region under stress.*

4. Lessons learnt

Information given in Tables 1 and 2 is sufficient to understand the implications of cyclones, winds and storm surges. The worst impact is caused by storm surges and the consequent flooding of lowlands, displacement of coastal dwellers and loss of life and property. The risks posed by recurring cyclonic disturbances and associated hydrometeorological episodes is the greatest coastal

hazard for the Indian coasts and the inhabitants of the coastal zones. Therefore, the vulnerability of Indian coastal lowlands to chronic and extreme hydrometeorological hazards is obvious.

5. Need for management of coastal lowlands

Along the east coast of India, severe storm surges are responsible for frequent and sometimes dramatic modifications of the landscape. In addition to physical and ecological changes, private and public holdings are destroyed, communication and transportation facilities are disrupted, and loss of life is a recurring phenomenon. Such obvious natural hazards notwithstanding, coastal development in India has proceeded at a rapid pace even in areas highly vulnerable to the forces of the ocean. It would appear that damaging cyclones have not been a deterrent to coastal construction efforts.

Herein lies the need for the management of low relief open coasts. Coastal lowlands are most susceptible to storm surges, and are prone to instantaneous flooding. Maximum destruction is observed along such stretches. In view of these phenomena, communities and governments have to make a choice: either keep away from vulnerable coastal stretches and opt for a sustainable future, or, occupy coasts prone to hydrometeorological hazards, suffer from incalculable social and economic losses, and face irreversible impacts. A coastal manager needs to know that the east coast of India has been hit by a minimum of 4 high intensity cyclones every year over the last 100 years.

Considering intense development along the coasts of the country, the Ministry of Environment and Forests (MEF) enacted the CRZ Notification issued under the Environment Protection Act of 1986 (MEF, 1991). The main purpose was to control, minimize and protect environmental damage to sensitive coastal stretches from unplanned human interference. The Government of India therefore declared coastal stretches of seas, bays, estuaries, creeks, rivers and backwaters which are influenced by tidal action (in the landward side) up to 500 meters from the High Tide Line (HTL) and the land between Low Tide Line (LTL) and HTL as Coastal Regulation Zone (CRZ). The CRZ Notification has placed India amongst the select countries in the world to frame laws to legally protect sensitive coastal ecosystems, to formulate guidelines for coastal activities, and to demarcate areas for conservation (Mascarenhas, 1999).

The CRZ Notification of 1991 comprises four main categories (MEF, 1991): CRZ I, CRZ II, CRZ III and CRZ IV depending upon the type of ecosystems and development along coasts. The main essence of CRZ Notification of 1991 was to protect ecologically sensitive coastal network. But the main issue of interest to the present topic is that CRZ I also includes areas likely to be inundated due to rise in sea levels due to global warming. However, it may be pertinent to note that there is no provision meant to mitigate the rise in water levels due to hydrometeorological phenomena such as storm surges which frequently flood low-lying coastal wetlands. This issue is of particular concern to us here.

Although there is a lot of research related to the forecasting, mitigation of storm surge events and post disaster relief (Stenchion, 1997; Dube et al., 1997; Kumar et al., 1998; Raghavan and Sen Sarma, 2000; Marchand and Valk, 2001), no author has ever considered whether it is advisable to build (or rebuild) on such vulnerable coasts. Since hydrometeorological events recur along the east coast of India, and since monetary losses have been prohibitive, we have to consider whether it is economically viable to rebuild as before, whether to abandon the afflicted

coast and move inland, or, whether to consider larger setbacks, with intervening afforestation, before rebuilding. In the long term, the third alternative will definitely be cost-effective and less vulnerable, if coasts prone to hydrometeorological hazards are also included under CRZ.

As a remedial measure, although erection of costly coastal embankments may protect against tides, storm surges have the capacity to overrun hard structures. In fact, it is found that damage due to extreme events is often greater in stabilized areas (Dolan et al., 1978). Further, these embankments act as barriers to post surge discharge of flood waters and thus aggravate flood situation instead of controlling it (Ali and Chowdhury, 1997).

In comparison, coastal forests particularly mangroves which line coasts are very effective in reducing wind speed of cyclones and also lowering the height of associated storm surges as observed in Bangladesh (Ali and Chowdhury, 1997). Mangrove-rich Sunderbans suffer less from cyclonic winds and surge attacks than those areas where there are less or no mangroves. However, the situation is different along high-energy open sea coasts, and low relief coastal plains or lowlands that back them. It is here that the need is felt for coastal spaces in the form of green belts or forested shelter belts so as to attenuate wind energy as well as to placate wave energy that results in the invasion by storm surges. In this respect, the thick spread of tall casuarina plantations which are observed along coastal strips north and south of Vailankani in Tamil Nadu, north and south of Pondicherry, and at several stretches along the East Coast road up to Chennai will undoubtedly stand against an eventual onslaught of high speed winds.

In conclusion, it is imperative that: (1) coastal stretches prone to storm surges be also included in the CRZ, (2) adequate forested shelter belts be maintained along vulnerable coasts, and (3) "no development zones" along coastal lowlands be made mandatory.

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References

- Ali, A. and Chowdhury, J.U.*, 1997. Tropical cyclone risk assessment with special reference to Bangladesh. *Mausam*, 48:305-322.
- Dolan, R, Hayden, B. and Heywood, J.*, 1978. Analysis of coastal erosion and storm surge hazards. *Coast. Eng.*, 2:41-54.
- Dube, S.K., Rao, A.D., Sinha, P.C., Murty, T.S. and Bahulayan, N.*, 1997. Storm surge in the Bay of Bengal and Arabian Sea: the problem and its prediction. *Mausam*, 48:283-304.
- Kumar, K.V., Bhattacharya, A. and Subramanyam, C.*, 1998. Coastal morphological influence for tropical cyclone track deviation along Andhra coast. GIS and remote sensing-based approach. *Curr. Sci.*, 75:955-958.
- Mani, J.S.*, 2000. Coastal processes in Tamil Nadu and Kerala: environmental and socio-economic aspects. In: *Environmental problems of coastal areas in India*, Editor, V.K. Sharma, Bookwell Press, New Delhi, pp. 201-216.
- Marchand, M. and Van der Valk, B.*, 2001. Integrated coastal management in Andhra Pradesh. *Tropmet 2001, Meteorology for sustainable development*, 6-9 February 2001, p. 106.

- Mascarenhas, A., 1999. The Coastal Regulation Zone of Goa: oceanographic, environmental and societal perspectives. *Current Science*, 77(12):1598-1605.
- Ministry of Environment and Forests (MEF), The Gazette of India, Notification, S.O. no. 114(E), 1991, February 20.
- Murty, M. V.R., Bhagavan, S. V.B.K. and Rao, A. V.R.K., 2001. Impact of storm surge for different geo-environmental conditions along Andhra Pradesh coast. *Tropmet 2001, Meteorology for sustainable development*, 6-9 February 2001, p. 3.
- Raghavan, S. and Sen Sarma, A.K., 2000. Tropical cyclone impacts in India and neighbourhood. In: *Storms (Volume I)*, Eds. R. Pielke and R. Pielke, Routledge Hazards and Disaster Series, New York, pp. 339-356.
- Rao, Y.R., Chittibabu, P., Dube, S.K., Rao, A.D. and Sinha, P.C., 1997. Storm surge prediction and frequency analyses for Andhra coast of India. *Mausam*, 48:555-566.
- Shrestha, M.L. 1998. (Ed.) The impact of tropical cyclones on the coastal regions of SAARC countries and their influence in the region. SAARC Meteorological Research Centre, Agargaon, Bangladesh, 329 pp.
- Stenchion, P., 1997. Cyclones and disaster management. In: Special issue, Ocean response to tropical cyclones, *Mausam*, 48:609-620.
- Thapliyal, V., Desai, D.S. and Krishnan, V., 2000. Cyclones and depressions over north Indian ocean during 1999. *Mausam*, 51:215-224.

Table 1 - Details of various types of wind systems which formed in the Bay of Bengal and affected the east coast of India during the period 1891 - 1991 (Compiled from Shrestha, 1998).

Types of disturbances	Cyclonic disturbances	Depressions / Deep depressions	Cyclonic storms	Severe cyclonic storms
Number	1009	592	268	149
Maximum Minimum	158 (Aug) 4 (Feb)	131 (Aug) 1 (Mar)	51 (Oct) 0 (Feb)	38 (Nov) 1 (Jan)
Yearly average	10	6	3	15
Percent of total	—	58	27	15
Wind speed (km/h)	31->118	31-61	61-88	88->118

Table 2 - Wind speed, storm surges and inland penetration of saline storm waters associated with cyclones along Tamil Nadu coast (Source: Mani, 2000)

Period	Area affected	Wind speed (km/h)	Storm surge height (m)	Inland penetration (km)
November 1952	South Nagapatnam	—	3	8
December 1955	Tanjore	200	3-5	3-8
October 1963	Cuddalore	139	6	—
December 1964	Rameswaram	193	3-5	—
December 1967	Nagapatnam	130	—	Tanjavur area
November 1978	Ramanathapuram	212	3-5	—
November 1991	Near Karaikal	89	—	0.25
December 1993	Near Karaikal	133	3-4	2