

Natural hazards, disasters and human kind: whither ecosystem management?

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Abstract:

Natural hazards such as yearly storm surges that create irreplaceable damage, the December 2004 tsunami that demolished large parts of the Indian coast, and the June 2013 Himalayan floods that swept river banks proved yet again that persistent extreme events have a tremendous damage potential. Loss of life due to storm surges (10,000 people in 1977) and destruction of property (12 lakh houses in 1999) are devastating. Nearly 15,000 people are estimated to have perished in the recent floods in the Himalayas. Monetary loss due to the tsunami touched 3,242 crore rupees. Encroachment of sensitive landforms is a major concern. As such, the relentless natural hazards culminate in disasters when humans come in the way of powerful natural forces. Abandoning vulnerable geomorphic features, managed retreat, or safer setback with intervening forested landforms are feasible long-term options. The incalculable human misery that ultimately follows is an ideal opportunity to focus Indian attention on the need to completely overhaul our national natural hazard policy. More importantly, it is the time for the Indian scientific community to effectively instil the results of scientific research into the political domain, inculcate the habit of public interactions, and make their voices heard in the affairs of natural ecosystems.

Keywords: *natural hazards, sensitive landforms, storm surges, tsunami, floods, India*

Preamble:

The way Katrina humbled the US coast in 2005 (Pilkey and Young, 2005), recurring hydro-meteorological events have inflicted on the Indian east coast for over a century (Valdiya, 2001; Mascarenhas, 2004). The loss of life (10,000 people in 1977) and property (12 lakh houses in 1999) have been mind boggling, the monetary loss is staggering, and overall impacts are enormous (Mascarenhas, 2004). A decade ago, a tectonic/oceanographic event of greater magnitude, the tsunami of December 2004 that demolished large parts of the south Indian sea front within a few minutes; monetary loss touched 3,242 crore rupees (Mascarenhas, 2006; Mascarenhas and Jayakumar, 2008). This event was a cruel reminder that all is not well with the way Indian coasts are encroached. In June 2013, a cloudburst produced a debris avalanche that descended through Himalayan valleys and carried anything and everything that obstructed its way (Uttarakhand Space Centre, 2013; Srinivasan, 2013; Das, 2013). About 100,000 civilians were stranded (Srinivasan, 2013), 15,000 deaths were reported (by the media), 11,000 were missing or buried in the debris, 5,000-6,000 animals perished, 144 bridges destroyed, 400 villages swept away, 1,636 roads damaged, 19 hydropower projects completely destroyed and a loss of 12,000 crore was incurred by the tourism industry alone (Das, 2013). Time and again, persistent extreme events (Table 1) seem to catch our authorities off guard.

The Disaster Management Act (Ministry of Law and Justice, 2005) defines disaster as a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or man made causes resulting in substantial loss of life, destruction of property, or degradation of environment. However, a fundamental concept needs a review. Every time a natural phenomenon creates havoc, it is labelled as “natural disaster”. A common fallacy is that floods, cyclones and earthquakes are disasters (Stenchion, 1997). These are hazards, derived from natural events which are potentially destructive, and end as tragedies if and when a community is afflicted (Stenchion, 1997). Therefore, whenever humans come in the way of powerful natural forces, a major catastrophe is certain.

Natural hazards – lessons not learnt:

The recurrent natural hazards notwithstanding, haphazard growth of settlements continues at a rapid pace. Shockingly, hazardous regions are taken over by humans. Crowded structures in susceptible coastal stretches (Pilkey and Young, 2005; Mascarenhas, 2006; Mascarenhas and Jayakumar, 2008) and multiple dams across landslide prone Himalayan waterways (Valdiya, 2011; Grumbine and Pandit, 2013) only increases vulnerability to hazards. Such settings are most severely destroyed.

Apparently, the severity of damaging extreme events has not been a disincentive to the construction programs.

A major cause for the Himalayan flood was water charged with moraine deposits (boulders, sand and clays) which came hurtling down due to the breaking of the moraine lake barrier, located ~4 km uphill of Kedarnath. This flow eroded the channel bedrock during its course, and explains how huge boulders were seen moving in the floods. The high speed of debris-charged water was due to the steep gradient from Kedarnath town down to Rambada to Gaurikund. The onrushing water undercut the river banks which are mostly composed of loosely packed Himalayan sediment composed of sand, silt and clay with interspersed boulders (Disaster Mitigation and Management Centre, 2012; Uttarakhand Space Centre, 2013; Srinivasan, 2013). The major affected areas are Kedarnath valley, Alaknanda, Mandakini and Bhagirathi rivers which flow through Rudraprayag, Rambada, Gaurikund, Chamoli and Uttarkashi.

Under the Environment (Protection) Act 1986 the Central Government notified entire watershed of about 100 kilometers stretch of the river Bhagirathi from Gaumukh to Uttarkashi covering an area of 4,179.59 square kilometers as the Eco-sensitive Zone (MoEF, 2012). The authorities were directed to prepare a Zonal Master Plan. No development was allowed in areas having a steep slope or areas which fall in fault or hazard zones or areas along slopes with a high degree of erosion. Cutting of hills that cause ecological damage and slope instability was forbidden (MoEF, 2012).

However, research has revealed dam building as the most significant threat to riverine ecosystems (Valdiya, 2011; Grumbine and Pandit, 2013). Based on the number of proposed dams, the Indian Himalaya would have one dam for every 32 km of river channel. Around 88% of proposed dams are located in these ecosystems rich in biodiversity, and over half of the dams would be in dense, relatively undisturbed forests (Grumbine and Pandit, 2013). Man-made structures have compounded the problem by not allowing free flow of rivers in spate; construction of embankments has aggravated matters as accumulation of sediments has raised the level of the channel beds; channels are mostly choked (Valdiya, 2011). Inappropriate land use practices such as haphazard road construction, human settlement close to or along the river banks, de-forestation of hill slopes, human impact due to tourism related activities, and more particularly, dam building activity are the reasons why a natural hazard ended in a tragedy. Creation of road network for pilgrims is a cause for concern. These roads are not scientifically planned, as construction debris is thrown over into the rivers creating slope instabilities and choking of rivers. Saturation due to rainwater leading to increased pore water pressure in the overburden mass on the hill slope seems the most probable reason for triggering destructive landslides. Thus many river banks collapsed, along with roads and

dwellings built atop these unconsolidated hill slopes (Disaster Mitigation and Management Centre, 2012).

Following the December 2004 tsunami, human settlements were destroyed, huts on dunes were washed off, improvised wooden shops vanished, and some coastal villages were wiped off entirely. The reason for such a disaster was that crowded houses were built too close to the shore, on levelled sand dunes. With an absence of buffer zones, and flouting of coastal regulations, habitations were impacted by direct wave attack (Mascarenhas, 2006; Mascarenhas and Jayakumar, 2008). One year later (January 2006), despite adverse impacts, hectic rebuilding activity was observed at several places, make-shift huts are back (Figure 1); most houses are rebuilt on former foundations, with coastal setbacks treated with impunity (Mascarenhas and Jayakumar, 2008). Similarly, sea walls were overrun, dissected and dislodged by mighty waves, a bridge column 1 km upstream was dislocated (December 2004). That was because there is no way to protect a sea wall from direct hit by virulent oceanic forces. One year later (January 2006), the boulder wall at Pondicherry city is widened (Figure 2), and the one at Nagapattinam port was rebuilt in concrete (Figure 3), at a higher cost, and as a taller and longer fortification (Mascarenhas and Jayakumar, 2008). Thus, after the initial panic subsided, it was business as usual at several coastal sites in Tamil Nadu.

The inhabitants of coastal Tamil Nadu lost their lives because they were occupying landforms that they were not supposed to alter and build upon (Mascarenhas, 2006; Mascarenhas and Jayakumar, 2008). The prevailing CRZ laws prohibit indiscriminate use of sea side spaces, as sand dunes are fully protected from human interference (MoEF, 1991). Similarly, the people in the Himalayan hill slopes paid the price because fragile, steep slopes prone to (recurrent) landslides were deforested and usurped, and tampered in favour of multiple dams (Valdiya, 2011; Grumbine and Pandit, 2013) and tall buildings which had no business to be there. Environmental guidelines (MoEF, 2012) that forbade construction activity were defied and the ecosensitive zone criteria were ignored. Although CRZ notification (MoEF, 1991) regulates coastal development, and the Himalayan slopes are governed by the ecosensitive zone guidelines (MoEF, 2012), the country does not have a functional natural hazards policy. Therefore, several factors cause recurring disasters followed by human suffering: (a) non-implementation of existing policies, (b) breakdown of enforcement, (c) lack of appropriate setback, and (d) absence of post-disaster redevelopment guidelines.

The need to recognize geological processes, vegetated landforms and setbacks:

Will history repeat itself at Kedarnath and the downstream fragile hill slopes? Will it be business as usual in the days ahead? It was hoped that the tsunami would boost natural hazard policies; this

aspiration was never fulfilled. Another tragedy has gone by, and every time the unsuspecting individuals suffer endlessly. Therefore, it is obvious that the Indian science fraternity is not able to reach a consensus on how to react. The threat therefore persists.

Experiences from storms have set new directions for coastal management on a global scale (Pilkey and Young, 2005; Pilkey et al. 2000). Knowledge of coastal geological processes and the interaction of forces of nature with human-built coastal environment is a fundamental process that has to be understood. Coasts offer natural buffer protection, but when human development gets in the way, coastal physical and storm processes turn into natural hazards that culminate in disasters. Without the human-built environment to interact with, storms (or floods) are a different matter (Stenchion, 1997; Pilkey et al. 2000; Pilkey and Young, 2005). Ecosystems need to be functional, for which space is needed for them to evolve. Therefore, when coastal processes are ignored and natural protection removed, the vulnerability to hazards is increased as there is no way to defend a structure against direct wave, surge or flood attack (Pilkey et al. 2000; Pilkey and Young, 2005).

Natural coastal landforms take the brunt of natural processes and thus protect lives and property. Bitter lessons of the past emphasize the need to utilize the natural buffer capacity of coastal ecosystems, coastal forests and hill slopes. That is why protection against natural hazards begins with preservation of natural landforms that have natural resistance against wave attack, flooding or erosion (Pilkey et al. 2000). Vegetated landforms have an inherent hazard-prevention value and hence reinforce the need to classify them as critical areas to be preserved. The most ideal low-risk development is the one that recognizes natural geological processes, preserves inherent landforms, and promotes afforestation. A public policy for natural hazard management, by considering suitable options for adaptation (setback zones, shifting of buildings, no development in susceptible areas, relocation, realignment, creating upland buffers, appropriate land use, regulation of hazard zones and improved drainage) is imperative (Valdiya, 2001; Mascarenhas, 2004; Mascarenhas, 2006; Mascarenhas and Jayakumar, 2008). Therefore, appropriate setbacks in the form of forested natural landforms, may well be the last option to save sensitive ecosystems and its inhabitants from the ravages of natural events.

Here, the science – scientist – policy – society nexus comes into play. Have we, as earth scientists, fulfilled our duty towards mankind by warning about the perils rapacious development? Unfortunately, the voice of the scientific community appears silent (Pilkey and Young, 2005; Valdiya, 2012). Paradoxically, the scientific literature is replete with research papers describing the mapping of vulnerable zones; but sadly, the fruits of scientific research have not percolated the political system and, as such, scientific results rarely reach the public. Obviously, a stronger, direct

presence of scientists on individual local projects is needed to counter the hugely powerful construction lobbies. Scientific knowledge brings with it societal responsibility (Pilkey and Young, 2005; Valdiya, 2012). Ultimately, environmental preservation and human welfare is the key to sustainable ecosystem management.

In summary, the relentless natural hazards have invariably ended up in human agony. These calamities offer an ideal opportunity to focus on and call for the need of a national natural hazards policy. A public instrument that identifies geological processes, recognizes the protective value of landforms, acknowledges mandatory buffer zones and considers options for adaptation, is the sustainable alternative to attenuate the devastation by natural events. More importantly, the Indian scientific community has an obligation to forcefully project the results of scientific research into the political domain, inculcate the habit of public interactions through awareness, and make their voices heard so as to rescue natural ecosystems.

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Table 1: Anatomy of some major recent natural hazards that culminated in unprecedented disasters (Sources: Mascarenhas, 2004, 2006; Mascarenhas and Jayakumar, 2008; Valdiya, 2011; Srinivasan, 2013; Das, 2013, and references therein). Figures in this table are maximum values.

| | Himalayan floods | Storm surges | Tsunami |
|--------------------------------------|---|--|---|
| Natural hazard | Cloud burst | Severe cyclones | Undersea earthquakes |
| Natural process | Torrential rainfall (2-10 cm/h) | Strong wind (260km/h), high waves (12 m), rain | Powerful instantaneous high wave (6.5 m) |
| Duration | 1-2 days | 2-3 days | About 1 hour |
| Frequency | Frequent in Himalayas | Average 1.5 severe storms yearly | Appeared after 63 years |
| Areas affected | River valleys | Large coastal areas | Narrow coastal strip |
| Damage potential | Flash floods, threats to population, damage to houses on floodways; coarse deposits on river beds; loss of carrying capacity of rivers; collapse of roads | Persistent flooding; threats to population, damage to houses, property, livestock; destruction of infrastructure; changes in land use patterns; modifications of landforms; alterations of vegetation; effects on ports, harbors | Flooding; threats to population, damage to houses, property, livestock; destruction of infrastructure; modifications of landforms; overtopping of seawalls; impact on fishing ports |
| Inundation | (No flat land) | Up to 35 km inland | Up to 0.84 km from coastline |
| Effect on dwellings / infrastructure | About 144 bridges collapsed, 1,636 roads damaged, 19 power stations affected | Several kilometres inland | Up to 132 meters from dune line |
| Geological setting | Loose sedimentary sequences, moraines | Coastal beach-dunes, lowlands | Coastal beach-dunes |
| Impact on landforms | Landslides, erosion of river banks | Beach and dune erosion | Dune breaching, erosion |
| Impact on vegetation | Trees uprooted along eroded banks | Uprooting of dune creepers, but mostly casuarinas | Frontal vegetation within 5 to 25 m strip damaged |
| Loss of human lives | Around 15,000; 11,000 missing and 100,000 rescued | 10,000 in 1977; 9,900 in 1999 | 8,726 in 1 day |
| Loss of property | 400 villages swept away, 5000-6000 animals perished | 12 lakh houses in 1999 | ---- |
| Economic loss | 12,000 crore | 2,750 crore in 1999 | 3,242 crore |



Figure 1: Business as usual: the scenario along Velankanni beach before (1998) and after the December 2004 tsunami. Top: Makeshift structures occupy entire beach width of 75 meters (November 1998); Centre: Made of bamboo and coconut leaves, the thatched huts were washed off in totality and the beach was flattened (April 2005); Bottom: One year later, the shops are back despite monetary losses (January 2006). Note full fledged electricity connections along with a sign board warning about tsunamis. The shrine of Velankanni is seen in the background (Photos: A. Mascarenhas, NIO, Goa).



Figure 2: An example of bureaucratization of sea walls. Top: A modest rubble protection wall existed at Pondicherry since long (April 2005); the tsunami did not affect the city coast, except for mild overwash; Bottom: The sea wall, now with large boulders, has been extended about 30 meters sea ward for no reason whatsoever (January 2006) (Photos: A. Mascarenhas and S. Jayakumar, NIO, Goa).



Figure 3: In what appears as a challenge against eventual natural extreme events, the earlier low sea wall (April 2005) that was overtopped by the tsunami, has been extended about 150 meters southward as a taller and broader concrete fortification; beach erosion has already started at the distal end (January 2006). Also note that fear impelled villagers to plant coconut saplings on the beach; these plants perished within a year. The Nagapattinam light house is seen in the background (Photos: A. Mascarenhas and S. Jayakumar, NIO, Goa).