FORUM

PREPARING FOR GLOBAL WARMING

Every year in the U.S., high winds and storms cause billions of dollars in damage to coastal structures. This amount is expected to continue to increase as more people settle in growing coastal developments. In addition, we must now focus on an additional source of risk to coastal areas: disasters induced by global warming and an associated rise in sea level.

The concern for enhanced greenhouse gases that might modify regional climate has raised considerable interest in the projection of regional climatic response to global warming. Current models simulate climate variability, but their resolution is too coarse to predict regional climate details accurately. Despite uncertainty in the current data, climatic warming does seem to have a definite identity apart from climate noise. Less ambiguous than computer models are the worldwide records of sea level fluctuations. A century-long 10–30 cm rise indicates a warming trend and subsequent melting of glaciers and ice sheets whose runoff fills the ocean, though the effects of unevenly distributed tide gages, land subsidence and crustal motions remain a point of debate.

Climate changes may also affect waves, winds and tides to yield spatiotemporal variations. By 2030, an average increase in sea level of 18 cm is expected, indicating a rate of rise three to six times faster than that of the last century. Even if emissions controls curb greenhouse gases, the rise in sea level will continue since it will take time for the climate to recover. Physically, warmer seas will provide necessary ingredients for more frequent development of storms.

The frequency of extreme climatic activity depends on changes in the mean and standard deviation of their occurrences. An expected increase in the mean value with constant variability due to global warming would enhance the probability of high extremes. This introduces a concern over the damaging effects of multiple successive extreme events. Indeed, the likelihood of destructive double events may be upgraded from unlikely to probable within an average lifetime.

Sea-level rise coupled with superstorms threaten coastlands with flooding under high-tide storm surge and wave action, beach erosion and construction damage, and the flooding of vital evacuation routes. For these reasons, it is very important to investigate the impact of the consequences of global warming. If the climate change begins to have an effect, the present sites of large cities would have to be adapted by adding protection from storms on the rising sea and from coastal erosion. Current safety margins would have to be updated to include both the retrofit of existing structures and the construction of levees and sea walls to alleviate the projected damage. Construction practices would have to be modified to include elevating future structures; raising existing structures; and building dikes, berms and pumping facilities. Vital evacuation routes would have to be elevated to avoid flooding, and coastal erosion would have to be offset by dredging and replacing sand at strategic locations.

Yet, before any adaptive measures are taken to decrease the potential for catastrophic damage to a structure, the amount of risk and the subsequent consequences must be assessed since extensive adaptations could cost in the billions of dollars. We need to develop a framework within which to assess risk and identify facilities at risk. Although little is known of the relationship between tropical storms and their degree of devastation, this framework will permit integration of future climate-change scenarios in the overall tropical storm hazard and evaluation of its impact on the risk to coastal zones.

A key to risk analysis is the assessment of damage potential. We must seek better quantitative procedures to evaluate damage potential. A multihazard approach, which would cross-cut similar activities in earthquake damage, concentrating not only on structural damage but also on losses due to rain penetrating into building enclosures, would be an excellent first step in a long-term effort to preserve the world's potentially endangered coastal cities. Should the cities opt to adapt, future structural design standards will have to be modified to account for an increased frequency of extreme conditions.

Investment policy will have to include a weighing of the economic trade-offs, with the help of the risk analysis scheme, to determine where the potential damage to or loss of a structure should be gambled against the cost of added safety measures. Investment in a safety margin will also have to be justified according to the probability that the alteration will be needed.

The effect of global warming may be forestalled by adopting more efficient building codes that include measures to reduce energy consumption; developing more efficient building envelopes, cladding and curtain walls to cut down heating and cooling demands; using more white roofs and pavement surfaces that reflect sunlight; developing a new glazing to retain heat in winter and deflect it in the summer; and using passive solar techniques in locating windows and overhangs.

Uncertainty about the effects of global warming may be minimized by monitoring and cataloging the climate; sea level; stream runoff; and hurricane and storm tracks, occurrences and intensities. Finally, by simply improving current structures to resist current climatic extremes, the future impact of an extreme climate change may be diminished as adaptation measures for coastal areas are developed in the immediate years to come.

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