Seasonal Diversion: Global Warming Christmas Song

POLICY IMPLICATIONS OF SEA LEVEL RISE: THE CASE OF THE MALDIVES

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The Maldives are vulnerable to sea level rise because they are not vulnerable to storms. Although that statement may sound like a paradox, it is roughly analogous to our discussion of wetlands, in which we noted that areas with low tidal ranges are more vulnerable than areas with large astronomic and storm tides. Because storm surges are rarely over 30 cm, it is been safe to develop land that is only about 40 cm above high tide, and most of the population lives on land within two meters of sea level; virtually the entire nation is within four meters of sea level.

In February 1989, I had the pleasure of visiting about 20 islands in the Republic of Maldives along with Dr. Colin Woodruff and a number of engineers from Delft Hydraulics Laboratory over a period of about 10 days. Particularly useful was Dr.Woodruff's decision to bring along a rod and transom, which made it possible to measure the elevations of a typical transect across several of the islands. The following sections recount some of my observations and courses of action that seem reasonable given what I was able to learn.

Observations at specific islands

Male. The capital of the Maldives appears to be generally about 2 meters above sea level, although some of the reclaimed areas are somewhat lower. During storms in 1987 and 1988, the reclaimed areas were flooded by low-period waves. Although the damage was minimal, the experience was a forceful reminder of how vulnerable the Maldives can be to even a small rise in water levels, and is generall viewed as the catalyst that prompted officials to begin considering the implications of higher sea level.

The initial response to this threat was to begin construction of a series of breakwaters on the outer coast of Male, which will protect the capital from damaging storm waves. Nevertheless, they would not prevent a flooding from a sustained rise in water levels. Fortunately, even a one meter rise in sea level would leave Male somewhat above the level of high tide.

A more immediate concern is the dwindling of the freshwater table. With over 50,000 residents on one square kilometer of land, the annual recharge into the aquifer is much less than annual withdrawals for consumption. As a result, fresh water is only available in the center of the island, and even there, the freshwater lens is narrowing. Fortunately, there is ample rooftop collection to supply drinking water; but cleaning and commercial uses still depend on groundwater.

Because the groundwater table will be largely "mined" in the next decade, one might view saltwater intrusion do to sea level rise as irrelevant. Certainly a policy response will be necessary in the near term even without sea level rise, such as importing water from another island. Nevertheless, once these responses are in place, the groundwater would continue to supply some of Male's needs. Sea level rise, however, would reduce the freshwater storage capacity of Male, as well as any adjacent islands that might be a supplemental source.

Edifushi. In response to dwindling water supplies and overcrowding in general, the Maldives have embarked on an ambitious plan to create a number of new cities on islands that are relatively uncrowded today. The first island we visited was Edifushi, a well planned community in the Baa atoll where freshwater is still plentiful. The island also has a reasonable elevation.

Tulhadoo. With 1900 people, this island is less crowded than Male but more so than most islands in the Republic. It is probably the most vulnerable we visited. Most of the land is about 70 cm above high water, and reclaimed areas are only 35 cm above high water. During the 1987 storm, the reclaimed areas had to be evacuated. Therefore, a 35-cm rise would completely inundate the reclaimed lands, and would leave the whole island underwater during a repeat of the 1987 storm. Because buildings generally have floors at ground level, they are flooded whenever the surrounding land is under water. Reclamation has at least temporarily halted as a result of a ban on mining the adjacent reef.

As discussed above, the layer of freshwater is only about 10 cm thick during the dry season. One can get fresh groundwater only by digging temporary holes, removing a bit of water, and then covering them up. The water is already too salty for fruit trees or watering crops; although it is hard to see how it could get any worse, sea level rise could further diminish water availability by increasing groundwater loses through evaporation. (i.e., the water table is now 60 cm below ground, but it would only be 30 cm above the ground with a 30 cm rise in sea level.

Goidu. This relatively prosperous island has plenty of vacan land and somewhat more elevation than Tuhladoo, with most of the developed part one meter above the high water mark. Moreover, the buildings generally have floors about 30 cm above ground level; the elevation of the Mosque is one meter above the high water mark, suggesting that this facility will almost certainly withstand floods for the next century.

The island also has plenty of fresh groundwater. Given the relative elevations, the substantially lower population density, and the greater island width, a 30 cm rise in sea level would leave the island in better shape than Tuhlado is today.

Fahendu and Falidu are similar to Goidu in many ways, but have higher elevations. The former is about 3 meters above high water, with houses 10 cm above the ground and the Mosque well above the ground. The island chief explained to us that people used to always build floors above the ground to discourage creatures from entering, as well as flooding, but that economics sometimes discourages them today. Falidu, while poorer, is generally in a similar situation.

Thoddu This island has a 3.5 meter (high water) ridge, which declines to about 2.5 meters in the center. About 1 km wide, it has abundant freshwater and is one of the most agriculturally important islands in the nation. The water table is about 1 ft above sea level during the dry season.

Although sea level rise does not immediately threaten this island with inundation--even a one meter rise would leave it less vulnerable than Male is today, agriculture could be hurt. For example, Male has already lost its mango trees due to saltwater penetration. Although bananas and papayas have shorter roots, they could eventually be vulnerable, and less water would be available for irrigation. (Fortunately, coconut tolerates saltwater.) However, there are grounds for optimism, at least within the short run. If the water table is thirty centimeters above ground level this suggests very abundant supplies.

Nevertheless, wells may have to be rebuilt because their current depths are designed to tap freshwater without getting the salt water. If the entire water table moves upward, than both fresh and saltwater will seep into the well, where they will mix.

Addu Atoll. At the southern tip of the Maldives, we visited four islands that are connected by causeways. One gets the impression that this area may eventually constitute the second city of the Maldives. It already has an airport, industrial activity, plentiful electricity, a hotel, an area of vacant land as large as Male itself, plenty of water, a hospital, large houses on large lots with plenty of trees, and opportunities for waterfront development desired by many of the young professionals. But the islands are only about 70 cm above high tide, except for Gan, which is about one meter above high water.

Fua Mulaku. The largest island in the Maldives, it is also one of the higher islands. With a freshwater lake in the middle that is twelve feet deep, this island has plentiful freshwater supplies. Yet storms have carried enough saltwater onto the island to disrupt agriculture in the past, and a higher sea level would make such incidences even more frequent.

Thaa Atoll. All of the islands we visited are extremely low and vulnerable to a rise in sea level.

Possible Responses

Whether you like it or not, the Maldives will have no choice but to adapt to sea level rise.

The possible responses to inundation and flooding fall roughly into three categories: abandoning islands, holding back the sea with dikes, and building the island upward. None of these options would be problem-free. People have been reluctant to leave their islands; moreover, this is more of a temporary than permanent solution because eventually the higher islands would also have to be abandoned. In the absence of coastal engineering measures, it is unclear whether the entire nation would be inundated or if storms might create some new islands; it seems unlikely that the Maldives would want to stake national survival on the untested hope that nature would create new islands onto which people could migrate.

Dikes have proven useful for many nations, most notably the Netherlands, where 50 percent of the country is below sea level and protected by dikes and pumps. Many coastal cities below sea level also are protected by dikes, including New Orleans and Bangkok. Moreover, seawalls have been used for protecting above cities that are above sea level from flooding.

Although they can provide useful protection from waves, conditions in the Maldives do not favor dikes as much as in the Netherlands: Because the cost of building a dike depends on its length, these structures are more likely to be cost effective when wide area is being protected on one side only than when a narrow area must protected on several sides. Moreover, it would be almost impossible to maintain much of a freshwater table because one would have to pump out the part of the water table where freshwater would normally reside. Finally, with the exception of Male, the costs may be greater than the value of the land being protected, and in Male, the loss of the waterfront view would be unacceptable.

In my view, the most generally appropriate means of protecting the nation will be to gradually elevate the islands. This will require a lot of sand and coral, but it would enable the islands to retain storage capacity for groundwater, and not substantially change the character of the islands. Moreover, it would make use of the existing capacity for removing coral from the sea; simply shifting the use from the creation of land to the maintenance of land.

Although the Maldives are one of the most vulnerable nations, rising sea level does not threaten national survival, provided appropriate measures are taken in response to and in anticipation of the problem. Adaptation is possible. Many people there already spend much of their time dredging material from the bottoms of lagoons and using the material to create land; those energies might be used to gradually raise islands. Moreover, the nation already has some experience, albeit controversial, at relocating populations.[1] Although the motivation has been primarily to eliminate overcrowding or satisfy requirements of the Koran that there be at least 40 male adults in a particular village, the experience gained may make it easier to move people from the very low to higher islands.

Policy makers need a broad vision of how the country will respond to sea level rise, but the actual response will consist of numerous discrete actions. Where possible, they should be consistent with the long-term response. We briefly list a number of particular actions that seem appropriate for the Republic of Maldives.

1. National resettlement efforts should focus on islands with substantial elevation. Because the lowest islands have limited freshwater, the Maldives would avoid promoting their development even without a rise in sea level. Nevertheless, if one ignores future sea level rise, there is little reason to favor an island with four meters elevation over an island two meters above high water, since both are above flood levels and would have substantial water tables. But by the time sea level rises 1.5 meters, the latter island would have the problems Tulhadoo faces today while the former would still have ample groundwater and be well above flood levels

2. Newly-reclaimed land should be at least one meter above high tide after the land has settled. Besides improving the ability of islands to avoid inundation due to sea level rise, this would increase the groundwater storage capacity of islands.

3. Floors on new homes should be at least three feet above high tide. In special cases where this is not possible, the ceilings should be high enough to accommodate a subsequent two-foot elevation of floor levels as sea level rises.. Even if sea level rises more slowly than predicted, higher floor levels will protection from floods.

4. The national government should issue regulations soon. It is important to act now, while the floods are still fresh in everyone's minds and people remember the impact of not building high enough.

5. Regulations should have sufficient incentives to ensure compliance. In the United States, for example, we do not allow people to live in a house until it satisfies the building codes. One island chief even suggested revoking the license to use the land if a citizen fails to comply after being warned. Another option would be to provide flood relief assistance only to individuals or islands that implement sound planning.

6. The practice of building Mosques at higher elevations than other buildings should be continued. These buildings will last longer than other buildings, hence you have to consider how high the sea might be 200 years from now. In addition, the higher elevations would provide a shelter from flood waters if a record-breaking storm surge were to occur.

7. The national government should undertake outreach efforts to convince the public of the need to prepare for rising sea level. Because this is a problem for the next generation, these efforts should start with the school systems. In addition, discussions should be held with the various respected elders on each of the islands. Radio and newspaper coverage are a start, but they rarely can get into the specifi c implications that a particular island faces. Once people understand the potential impacts on their own islands, they will support the governments efforts to address the problem.

8. Brochures should be developed explaining the problem to tourists. In some areas such as the USA where people have not heard of the Maldives, the sea level rise issue actually is a vehicle publicizing the tourist resorts. The Maldives should be proud of its concern for the environment, and of the fact that you are addressing the problem while other resorts ignore it. Resort investors have no more reason to fear sea level rise in the Maldives than anywhere else, and perhaps less since that nation is addressing it. This nations sends one hundred thousand potential ambassadors back to their homes in

Europe, North America, and Asia each year; arm them with information and they will help make the case.

9. The possibility of creating a coral reef research center in the Maldives should be explored. We simply do not know everything we need to know to prepare for a rise in sea level. We know that coral can grow with the rising sea level, but we do not know how fast. And even less is known about how much sand will be produced, and whether natural processes would continue to create new islands with an accelerating sea level. We need to learn how to harvest the coral in a way that entourages its growth, rather than destroys it. We need to learn how to restore coral to areas like Male.

Such a center would be in the interest of international science for two reasons: First, we have a government here intensely interested in protecting the environment and implementing recommendations that might result from more research. Second, a center here would be different from other centers, in that it would be motivated by the need to solve practical problems. Provided that it is part of a long-term research program, the need to solve current problems often stimulates better research than science for the sake of science.

A research center would be in the Maldives interest for many reasons. First, it is the best way to guarantee that conclusions from ongoing research are applicable to the Maldives. Perhaps more importantly, it may be the only way to ensure that twenty years from now, you have Maldivian experts on coral atolls. One should be skeptical about solving the problems by relying completely on foreign scientists. They may be necessary for opening an institute, and they can provide important research; but they will eventually go home and true expertise requires people to spend decades studying the Maldives. Moreover, scientists have an important role to play in educating the local people, which requires familiarity with the native tongue. It is hard to imagine a more noble calling than for a few young people to decide today that they will dedicate their careers to understanding these atolls and convincing people to do whatever must be done to save them.

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Notes:

1. Last spring, when we all gave our presentations to the President and assembled guests, I suggested that the Maldives could keep pace with sea level rise if every family would add one wheelbarrow of coral sand per month to their yards. This week, a number of Maldive residents told me that the people who do not like that idea are calling me the "wheelbarrow professor." I did not mean to suggest that the best way for adapting to global warming is for every adult male to row out and bring back one wheelbarrow of sand each month, but only to show the Maldvies need not dispair because even without foreign help, you have the power to protect your inhabited islands.

2. President Gayoom's speech to the United Nations was a key first step in engaging the Maldives in the climate change issue, and in the eventual creation of the Alliance of Small Island Island States.