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Mini Review

Two examples of environmental problems from Chinese state planning

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Abstract

We present two recent and environmentally potentially catastrophic but otherwise politically decisive and perhaps even praiseworthy governmental actions of the Peoples Republic of China. One is China's world-renowned Three Gorges Dam project. This is perhaps one of the world's largest hydroelectric dams as yet and most certainly the daring and even audacious construction project. Sadly, it also defies the understanding of atmospheric circulation patterns. The other is the construction and use of atoll reefs to house military bases. This too is certainly a brilliantly conceived novel idea but its time has been unfortunately ushered perhaps a couple of million years too early. Both these are examples of the most brilliantly executed but otherwise ill-conceived notions that should not have been undertaken in the first place.

Introduction

China and India today are perhaps the world's oldest civilizations that have been continuing for upwards of five thousand years or so. And that itself implies an experience of all conceivable kinds of environmental changes as well as catastrophes. One would therefore expect these two civilizations to have automatically learned to adapt to them and overcome or tackle the associated problems. But their difference has been that while China has focused more on the practicalities of problem-solving here than on the intellectual reasoning of what and why India has always looked more at the latter than on the former. Thus China was the first civilization to discover paper, ink and gunpowder, whereas India was able to send religion to China. Little surprise then, that China saw and navigated through the tackling of science and engineering-related mega-projects, but has been rather weak in understanding the fundamentals of the problems and formulating the solutions for the root causes of these problems themselves.

Two examples of these problems/projects are presented he

central China, and has been the world's largest hydroelectric dam since 2012 in terms of electricity production (Zhou, et al. [1], Huang and Wu [2]). As a matter of fact, by 2019 China had already built over 40% of the world's dams, even though worldwide the trend had already turned against that. Apart from the possibility of more reservoir-induced seismicity (with 3,429 earthquakes in 2003-2009, compared to only 94 during 2000-2003, as the dam geologically sits on two major faults) and the loss of innumerable species (the Baiji dolphin species that lived in Yangtze river for over 20 million years was declared extinct in 2006 [3], for instance), we are also seeing the deleterious effect of the dam on tropospheric circulation.

Look at the general declining trend of precipitation [4,5], or rising trend of evaporation, worldwide through the last century, shown in Figure 1. This trend has varied with latitude and, superposed over the general overall decline in precipitation, is the fact that evaporation has been the most at about 5°N-20°N and about 20°S latitudes, consistent with the general model of atmospheric circulation. After all, for the earth spinning on an axis largely vertical to the orbital plane, evaporation should dominate precipitation at about 30°N and 30°S latitudes, except

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that the distribution of land and oceans is not symmetric between the northern and southern hemispheres. Earlier, it was wrongly felt that the dam would cause more frequent and heavier flooding. Instead, being located as it is at about 30°N latitude, what has happened is increased evaporation and now much of the Yangtze river basin has already dried up. Since this dam is a hydroelectric one, this loss of its power generation capacity has been an irreparable loss for the industry (e.g., Davidson, 2022 [6]).

This can be readily appreciated from the Hadley cells of atmospheric circulation that are also shown in Figure 1 [7]. Notice how the Hadley cells at about 30°N and 30°S latitudes diverge upwards from the surface, these are typically the arid latitudes at which land tends to have deserts, of course, more towards the land's interior and towards the western margins of land. Likewise, the intertropical convergence zone at the equator tends to have rain forests, much the same way as the 60°N and 60°S latitudes too tend to have rain forests. The observed precipitation data on the 20th-century precipitation decline, also shown in Figure 1, clearly corroborate this not only in the arid latitudes but also at the intertropical convergence zone or the equator. Now, with the decreased precipitation or increased evaporation at about the arid 30°N latitude near which the Three Gorges Dam is located, why should it be any matter of surprise that locating such a large dam as the Three Gorges Dam here would only raise rather than reduce the aridity. And this is precisely what the observed drying of this dam now confirms.

Coral reefs

We now come to the other example here-the construction and use of atoll reefs to house military bases. As Mike Ives[3] points out in his October 2016 article 'The Rising Environmental Toll of China's Offshore Island Grab', "China is staking its claim on the South China Sea by building airstrips, ports and other facilities on disputed reefs" and "such activities are destroying key coral reef ecosystems and will heighten the risks of a fisheries collapse in the region". Now, building on

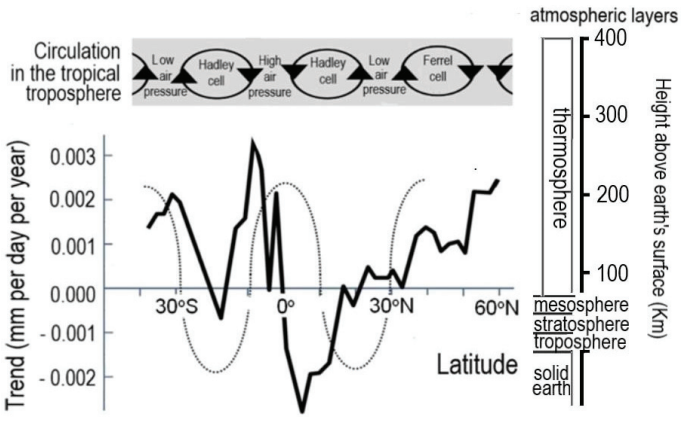

Figure 1: Shown by a solid black line is the precipitous decline in the observed rate of precipitation through the 1901-1998 period (taken from Hulme et al, 1998[3], but see also Lambert et al, 2004[4]). Notice the large fall at about 5°N-20°N and about 20°S latitudes. This is consistent with that expected from the general model of global atmospheric circulation shown by the dotted line and with the Hadley cells of atmospheric circulation in the multilayered atmosphere also shown here.

the coral reefs seems to be a brilliantly conceived novel idea but it is not clear if this idea itself is really as sound as it may superficially seem.

Figure 2 schematically shows how geophysics and biology combine to form the atolls and other reefs in the first place. This draws on the theory of "Structure and Distribution of Coral Reefs" that Darwin [8] first conceived during his voyage on the Beagle and is now known to involve the interplay of two forces: geophysics comes into the picture here by way of lithospheric flexure, because of which a once active and now dormant volcano starts sinking because of its weight and biology comes into the picture because corals, being sessile benthos, need their food to come to them and they do that most often by themselves harvesting the dinoflagellate zooxanthellae, yellow-brown algae that live in the coral polyps and photosynthesize by using the Sunlit surface water and the host coral's byproducts of cellular respiration and secretion from the host. Hence the need for the coral animal to live in the Sunlit surface waters, so that the algae can photosynthesize-in perhaps nature's most successful example of mutualistic symbiosis.

Thus, as shown in Figure 2, first a "Fringing Reef" forms fringing a dormant volcanic island, away from any freshwater source [9]. The second stage is when this reef evolves into a "Barrier Reef" through continued subsidence of the island as the reef must continue building upwards to keep harvesting its symbiotic partner, the algae zooxanthellae. This is when a lagoon forms separating the main island and the reef and is the intermediate stage towards the formation of the ultimate stage-the atoll reef-via continued subsidence of the island and the complimentary upwards building of the reef to cater to the needs of its symbiotic partner.

Any island-building efforts like those in the South China Sea are thus bound to affect both facets of this process. Construction on the reef will destroy the algae and thus disrupt the process of symbiosis, whereas any filling up and construction on the lagoon itself can only aid and neither disrupt nor retard, the subsidence process of lithospheric flexure. Not surprisingly, therefore and using satellite and computer-modeling data and previous studies of human impacts on coral reefs, scientists are concerned that China's current campaign may be causing irreparable damage. Coral reefs in the Spratlys and other offshore regions, including the Paracel Islands and Scarborough Shoal, supply larvae for fisheries that feed hundreds of millions of people. They also are a living seed bank that could help the region's marine communities deal with the long-term impacts of climate change.

Based on detailed studies of the satellite imagery and other data on the Mischief Reef, for instance, Leland, Cornillon, Rudnickas and Mouw [10] thus find the "backscatter increases of up to 350% in waters surrounding the reef, with plumes of excess sediment exceeding 250 km² at times during island-construction and the cumulative area impacted by dredging exceeding 1,200 km²" and argue from satellite-derived chlorophyll-a, backscatter, absorption and remote sensing reflectance that "dredging activities led to a decrease in

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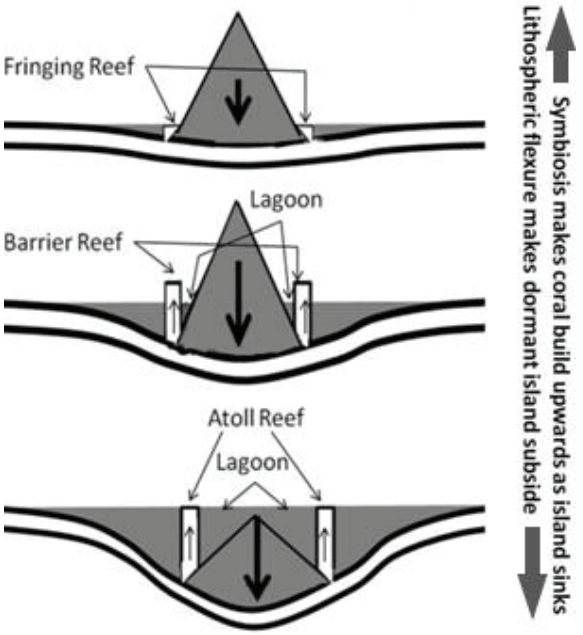

Figure 2: Darwin's theory of the "Structure and Distribution of Coral Reefs" is that there are three stages to an atoll formation. He theorized that atolls eventually form by the uplift and subsidence of the earth's crust in three stages. Initially, a fringing reef forms around an extinct volcanic island as the island and ocean floor subsides. With the continuation of the subsidence, that fringing reef first becomes a barrier reef and ultimately an atoll reef. We now relate the island's sinking to lithospheric flexure and the reef's continued rise to symbiosis.

biological health of the region resulting from the smothering of natural benthic habitats and reef complexes with sediment". These are very consistent with Darwin's original model for an atoll reef's evolution and any inability to take this model into cognizance is very much a failure of science and politics of the decision-making process there that the society at large will have to regret.

Concluding remarks

Both these examples clearly illustrate the enormity of undesirable consequences that can result from ignoring the available scientific insights and data. "What you're essentially talking about is destroying the equivalent of seven worldwide natural heritage areas," says Kent Carpenter, a professor at Old Dominion University in Virginia who has studied coral reefs in the Philippines for four decades, as quoted by Mike Ives[3]. Yet, in July 2016 when the Philippines won a landmark case at a United Nations tribunal, successfully challenging China's territorial claims in the South China Sea, Chinese President Xi Jinping vowed to ignore the tribunal's ruling and some analysts think that China's island-building efforts could raise geopolitical tensions and eventually lead to military conflict with rival claimants or the United States. As for the Three Gorges Dam, China herself is already paying the price for ignoring science using the argument that the supposedly envious world at large was unable and unwilling to digest the pride and prowess of a developing economy [11]. It may well be that this drying up is same process as what dried up the Aral sea earlier, and not just excessive irrigation there.

Before bad-mouthing the Chinese policy and decision-makers, though, we do need to note that atmospheric circulation is not as fully an exact science as yet as we would like. We do not know as yet what kind of coupling, if any, really exists between the convective cells of the atmosphere's tropospheric and stratospheric layers as also between the stratospheric and mesospheric layers. That work is still in progress. But kudos to the Chinese authorities, nonetheless, for the success of the "Great Green Wall" project [12].

Acknowledgments

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