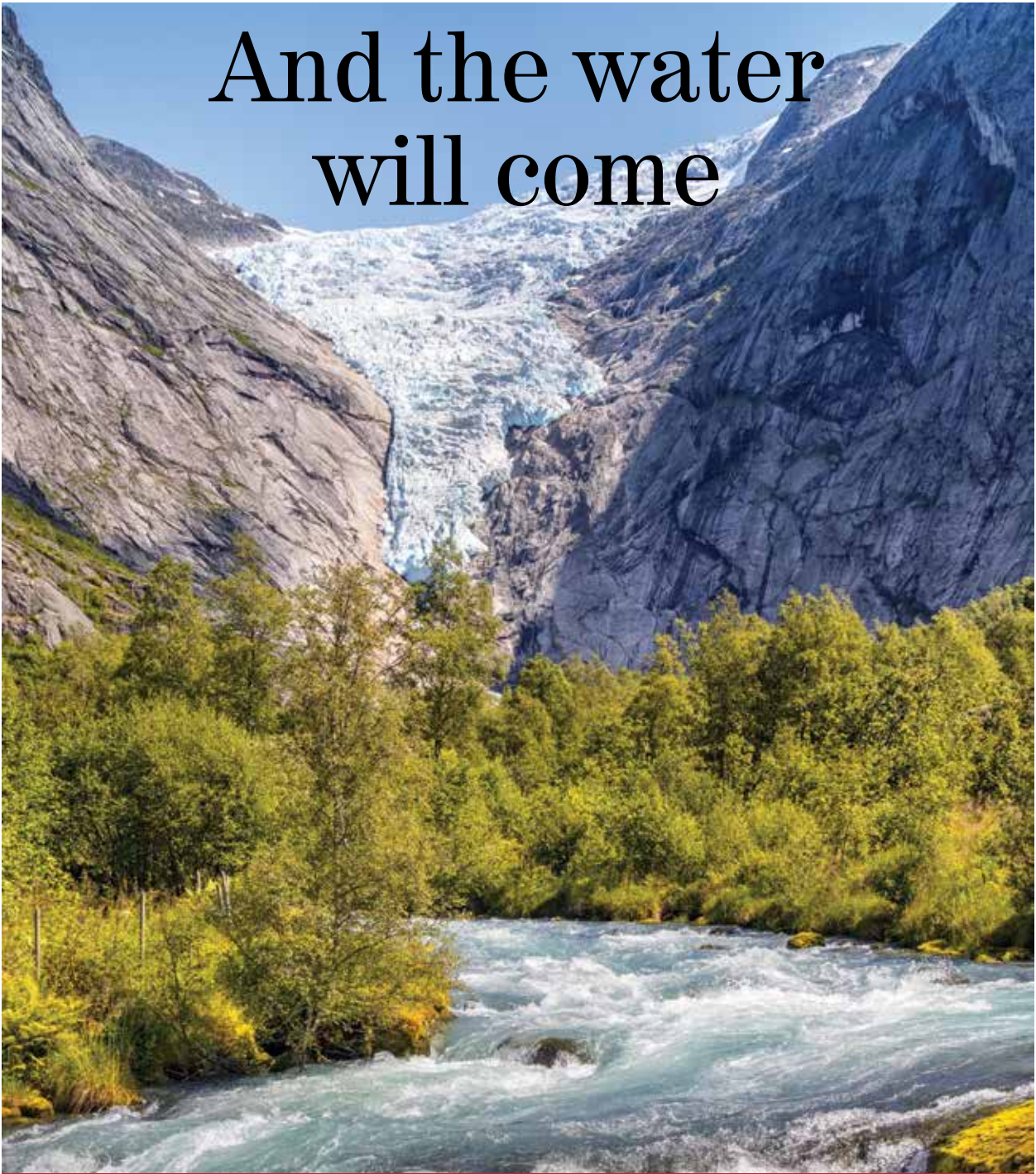


And the water will come



Recent analysis suggests that the problem may be on the world much faster and that the consequences of sea-level rise particularly upon coastal cities needs attention now, given the years it takes to remodel cities, let alone the huge expense.

By Mike Prior

Anthropogenic climate change is essentially a very simple process. Gases from human-based activity are emitted into the atmosphere. These inhibit the radiation of heat into space. As a result the atmosphere tends to warm at a rate which is greater than climate change from other sources, for example fluctuations in solar radiation, which operate on a much longer time-scale, sometimes millions of years. In the past these fluctuations have resulted in the formation of huge ice-caps covering much of the globe or, at the other extreme, no ice-caps at all. The presently predicted consequences of human-caused climate change, probably in the range of 2-4°C, are nothing like so extreme. The problem lies in the complexity of the changes in regional and local climate which will result from this relatively modest change; and the fast time-scale over which they will occur.

In Africa, the main shift will be in rainfall patterns, some regions having higher, some lower precipitation. Not all of these shifts will be malign; increased rainfall could benefit agriculture in some places. However, even in such regions, the costs of shifting crop patterns and adjusting to the changed climatic condition will be very high. Meanwhile, as the temperature moves upwards, the erratic and extreme climate events,

drought in some areas, heavy rain and floods in others, which have come to characterise much world weather, will continue. Cape Town residents know this very well. Meanwhile, one thing is certain; that the water is coming.

The last ice age ended some 12,000 years ago with its maximum glacial extent around 22,000 years ago. In this period much of the world was covered by huge ice-sheets which have been slowly retreating ever since. There were, for example, small glaciers in parts of the Lesotho Highlands and in the Drakensberg. The average temperature is estimated to have been about 60C below current levels. The remnants of this ice-age are the ice-

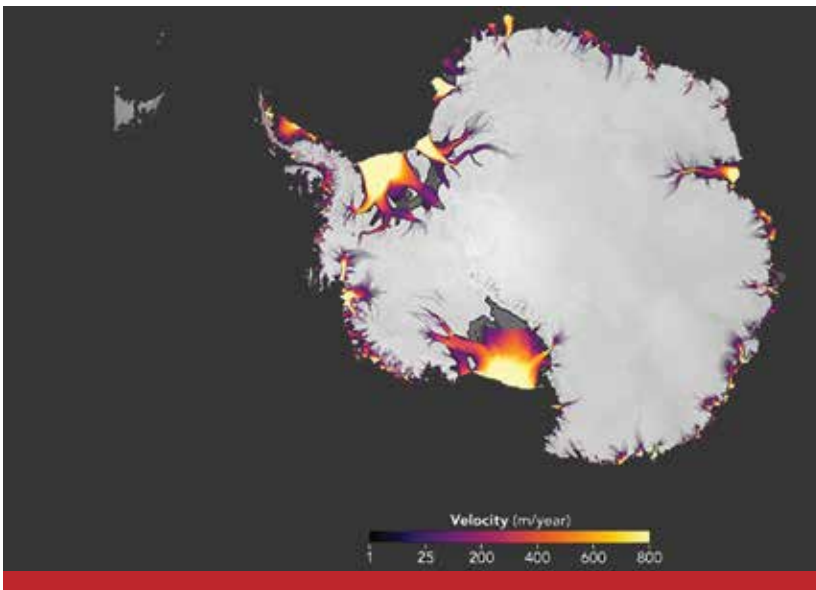
“As the temperature moves upwards, the erratic and extreme climate events, drought in some areas, heavy rain and floods in others, which have come to characterise much world weather, will continue.”

sheets which cover the landmasses of Antarctica and Greenland and the glaciers of the high mountains. Since this last glacial maximum, sea level has risen by more than 125 m, with rates varying from tenths of a mm/year to 10+mm/year, as a result of melting of major ice sheets.¹ This process will continue for many centuries to come. The factor which has altered this natural and long drawn-out process is human-based climate change which is likely to accelerate the process. By just how much and how soon is a matter of great uncertainty. The potential for sea-level rise is certainly great. If the Greenland ice-cap were to melt completely the sea-level would rise by nearly 7 metres whilst if Antarctica were to melt the rise would be as much as 60 metres.

Neither of these is likely for millennia but it does seem as if some degree of accelerated melting is taking place. In 2012, there was a sudden rise in surface-melting in Greenland which has been recorded in several dramatic videos.² One reason for this is the rapid increase in Arctic temperatures recently recorded most dramatically in 2018 when the land weather-station closest to the North Pole, at the tip of Greenland, spent more than 60 hours above freezing in February deep in the Arctic winter. Before this year, scientists had seen the temperature there rise above freezing in February only twice before, and then extremely briefly. This has resulted in a massive decrease in floating Arctic sea-ice to the extent that it is now thought that the Arctic may soon be ice-free for much, if not all, of the year. This would have little impact on sea-level but the accelerated collapse of the Greenland ice-cap mostly certainly will.

Antarctic melting is much more debated and appears to come about by a different mechanism with water coming out from under the ice-cap because of higher temperatures in the surrounding sea. It is, indeed, possible that increased snow-fall on the frozen surface compensates for this loss from the bottom of the ice. However, data released by NASA in February, 2018 suggest that ice-flow from Antarctica, particularly from the western ice-sheets, is accelerating. It found that:

In total, Antarctica was losing



THE FLOW OF ANTARCTIC ICE, DERIVED FROM FEATURE TRACKING OF LANDSAT IMAGERY
Source: NASA

roughly 1,929 gigatons of ice per year in 2015, the vast majority of which is replaced by new snowfall. But not all of it is replaced by snow, which creates an imbalance that contributes to sea level rise. In 2015, Antarctica lost 183 gigatons of ice that was not replaced by snow. That is 36 gigatons more than the continent was losing per year in 2008. So in total, Antarctica's ice loss—which can also be viewed as its contribution to sea level rise—has accelerated since 2008. (A gigaton is one billion tons.)

West Antarctica has been losing a lot of ice in recent years, and at an ever-growing pace, while East Antarctica is losing ice more steadily. The West Antarctic ice sheet is of particular concern because, like a building that stands on an uneven

become the biggest source of sea-level rise, according to the first complete underwater map of the world's largest body of ice.⁴

Warming waters have caused the base of ice near the ocean floor around the south pole to shrink by 1,463 square kilometres between 2010 and 2016, according to the new study published in *Nature Geoscience*. The research suggests climate change is affecting the Antarctic more than previously believed and is likely to prompt global projections of sea-level rise to be revised upward. Until recently, the Antarctic was seen as relatively stable. Viewed from above, the extent of land and sea ice in the far south has not changed as dramatically as in the far north. But the new study finds that even a small increase in

temperature has been enough to cause a loss of five metres every year from the bottom edge of the ice sheet, some of which is more than 2km underwater.

“What’s happening is that Antarctica is being melted away at its base. We can’t see it, because it’s happening below the sea surface,” said Professor Andrew Shepherd, one of the authors of the paper. “The changes mean that very soon the sea-level contribution from Antarctica could outstrip that from Greenland.”

There is little doubt that both the Antarctic and Greenland ice-caps are melting as are the glaciers in the high mountains and that the rate of this melting is accelerating. The mechanisms of melt and its rate remain controversial in some areas as does the key question:

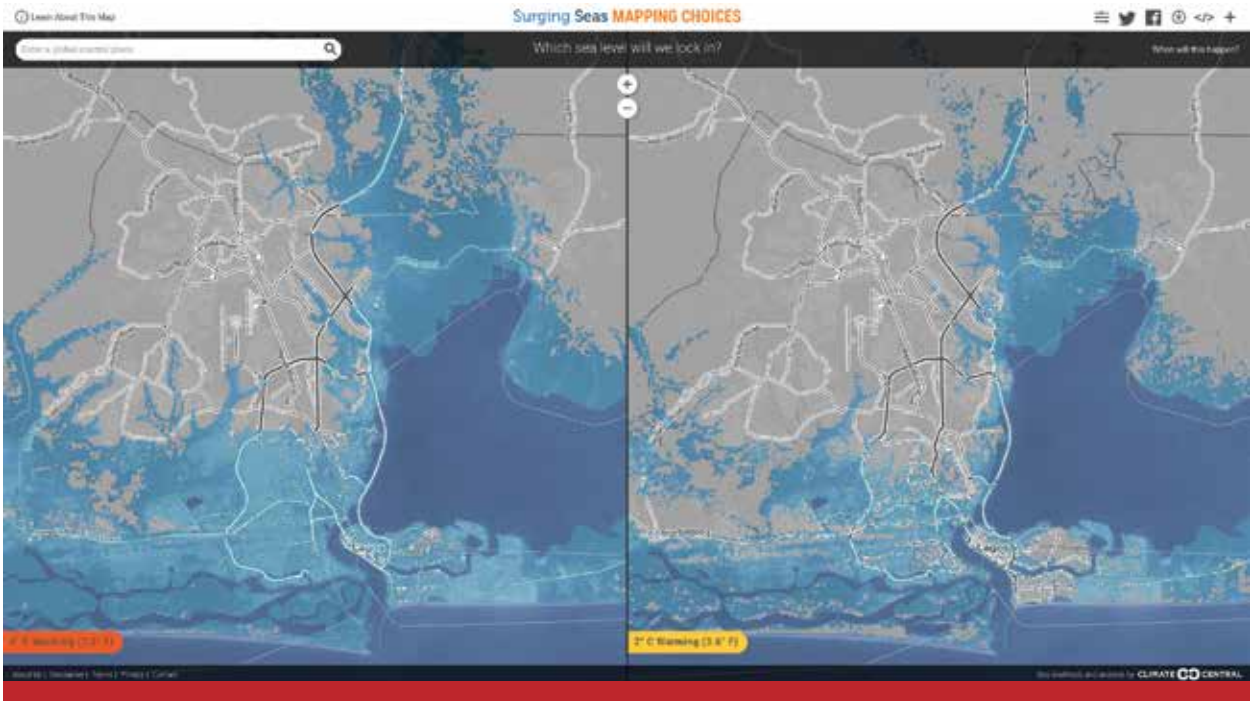
“There is little doubt that both the Antarctic and Greenland ice-caps are melting as are the glaciers in the high mountains and that the rate of this melting is accelerating.”

foundation, it is inherently unstable, making it especially vulnerable to the warming climate. If the entire ice sheet were destabilized and melted into the sea, researchers estimate it would lead to 3 meters (9 feet) of sea level rise globally. Models suggest that under a low-emissions scenario, where the world commits to “peaking” and then steadily reducing emissions in the near future, complete destabilization of the West Antarctic ice sheet is possible to avoid. But under medium- or high-emissions scenarios, the loss of the ice sheet becomes inevitable.³

These conclusions have been given even greater weight by recently published research which shows that hidden underwater melt-off in the Antarctic is doubling every 20 years and could soon overtake Greenland to



CAPE TOWN



LAGOS

just how fast is sea-level going to rise and at what level will it stabilise at least in a human timescale of decades. Until quite recently, estimates tended to look towards the end of this century thus parking the problem somewhere in the future. However, more recent analysis suggests that the problem may be on the world much faster and that the consequences of sea-level rise particularly upon coastal cities needs attention now, given the years it takes to remodel cities, let alone the huge expense.

Researchers at Climate Central, a US-based institute which works on various aspects of climate change, has produced an interactive map-tool which enables the impact of various temperature scenarios on the extent of flooding in world cities to be seen in vivid detail. Worldwide, the greatest attention has been paid to the megacities on the coasts of China and elsewhere in Asia and, of course, the startling news that Miami and even Disney World are likely to disappear. However, several African cities are also at risk as shown in the accompanying figures. (All are derived from [where many other cities can be viewed.\)](https://choices.climatecentral.org/#13/-6.8404/39.3272?compare=temperatures&carbon-end-yr=2100&scenario-a=warming-4&scenario-b=warming-2,</p>
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Cape Town will get off relatively lightly given its topography though, even at the 2°C rise which is probably the best that can be hoped for, its magnificent waterfront will largely disappear. There will be rather greater flooding along the southern part of the peninsula.

The huge city of Lagos will be much less fortunate as much of its metropolitan area is effectively at sea-level built around a large lagoon. The city's population is disputed and depends upon the area chosen but it is certainly in excess of 20 million and growing. The number of people that could be displaced by sea-level rise is very uncertain. Jeff Goodell, the author of *The Water will Come*, an inspiration for this article, writes:

*Various studies have come up with numbers ranging from three million to eight million. Whatever the number, you only have to spend a few hours in Lagos to understand that sea-level rise will displace a lot of people, and those people are going to have to go somewhere.*⁵

He continues:

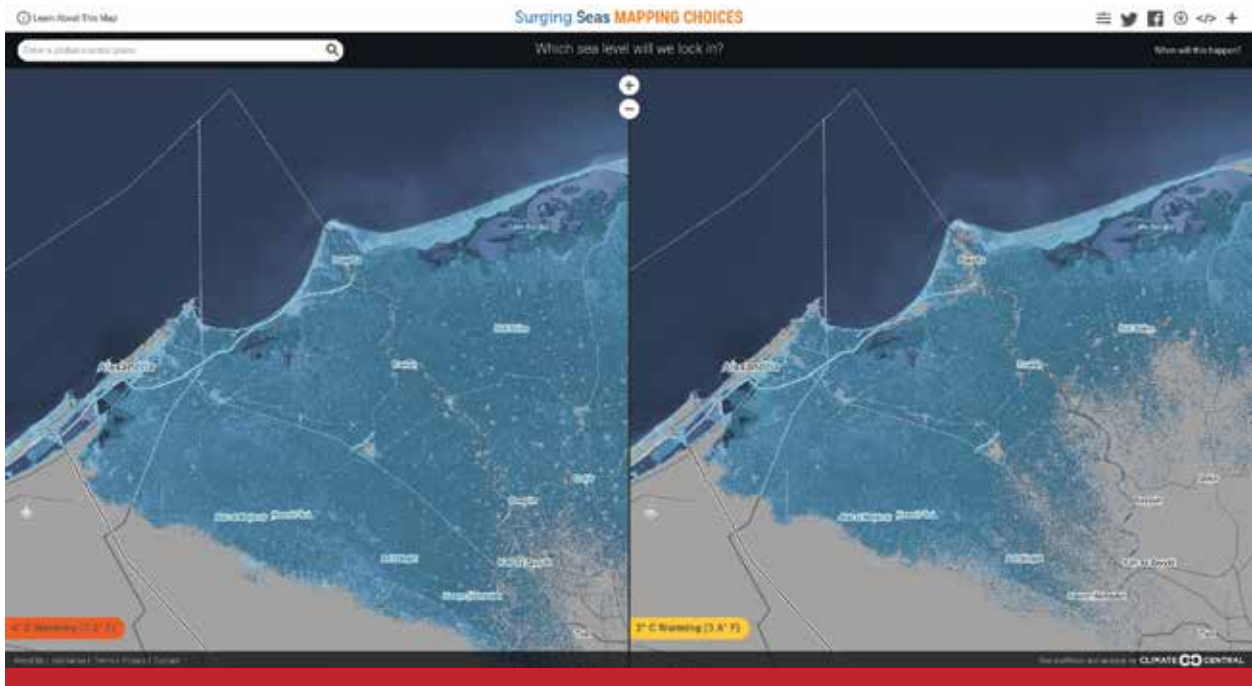
West Africa is particularly vulnerable, especially the four-thousand-mile-long sub-Saharan coastline that stretches from

Mauritania down to Cameroon. It's mostly low-lying and sandy – in some places the sea is eating more than a hundred feet of land in a year. In a region where 30% of the population lives along the coastline, according to the World Bank, this is a potentially catastrophic problem...

Lagos is not the only city at risk. In Accra, the capital of Ghana, low-lying areas of the city now flood every year during the rainy season. Parts of Nouakchott, the capital of Mauritania, already have lost up to eighty feet of beach every year, and erosion has already damaged several hotels in Gambia and Senegal, as well as an important water treatment facility in Cotonou, Benin's economic hub. On the outskirts of Lomé, the capital of Togo, rows of destroyed buildings line the beaches.⁶

In the north of Africa, the ancient city of Alexandria will essentially disappear, along with much of the heavily-populated Nile Delta, thus joining the submerged lighthouse of Alexandria, one of the seven wonders of the world.

The key question is not whether but when this devastation will come and this is a topic with widely varying estimates. A factor which confuses the issue is that, in a period when by



ALEXANDRIA

geologic standards, the sea-level is rising fast, there will be large storm and tidal surges capable of causing huge damage and then retreating. The recent rise in the number and size of hurricanes is evidence of this.

One thing is beyond controversy; forecasts of sea level rise are increasing almost yearly.

When the Paris Climate Change Agreement was drafted just over two years ago, it was based on reports that ice sheets would remain stable and on the assumption that sea levels could rise by up to three feet two inches by the end of the century. In 2015, NASA estimated a minimum of three feet. In 2017, a report by the National Oceanic and Atmospheric Association (NOAA), the pre-eminent climate science agency in the United States, revised estimates up dramatically, stating that by 2100 sea levels could rise by more than eight feet. In the April, 2018 edition of *Scientific American*, a specialist in Arctic warming, Prof Jennifer Francis from Rutgers University in the USA, writes:

We published a paper [in 2003] with a stunning, controversial conclusion: At the current rate of change, there was a real possibility that within a century, the world could witness a summer Arctic Ocean that would be ice-free, a

state not seen for thousands of years. Today I am startled again because it now appears that the ocean will likely be free of summer ice by

“West Africa is particularly vulnerable, especially the four-thousand-mile-long sub-Saharan coastline that stretches from Mauritania down to Cameroon. It’s mostly low-lying and sandy – in some places the sea is eating more than a hundred feet of land in a year.”

2040—a full 60 years earlier than we had predicted little more than a decade ago.

The Arctic is changing exactly the way scientists thought it would but faster than even the most aggressive predictions. The recent behaviour is off

the charts. In just three years more than a dozen climate records that had each stood for many decades have crumbled, including those for disappearing summer sea ice, decreasing winter sea ice, warming air and thawing ground.

These trends signal trouble for people around the world. The last time the Arctic was only slightly warmer than today – about 125,000 years ago – oceans were 13 to 20 feet higher. Goodbye Miami, New Orleans, the naval base in Norfolk, Va., most of New York City and Silicon Valley, as well as Venice, London and Shanghai.

In the scale of economic damage, African cities do not figure in the top ten of the world. The Lagos huts which will be wiped out are worth very little compared with Miami Beach or Manhattan. But in terms of the numbers of people displaced by coastal flooding, West Africa does come quite high. The immediate question which arises is, of course, just who will pay for either the works needed to resist flooding or the new habitation for the displaced.

In terms of blame for causing the climate change, given that greenhouse gases remain in the atmosphere for many decades, there is no doubt that, at least morally, historic totals of greenhouse emissions should be the decisive factor. Put this way, the

totals from 1850 to 2011 as collated by the World Resources Institute are as follows:

USA	27%
EU	25%
China	11%
Russia	8%
Japan	4%
The rest: nowhere	

These countries do not, of course, see it like this. In 2013, the International Climate Change Conference meeting in Warsaw did set up the Warsaw International Mechanism for Loss and Damage (WIM) which has, ever since, been talking about such a process. The Mechanism has an Executive Committee with some 20 members which has met regularly ever since 2013. According to a detailed report on loss and damage prepared by researchers at University College, London, "Any discussion on liability and compensation for loss and damage remains a 'red line' for industrialised countries and, so far, the WIM has made only modest progress in terms of building concrete support mechanisms for vulnerable countries."⁷ They discuss the COP 22 at Marrakech, in 2016, the annual gathering of the United Nations Framework Convention on Climate Change, in these terms:

At Marrakech, finance for loss and damage was a much discussed topic, however, this did not result in any concrete commitments. Although there were several calls to provide the WIM with more resources, this issue was essentially postponed: A technical paper will be prepared by the secretariat as an input to the upcoming review of the WIM in 2019 to elaborate "the sources of financial support" (draft decision FCCC/SB/2016/L.9). In addition, draft decision FCCC/SB/2016/L.8 highlights the need for the Executive Committee to include in its five-year workplan a strategic workstream dedicated to enhancing action and support, including finance, technology and capacity building. At the time of negotiations, the indicative five-year workplan contained only a place-holder for the finance-related workstream.

This theme of endless talk appears to have been repeated at COP 23 held in 2017 in Bonn when the WIM agreed on a new "five-year rolling workplan" for the mechanism, finalising a proposal from October. However, the WIM has yet to bring forward any concrete plan on finance – the key difficulty in loss-and-damage discussions. A one-off "expert dialogue" was also agreed for the May intersessional in 2018, which will inform the next review of the WIM in 2019.

In 2009, at the Conference in Copenhagen, the Green Climate Fund was set up to help poorer countries cope with climate change. It had a target of mobilising \$100 billion in finance. In April, 2018, it had received \$10.3 billion in pledges, a figure which has been static since early 2016. By way of comparison, according to Goodell, the cost of a project to build a

“The immediate question which arises is, of course, just who will pay for either the works needed to resist flooding or the new habitation for the displaced.”

defence wall around Lower Manhattan alone is put at at least \$3 billion, probably more.⁸

Essentially, when the floods come, Africa will be left to fend for itself unless the developed world takes a much harder look at its responsibilities. Quite soon, these countries will also have to face their own problems and spend large sums on flood defence. The one major country which appears to be taking climate change seriously is China and it may be that help will come from this source. However, it will come at a price.

On a lighter note, in the USA, it appears, according to Carl Hiaasen, chronicler of Florida low-life, that rising sea-level is already being exploited to make money. In his latest novel, *Razor Girl*,⁹ a plot-line records how eroded beaches are replaced by sand taken

from other beaches:

Florida's beaches erode pitilessly, the unstoppable rise of sea level presenting a nightmare scenario for waterfront hotels, coastal developers and real-estate agents. Once upon a time you could get away with selling submerged land to faraway rubes, but those days were over. Now buyers wanted to visit the property first, and not by paddleboard. Likewise, high-end vacationers to the Sunshine State derived no tropical enchantment from the sight of waves crashing through their hotel's lobby.

Climate change created a boom for a hurricane-spawned industry known as "beach renourishment," a process by which thousands of tons of sand are dredged from the sea shallows and dumped onshore to replace the acreage washed away by nature. The enterprise is as costly as it is futile, though for a few glorious months the shoreline appears authentic if not pristine. This fluffing of public beaches is funded by helpless taxpayers, while privately held oceanfront is often augmented at the expense of the property owners. Either way, beach-renourishment deals are fabulously profitable for the contractors because the job never expires – every grain of sand you dump gets washed away.

It seems as if, at least in Trump's America, even climate-change deniers have found a way to make a quick profit. ■

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